Research on the Influence of Regional Industrial Cluster and Regional Economy Based on ANN-RBF Algorithm - Take Shanghai, China as an example

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Abstract. The scientific planning of urban future space layout improves the quality of the regional economy for the city's future development and has important guiding significance. Taking Shanghai as an example, this paper first quantifies the regional industrial cluster and regional economy, then constructs the artificial neural network-radial basis function (ANN-RBF) algorithm and sets the algorithm test index. Based on data collection, RBF is used for contribution analysis to explore the impact of regional industrial clusters on regional economic indicators in Shanghai, China. The results show that the ratio of foreign investment (11.4%), the percentage of the tertiary industry's added value to the secondary industry's (10%) to the regional economy of Shanghai, China is more prominent than the other indicators. The scientific and technological achievements, energy consumption per unit of GDP, and electricity consumption accounted relatively small. This paper's significance is conducive to analyzing the correlation between regional economic and industrial cluster indicators in Shanghai, China.

Keywords: RBF, Neural Network, regional economy, Shanghai, China.

1. Introduction

In the process of industrialization of a country, industrial clusters are a major feature that cannot be ignored, and regional large industrial clusters will greatly enhance the competitiveness of enterprises in the region. At the same time, the development of enterprises in regional industrial clusters will also promote the high-quality development of the regional economy, [1] and bring huge potential benefits for regional construction and development.

The impact of the new coronavirus epidemic has led to a cold global economy and an economic downturn. The recovery and vitality of the economy are profoundly affecting the global cause of people's livelihood. At the same time, all aspects of industrial clusters also affect economic development with their irreplaceable power. In this context, countries have implemented corresponding measures and promulgated policies to help industrial clusters and economic development. For example, during the '14th Five-Year Plan' period, the Chinese government promulgated the '14th Five-Year Plan for Promoting the Development of Small and Medium-sized Enterprises' and other relevant documents, proposing that in order to further promote the high-quality development of small and medium-sized enterprises in the private economy, it is proposed to cultivate a number of small and medium-sized enterprises characteristic industrial clusters during the '14th Five-Year Plan' period and give them key support; EU set up the European Cluster Observatory to promote industrial information exchange, collect cluster information and deepen industrial cooperation; german industrial clusters are mainly produced through competition, and the winning enterprises will receive some government funding; Russia expects to build eight new industrial clusters in Siberia in the future, including precious metals and tourism, and expects to create 450,000 jobs by 2030, attracting investment of more than RUB 9 trillion. The above measures and cases in

different countries are enough to see that it is very important to study the impact of regional industrial clusters on the regional economy.

Since the concept of "industrial cluster" was put forward, many scholars have made their elaboration and explanation on the issue of "the impact of the industrial cluster on the regional economy." Through the study of different cities and different industries, the theory of the impact of the industrial cluster on the regional economy has been enriched. As far as the primary industry is concerned, Fang [2] analyzed the planting scale, production structure, input-output, and other related data of the characteristic edible fungi industry in Gaochun County, Inner Mongolia Autonomous Region, China, and summarized the industrial clusters in this area. The integration efficiency of regional resources, reducing production costs, improving the utilization efficiency of production materials, promoting the standardization and scale of production, and improving industrial competitiveness. As far as the second and third industries are concerned, Chen [3] and other authors use the method of case analysis to analyze and study the relevant data of the Ruiqi automobile industry cluster in the Wuhu Economic and Technological Development Zone of China, showing how the Chery automobile industry cluster promotes the sustainable development of the regional economy and the role of the company in the localized production network, summarizing the conclusion that the industrial cluster may lead to greater regional export and employment growth to promote sustainable economic growth, and proposing to promote the sustainable development of the cluster by encouraging the network connection between enterprises. Pu and Sang [4] discussed the role of industrial clusters in the innovation and development of the bio-pharmaceutical industry by analyzing the innovation capability of China's bio-pharmaceutical industry and recognized that bio-pharmaceutical industry agglomeration can improve production efficiency, promote industry innovation and development, and thus drive economic growth through better matching mechanisms of industrial chains.

