Analysis of Factors Affecting Import and Export of Underdeveloped Regions Based on RBF Neural Network - A Case Study of Guizhou Province

Hanjing Mu[1,*], Dongjian Zhang[2]

[1]Business School Beijing Normal University, Beijing, China, 100088

[2]School of Finance Shanghai University of Finance and Economics Shanghai, China, 200433

*Corresponding author: 845655476@qq.com

Abstract. Guizhou Province, as an inland province of China without borders and seas, has relatively backward economic development, but its economic growth is fast and its development potential is great. Studying its import and export trade is important to improve residents ' income and accelerate internationalization. This paper analyzes and establishes the indicator system of regional import and export influencing factors through literature analysis, and then uses (radial basis function) RBF neural network to analyze the influencing factors of import and export in Guizhou Province. Taking the economic data of Guizhou Province from 2001 to 2020 as samples, RBF neural network is used as a tool to analyze the relationship between various influencing factors and total import and export volume. The results show that when the number of hidden layer neurons is 14 or more, the RBF neural network model accuracy is the highest, R^2 is 0.7005, and *MAPE* is 0.0834. Among the first-level indicators affecting import and export, the importance of the regional internal economic level is the highest. Among the second-level indicators, the importance of scientific and technological progress is the highest, followed by GDP.

Keywords: Regional import and export; RBF neural network; influencing factors; Guizhou Province.

1. Introduction

Import and export is an important tool to promote the economic development of a country or region. It is conducive to opening up foreign markets and guiding the transformation and upgrading of Chinese industries. It is of great significance to improve residents ' income and accelerate the internationalization of the local economy. Since the construction of the Belt and Road, the import and export of Guizhou Province continues to grow, and the structure of foreign trade continues to optimize, but still faces many challenges. Therefore, exploring the influencing factors of import and export trade has a more positive sign for the development of Guizhou Province. At present, there are many studies on the influencing factors of import and export.

In terms of research content, Xiong [1] believed that there is a positive correlation between import growth and GDP by analyzing the data on GDP and import and export trade in various countries. Shi et al. [2] argue that imports and exports are affected differently in the short and long term and that exports have a greater impact on economic growth in the short term. Patel et al. [3] obtained the influence of exchange rate, foreign direct investment and other factors on the total import and export trade by studying India's foreign trade. Gao [4] believed that the main influencing factors of total exports are economic growth and commodity structure. Wang [5] found that China's total trade import and export volume is greatly affected by the RMB exchange rate and foreign exchange reserves. In terms of research methods, Tian et al. [6] believed that radial basis function (RBF) neural network can effectively approximate the relationship that is difficult to be described in time series, which is superior to nonlinear regression and multi-layer feedforward (BP) network prediction. Yu [7] analyzed the evolution characteristics and influencing factors of Chongqing's foreign trade in ' time series ' and ' spatial pattern ', and provided useful enlightenment for promoting Chongqing to accelerate the construction of inland open highlands, integrate the ' Belt and Road ' and the Yangtze River Economic Belt. Lei et al. [8] introduced the carbon productivity variable on the basis of the

conventional trade gravity model and used the extended trade gravity model to measure the influencing factors of bilateral trade between China and the five Central Asian countries.

However, there are still many deficiencies in the current research on the influencing factors of import and export, which are mainly reflected in the following aspects: in terms of research objects, more attention is paid to the import and export trade at the national level, while there are few studies on the provincial and municipal levels, especially in underdeveloped inland areas. In terms of research methods, most studies mainly use regression models to analyze the influencing factors, lacking innovation. In view of the shortcomings of the current research, this paper chooses Guizhou Province as the research object to obtain the influencing factors of import and export trade in underdeveloped areas. This paper will use RBF neural network to study the influencing factors, which can better avoid the problem that the calculation process of BP neural network is too tedious and lengthy, and has stronger nonlinear mapping ability, which can better reflect the actual situation of the system. The marginal contribution of this paper is: (1) Constructing panel data with provincial units. Since the province can carry out import and export trade more independently, if a country is used as a unit for research, a more universal conclusion cannot be drawn to guide trade activities within the province. (2) Construct RBF neural network model. The model has the advantages of strong approximation performance and strong mapping ability, which is suitable for solving the problems of import and export influencing factors and can better solve the common problems in the analysis process. (3) At present, China's research on underdeveloped areas is insufficient. This paper takes underdeveloped areas as the research object, which is of great significance to the development of underdeveloped areas in China.

2. Indicator construction

Based on literature analysis, the indicator system of regional import and export influencing factors is shown in Table 1. The specific construction process is as follows.