At present, most of the research on 'the impact of regional industrial clusters on the regional economy' is less use of models and data, vulnerable to subjective factors, or limited research areas. This article will start with China's largest industrial cluster-Shanghai industrial cluster in China, study the impact of regional industrial clusters on regional economic development, and put forward effective suggestions for industrial cluster development and government initiatives. Firstly, the index system of industrial clusters will be established, and the relevant data of industrial clusters in Shanghai, China will be collected. Then, the ANN-RBF algorithm will be used to train the data. Finally, according to the data analysis results, references, and local policies, reasonable suggestions will be put forward for industrial clusters to help economic development.

2. Construction of Index System of Regional Industrial Cluster and Regional Economy

2.1. Regional industrial cluster

Industrial cluster [5] is in the process of industrialization, in a specific geographical location, in a competitive and cooperative relationship, upstream and downstream relationship between adjacent enterprises to form stronger competitiveness, influence, to achieve sustainable development of enterprises and gathered together to form a space of economic organization system, it is an extension of the industrial chain, is the performance of the industrial structure optimization process. There are some obvious characteristics of industrial clusters, such as most of the enterprises in the cluster are around the same industry or related industries, most of the clusters are small and medium-sized enterprises with strong market penetration, and the supply and demand relationship between member enterprises is relatively close, and the learning effect between enterprises is significant. According to the different directions, industrial clusters can be divided into innovative industrial clusters and resource-based industrial clusters. Finally, through industrial clusters, the vertical integration of high concentration among enterprises can form economies of scale, reduce production costs, extend the industrial chain and product lines, and form a brand effect, to promote regional economic growth. By

collecting the relevant data on the Shanghai industry and referring to the literature on the industrial cluster index [6], the regional industrial cluster index constructed in this paper is shown in Table 1:

Table 1. Index system of regional industrial cluster

Index	The serial number	Index definition	Unit
Regional industrial cluster	Y1	Enterprise number	PCS
	Y2	Secondary industry employment-population density	Ten thousand people per square kilometer
	Y3	The density of the employed population in the tertiary industry	Ten thousand people per square kilometer
	Y4	Patent Number	PCS
	Y5	Industrial profits	Hundred million

2.2. Regional economy

Table 2. Regional economic index system

Index	Level indicators	The serial number	The secondary indicators	Unit
Regional economic	Regional economic structure	X1	Some of the added value of secondary industry and tertiary industry /GDP	/
		X2	Value added of tertiary industry/Value added of secondary industry	/
	Regional economic soundness degree	X3	Registered urban unemployment rate	/
		X4	The GDP growth rate	/
		X5	The CPI growth rate	/
	Regional economic development impetus	X6	RD funds /GDP	/
		X7	Number of scientific and technological achievements /RD funds	/
		X8	Education expenditure/fiscal expenditure	/
		X9	Deposit balance /GDP	/
	Regional economic development is green and sustainable	X10	Energy consumption per unit of GDP	Ton standard coal/ten thousand yuan
		X11	Electricity consumption per unit of GDP	Kilowatt-hours/ten thousand yuan
		X12	Wastewater discharge per unit of GDP	100 million tons / 100 million yuan
		X13	Industrial emissions per unit of GDP	One hundred million cubic meters per hundred million yuan
	Degree of regional economic openness	X14	Total imports and exports as a percentage of GDP	/
		X15	Foreign investment as a percentage of GDP	/

Regional economy [5] refers to the sum of various economic activities composed of different labor divisions such as industry and service industry in a particular region in the long-term economic activities. Its development depends on the natural and social conditions in this particular region, such

as the distribution of production factors, labor force, regional economic policies, and other social conditions, as well as natural conditions such as land and sunshine, which will affect regional economic development. The regional economy reflects the national economy, reflecting its comprehensive and regional characteristics.

As an essential influencing factor of the regional economy, the regional industrial cluster affects the regional economy by affecting the essential elements of capital investment, labor and talent attraction, production materials, and social resource allocation in various industries. The expansion of the scale of industrial clusters within an appropriate range can effectively provide jobs, attract investment, promote the extension of the industrial chain, and accelerate the development and iteration of professional technology, thereby driving the regional economy to rise, achieving the ultimate goal of regional economic growth, and achieving the best balance between regional economic and ecological benefits. By collecting the relevant data on the Shanghai industry and referring to the literature on regional economic indicators [7], the regional economic indicators constructed in this paper are shown in Table 2.

3. ANN-RBF Method

Artificial neural network (ANN) has been a research hotspot in the field of artificial intelligence since the 1980 s. It refers to a complex network structure formed by many neurons connected. This nonlinear dynamic system has successfully solved many practical problems in optimization, fault diagnosis, automatic control, prediction, and estimation. In forecasting research, the existing ANN mainly uses a back propagation neural network (BP) [8]. However, the traditional BP neural network algorithm has a slow convergence speed and is easy to fall into the local extremum, which makes training and prediction fail. To overcome the shortcomings of the BP neural network, Moody and Darken [9] proposed an RBF neural network. RBF neural network has a compact network topology, fast convergence speed that can approximate any nonlinear function with precision, and nonlinear solid fitting ability [10].

RBF neural network is a feedforward three-layer neural network with excellent performance. The network structure is shown in Fig.1. The input layer is composed of signal source nodes, which transmit signals. The hidden layer is a nonlinear mapping of the network input, the mapping function is RBF, and the output layer is a linear weighted sum of the output of the hidden layer neurons. Therefore, the RBF network can be regarded as a nonlinear mapping from input layer data space to hidden layer space and a linear mapping from hidden layer space to the output layer.

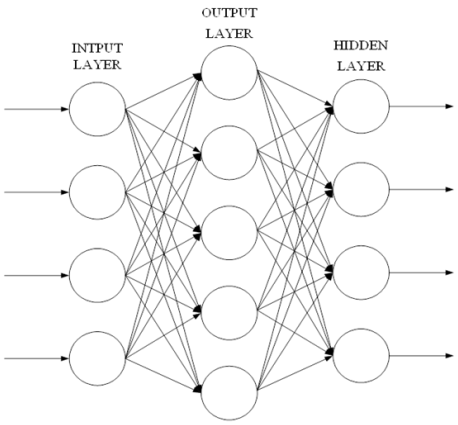

Figure 1. Schematic diagram of RBF neural network

The radial basis function is a locally distributed nonnegative nonlinear function concerning the center symmetry, which satisfies if $\|y_1\|-\|y_2\|$, then $\varphi(y_1)=\varphi(y_2)$, that is, a function that depends only on $r=\|y\|$. The basis function used in this study is the Gaussian function in Green's function [11]:

$$\varphi(\mathrm{r}) = \exp\left[-\frac{(r-c)^2}{2x^2}\right] \tag{1}$$

Where c is the center of the Gaussian function, and x what is the variance? The center c and variance x of the Gaussian function must be determined when the Gaussian function is applied. In this study, the self-organizing selection center method is adopted, which is realized by the K-Means clustering algorithm. The K-Means clustering algorithm generates S clusters according to the training sample set. Each cluster corresponds to a neuron in the hidden layer, and the centroid vector of the cluster can be used as the Gaussian function center c of the corresponding neuron. The x following formula determines the variance in this study:

$$x_1 = x_s = \sqrt{\frac{d_1 + d_2}{2}} \tag{2}$$

In the formula, d_1 and d_2 are the maximum distance and the second largest distance between the cluster centroids, respectively. Therefore, the excitation response calculation formula of any hidden neuron S is:

$$\Delta\lambda_{st}(k) = \eta(r_t - o_t)a_s + \alpha\Delta\lambda_{st}(k-1)x \tag{3}$$

$$a_s = \exp\left(-\frac{\square r - c\square^2}{2x_s^2 l}\right) \tag{4}$$

In the formula, l is the RBF overlap coefficient, which is used to control the number of overlaps between clusters. By increasing the coefficient, the size of the clusters associated with each hidden neuron can be increased, so that each input training sample can affect the distant clusters.