2.1 Regional internal economic situation

In the indicator system, the regional internal economic situation (X_1) is composed of four second-level indicators: GDP (X_{11}), fixed asset investment (X_{12}), CPI (X_{13}) and fiscal revenue (X_{14}), which are used to measure the basic economic situation of the region. With the continuous improvement of GDP, regional economic development will gradually turn from inside to outside, promoting the development of regional import and export. CPI is a tool to measure the inflation rate. The change in the inflation rate will affect the import and export. The fixed assets investment of the whole society can cause the adjustment of social industrial structure, improve the investment environment, and improve the competitiveness of Chinese enterprises, thus affecting the import and export. The increase in fiscal revenue will affect government purchases, thereby affecting imports and exports.

2.2 Regional external economic situation

This paper selects the RMB against the US dollar exchange rate (X_{21}), foreign direct investment (X_{22}), and the actual use of foreign capital (X_{23}) three second-level indicators to measure the regional foreign economic situation (X_2). Under China's floating exchange rate system, the RMB pegged to the US dollar limits the free trade of foreign exchange, which has an important impact on China's regional import and export. A large number of foreign direct investment can increase the international competitiveness of the region and inject vitality into the region, so it is also an important factor affecting regional import and export. The increase in the actual use of foreign capital can make investors get rich returns, and further promote investors to invest, thus affecting import and export.

2.3 Regional science and technology development level

The higher the level of regional science and technology development (X_3), the higher the labor productivity and the larger the scale of R&D activities. Therefore, this paper selects labor productivity

(X_{31}), technological progress (X_{32}), and R & D expenditure (X_{33}) three second-level indicators to measure the level of regional science and technology development. Among them, labor productivity is equal to the ratio of gross regional product to the total number of employed persons, technological progress is represented by the growth rate of total factor productivity, and R&D expenditure is the expenditure generated by systematic and creative activities in the field of science and technology to increase the total amount of knowledge and apply it to create new applications. The Influencing Factors results are shown in Table 1.

Table 1. Indicator System of Regional Import and Export Influencing Factors

	First-level indicators	Second-level indicators	References
Indicator System of Regional Import and Export Influencing Factors	Regional internal economic situation (X_1)	GDP(X_{11})	[9]
		social aggregate investment in fixed assets(X_{12})	[10]
		CPI(X_{13})	[11]
		financial revenue(X_{14})	[12]
	Regional External Economic Situation (X_2)	exchange rate of RMB against dollar(X_{21})	[9]
		foreign direct investment(X_{22})	[13]
		actual use of foreign investment(X_{23})	[9]
	Regional Science and Technology Development Level (X_3)	labor productivity(X_{31})	[13]
		technological progress(X_{32})	[13]
		R&D expenditure(X_{33})	[14]

3. ANN-RBF Method

Artificial neural network (ANN) is a widely parallel interconnected network composed of adaptive simple units. Its organization can simulate the interactive response of the biological nervous system to real-world objects. Artificial neural network is divided into many types, such as BP neural network, RBF neural network, perceptron neural network, linear neural network, self-organizing neural network, feedback neural network and so on. [15-16]

Radial basis function neural network, also known as RBF neural network, is a single hidden layer feedforward neural network proposed by J. Moody and C. Darken in the late 1980s based on the biological receiving domain. It has a strong nonlinear fitting ability, can map any complex nonlinear relationship, and has good approximation performance and fast convergence speed of the learning process. It is suitable for solving the problem of regional import and export influencing factors in this paper. RBF neural network consists of three layers: input layer, hidden layer and output layer. The schematic diagram is shown in Figure 1. The input layer node is responsible for transmitting the input signal to the hidden layer; hidden layer nodes are generally composed of Gaussian kernel function, responsible for nonlinear transformation of these indicator values and output linear combination; the output layer node is responsible for outputting linear results. The training of RBF neural network can be divided into two stages: the first stage is unsupervised learning, selecting memory samples/center points from sample data clustering algorithms can be used or a randomly given way can be chosen. The second stage is supervised learning, which mainly calculates the relationship/weight between the sample and the output after RBF conversion.