In the RBF network, the weight from the hidden layer neuron S to the output layer neuron M is denoted as λ_{st}. The output layer neuron linearly combines the output of the hidden layer, so that the output of the output layer neuron t is:

$$z_t = \sum \lambda_{st} a_s \tag{5}$$

The synaptic weights are finally determined by training. Training synaptic weights in the RBF network adopts the reverse error propagation method, equivalent to training a two-layer forward network. At the beginning of training, the ownership value is initialized as: $-0.001 \le \lambda_{st} \le 0.001$. Secondly, the training cycle after each input training sample is updated according to the following formula:

$$\lambda_{st}(k) = \lambda_{sm}(k-1) + \Delta\lambda_{sm}(k) \tag{6}$$

The change rate $\lambda_{st}(t)$ is calculated according to the following formula:

$$\Delta\lambda_{st}(k) = \eta(r_t - o_t)a_s + \alpha\Delta\lambda_{st}(k-1) \tag{7}$$

The data collected in this paper are periodic time series data with general characteristics, namely long-term trends, cyclical variability, seasonal variability, and irregular volatility. The long-term trend represents the long-term trend characteristics of economic time series; the cycle factor is a change with a cycle of several years. It may be a change in the economy, an economic change, or other cyclical changes; the seasonal variation factor is a cyclical change that repeatedly occurs every year, with a cycle of 12 months or four quarters; distinctive elements, also known as random factors, residual changes or noise, are caused by accidental events. Therefore, the feature selection prediction

model based on data can predict more accurately and scientifically [12]. This paper selects MAPE (mean absolute percentage error) and R^2 (coefficient of determination) as the test indicators.

$$MAPE = \frac{100\%}{n}\sum_{i=1}^{n}\left|\frac{\hat{y}_i - y_i}{y_i}\right| \tag{8}$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \tag{9}$$

MAPE is the average absolute percentage error, range [0, + ∞), the smaller, the better; MAPE of 0% represents a perfect model, greater than 100 % for a poor quality model. R^2 to characterize the effect of regression. For the sample data that has been obtained, $\sum_{i=1}^{n}(y_i - \bar{y})^2$ an R^2 expression is a certain number. Therefore, the more significant the R^2, the smaller the residual sum of squares $\sum_{i=1}^{n}(y_i - \bar{y})^2$, that is, the better the fitting effect of the model; the smaller the R^2, the larger the residual sum of squares, that is, the worse the fitting effect of the model. In the linear regression model, R^2 represents the explanatory variables' contribution rate to the forecast variables' change. The closer R^2 is to 1, the better the regression effect is [13].

4. Empirical analysis

4.1. Research object selection and data collection

With the development of China's reform and opening up, Shanghai has experienced more than 40 years of rapid development and has become a national central city. The State Council has approved it as China's international economic, financial, trade, shipping, and technological innovation center. Its industrial clusters are also growing in this process, becoming a vital force in boosting the economic development of Shanghai and even China. In recent years, the labor-intensive and resource-intensive industrial clusters in Shanghai, China, have gradually been suburbanized and marginalized, replaced by financial, industrial, and high-tech industrial clusters. The overall industrial structure has been significantly optimized and formed high-quality industrial clusters. [14] This paper uses the panel data of Shanghai from 1996 to 2020 to analyze the impact of regional economic development on the formation of industrial clusters.

Based on the Prospective Industry Research Institute, this paper obtains the number of registered enterprises in Shanghai, China, from 1996 to 2020 to measure regional industrial clusters. The rest of the evaluation indexes of regional industrial clusters and all the evaluation indexes of the regional economy are from Shanghai Statistical Yearbook from 1996 to 2020, disclosed by the Shanghai Municipal Bureau of Statistics.

This article has carried on the missing value processing for the above data. In addition, this paper uses the fixed proportion method to reset the upper and lower 1% values. If the value is greater than the 99% quantile value, it is set to the 99% quantile value. If it is lower than the 1% quantile value, it is reset to the 1% quantile value, and the outliers of the data are processed through the above operations. [7] The descriptive statistical results of each index after data preprocessing are shown in table 3:

Table 3. Descriptive statistical results of data

Level indicators	The secondary indicators	Max	Min	Mean	Coefficient of variation
Regional industrial cluster	Y1	403836.000	28194.000	151580.000	0.720
	Y2	0.076	0.029	0.057	0.240
	Y3	0.155	0.042	0.090	0.400
	Y4	2472.000	896.000	1746.000	0.310
	Y5	3324.850	519.550	1683.220	0.600
The regional economic	X1	0.172	0.027	0.103	0.350
	X2	208.630	-33.640	9.100	4.680
	X3	0.049	0.027	0.040	0.150
	X4	0.147	0.027	0.096	0.300
	X5	0.084	-0.003	0.023	0.840
	X6	0.041	0.014	0.026	0.340
	X7	26.050	0.760	8.750	0.890
	X8	0.157	0.110	0.133	0.120
	X9	3.987	1.744	2.730	0.240
	X10	2.193	0.320	0.883	0.620
	X11	5592.020	447.350	1245.240	1.000
	X12	0.007	0.001	0.002	0.820
	X13	1.542	0.386	0.838	0.440
	X14	1.701	0.616	1.152	0.280
	X15	0.009	0.005	0.007	0.150

4.2. RBF calculation

This paper hopes to explore the impact of the regional economy on regional industrial clusters in Shanghai, China, from 1996 to 2020. Given a large number of indicators of regional industrial clusters, this paper only shows in detail the analysis and calculation process of the impact of all regional economic indicators on all regional industrial cluster indicators; in this paper, based on SPSS data analysis software, combined with RBF neural network algorithm, into the above construction of each group of data for training.

Since the regional economic indicators of Shanghai and China are used for result prediction, the number of nodes in the input layer is set to 15. The function of this model is to explore the impact of regional industrial clusters in Shanghai, China, so the output layer consists of five nodes. The function of the hidden layer is to extract and memorize valuable features from the input layer to predict the neural network's output. To construct the radial basis function neural network with optimal performance, this paper sets the number of hidden layer nodes to 10 ~ 30 and trains them respectively to judge the optimal value of the number of hidden layer nodes. [15] In the training process, this paper uses MAPE and goodness of fit R^2 to measure the neural network's learning ability. It should be noted that, because this article is to train all the independent variables on all the dependent variables of the neural network model, we will get five groups of predicted values, by calculating can get five groups of MAPE values and five groups of R^2 value. For the convenience of calculation and result statistics, this paper's final MAPE and R^2 values are the simple arithmetic mean of the above five values, respectively. Table 4 reflects the training results of the model.

Table 4. Model training results

Number of hidden layer nodes	MAPE	R^2
10	13.011%	0.643
11	14.313%	0.507
12	12.235%	0.532
13	12.462%	0.567
14	12.575%	0.588
15	8.370%	0.679
16	8.414%	0.696
17	7.867%	0.717
18	6.990%	0.743
19	5.387%	0.828
20	5.184%	0.837
21	5.184%	0.837
22	5.184%	0.837
23	5.184%	0.837
24	5.184%	0.837
25	5.184%	0.837
26	5.184%	0.837
27	5.184%	0.837
28	5.184%	0.837
29	5.184%	0.837
30	5.184%	0.837

It can be seen from the above table that MAPE does not decrease when the number of hidden layer nodes is greater than 20, and R^2 does not increase when the number of hidden layer nodes is greater than 20. Considering the problem of model over-fitting caused by too many hidden layer nodes and selecting the radial basis neural network structure that produces the best performance, this paper sets the number of hidden layer nodes to 20. Therefore, this paper finally established a 15 ~ 20 ~ 5 three-layer neural network structure.

4.3. Importance analysis

This paper uses the Garson algorithm to determine the importance of regional economic indicators to the overall regional industrial clusters in Shanghai, China. Garson's algorithm uses the connection weights obtained by the neural network to judge the importance of different independent variable factors to dependent variables. Based on the radial basis neural network model constructed by 5.2, the influence of each index of the regional economy in Shanghai, China, is shown in Figure 2:

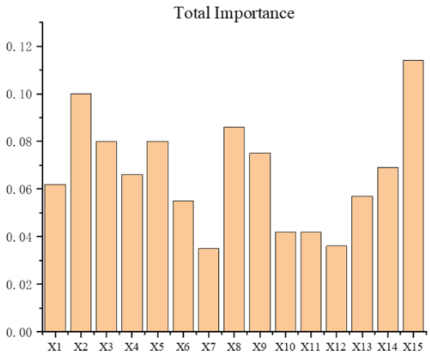

Figure 2. Importance of each index of the regional economy to the total index of regional industry cluster

Among the indicators, X15 (the proportion of foreign investment in GDP) has the most significant impact on the regional industrial clusters in Shanghai, China, reaching 11.4%. As one of the most

attractive hot spots for foreign investment in the world, Shanghai, China, has attracted more and more foreign investment in recent years, which has extensively promoted the flow of production factors among enterprises and helped to exert the synergistic effect among enterprises. The importance of X2 (the ratio of the tertiary industry's added value to the secondary industry's added value) reached 10%. Relative to the secondary industry, the tertiary industry has a broader range and stronger correlation between industries. For example, the financial industry in the tertiary industry can extend its tentacles to various fields and build a bridge between different enterprises, making the relationship between enterprises closer and more diversified from the original single production chain relationship. It can be considered that the increase in the proportion of the tertiary industry can reduce the threshold for industrial clusters to exert their influence so that more industries can be connected.

It can also be observed from the above figure that X10, X11 (unit GDP energy consumption, power consumption), and other indicators of sustainable development have little impact on regional industrial clusters. It is still a priority for regional industrial clusters to consider whether they can bring good economic benefits. Same as the above calculation and analysis process, table 5 shows the model calculation results of each index of the regional industrial cluster under the optimal performance radial basis neural network structure. Figure 3 is the analysis results of the importance of regional economic indicators to the five regional industrial cluster indicators:

Table 5. Model calculation results of regional economic indicators on regional industrial cluster indicators

Index	Number of hidden layer nodes	MAPE	R^2
Y1	25	0.018	0.992
Y2	17	0.007	0.996
Y3	28	0.004	0.999
Y4	25	0.015	0.988
Y5	28	0.013	0.995

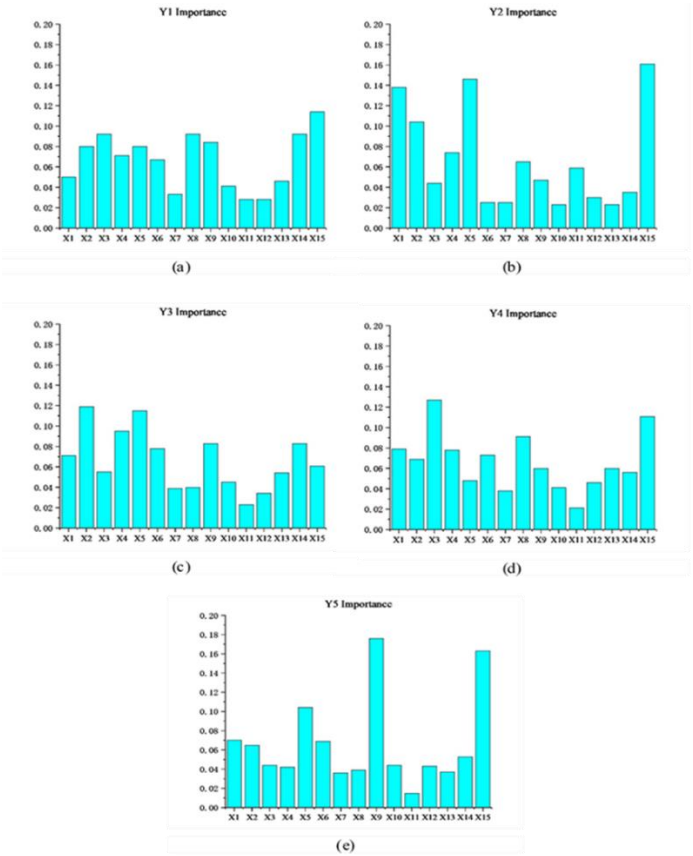

Figure 3. Importance of Regional Economic Indicators to Regional Industrial Cluster Indicators

In terms of the impact of each indicator on Y1 (number of enterprises), X15 (proportion of real foreign investment in GDP) is the most important, reaching 11%, and X11 (electricity consumption per unit of GDP) is the least important, only 3%. Among the influence of each index on Y2 (the density of employed population in the secondary industry), X15 and X5 (CPI growth rate) are more critical, 16% and 13.8%, respectively. For Y3 (tertiary industry employment-population density), X2 (tertiary industry added value / secondary industry added value), and X5 are more critical, 12% and 11.6%, respectively, and the importance of X11 is the lowest, only 2.4%. For Y4 (number of patents), X5 is more critical, reaching 11%, and X11 is the least important, only 2%. For Y5 (industrial profit), X9 (deposit balance as a proportion of GDP) and X15 are the most important, reaching 17.4% and 16.1% respectively, and X11 is the least important, only 1%.

CPI growth rate has a greater impact on the employment density of the secondary and tertiary industries. According to the Phillips curve of economics, an increase in the inflation rate in the short term can reduce the unemployment rate. The employment-population in Shanghai, China is mainly concentrated in the secondary industry and the tertiary industry. In the short term, the government will help to increase the employment-population in the secondary and tertiary industries by appropriately increasing the CPI growth rate, thereby increasing employment density and optimizing industrial clusters.

Foreign investment has a greater impact on the number of patents and industrial profits. The government can create an international first-class open innovation ecology and attract international innovation resources by building an international innovation cooperation platform and building a science and technology innovation center. The government can also strengthen the information construction of foreign investment, implement the project tracking and promotion mechanism, and coordinate and solve the project problems in time, to improve the utilization efficiency of foreign capital and promote the profit transformation of foreign capital and the transformation of scientific and technological achievements.

5. Conclusion

(1) In the calculation of test indicators, MAPE and R2 do not increase after the number of hidden layer nodes is greater than 20. The prediction error is small and the precision is high. In particular, it can accurately analyze the nonlinear relationship in complex systems, to obtain 15 main factors affecting Shanghai's regional economic indicators and analyze the importance of standardization. The results show that the standardization importance of 15 factors is more significant than 0.03, which is suitable for predicting the regional economy. Among them, the value added of foreign capital and the tertiary industry accounted for the most important proportion of the value added by the secondary industry, reaching 0.114 and 0.100 respectively.

(2) The above shows that the foreign investment in the regional economy of Shanghai, China, and the value-added proportion of the secondary and tertiary industries are the largest. The government should focus on the economic center and vigorously develop comparative advantage clusters to promote high-quality economic development.

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