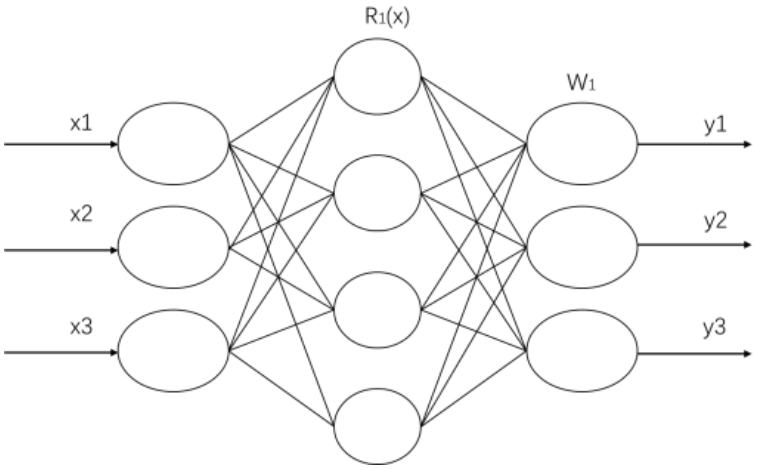


Figure 1. radial basis function neural network

It is assumed that the output layer of RBF neural network has only one node (and it is easy to expand to multiple output nodes), the hidden layer is composed of a set of radial basis functions, and the parameter vectors related to each hidden layer node are C_i (center) and i (width). Generally, each node of the hidden layer uses the same radial basis function (usually Gaussian function). The input and output of the network can be considered as a mapping relationship $f(x)$: $Rn \rightarrow R$ (n is the number of input nodes):

$$y = f(X) = \sum_{i=1}^{n_c} w_i \Phi(\|X - C_i\|, \sigma_i) = \sum_{i=1}^{n_c} w_i exp\left(-\frac{\|X-C_i\|}{2\sigma_i^2}\right) \quad (1)$$

To obtain the predicted y_i value, set the RBF network input vector to:

It is an *m-dimensional* vector including m past signal samples, where m is called the embedded vector length.

$$X_i = [y_i, y_{i-1}, \Lambda, y_{i-m}]^T \quad (2)$$

The most commonly used radial basis function is Gaussian function. Therefore, Gaussian function is selected as the basis function in this paper. The response of the jth hidden node to the input vector x_i is:

$$\Phi_{ij} = exp\left[-\frac{(x_i-c_j)^2}{2\sigma_j^2}\right] \quad (3)$$

Where σ_j is the center vector of the jth node of the c_j hidden layer, which can also be regarded as the weight vector of the unit, and σ_j^2 is the normalized parameter of the jth hidden node.

The network output is:

$$\hat{y}_i = \sum_{j=1}^{R} \Phi_{ij} h_j \quad (4)$$

Where: h_j is the output layer connection weight, R is the number of hidden nodes.

4. Test indicator selection

Model and algorithm optimization often requires continuous iteration, so it is necessary to do further testing to verify the correctness, validity and credibility of the model. This paper selects the two indicators of determination coefficient (R^2) and mean absolute percentage error (*MAPE*) to test

the trained model. The calculation formula is as follows [17-18]:

$$R^2 = SSR/SST = 1 - SSE/SST \tag{5}$$

$$MAPE = \frac{100\%}{n}\sum_{i=1}^{n}\left|\frac{\hat{y}_i - y_i}{y_i}\right| \tag{6}$$

The closer the absolute value of R^2 is to 1, the stronger the linear correlation between the two variables. The mean square error is the sum of the squares of the errors of the corresponding points of the fitting data and the original data. The value range of *MAPE* is $[0,+\infty)$, the smaller the value of *MAPE*, the more consistent the predicted value of the model with the true value, the higher the accuracy of the model, and zero *MAPE* represents the perfect model.

5. Authentic proof analysis

5.1 Research Object Selection and Data Collection

Guizhou Province, as a non-border and non-sea inland province in China, has relatively backward economic development, and its per capita disposable income ranks lower among provinces in China. In the past ten years, Guizhou's economic development has been very rapid. From the data of 2021, Guizhou's regional GDP reached 1958.642 billion yuan, and its GDP growth rate is at the forefront of China, up 8.1 % from the previous year. The year-end resident population was 38.52 million, 60,000 less than the previous year; the total import and export volume was 65.416 billion yuan, an increase of 19.7 % over the previous year, accounting for about 3.3 % of GDP. The data show that Guizhou's import and export trade has great potential in promoting its economic development. Therefore, studying the influencing factors of its import and export trade is of great significance for the long-term development of Guizhou's economy, accelerating its integration into the global production network and improving its international competitiveness [19].

The data used in this paper are the macroeconomic data of Guizhou Province from 2001 to 2020. The data are from Guizhou Provincial Bureau of Statistics and the National Bureau of Statistics. The descriptive statistical results of the data are shown in Table 2.

Table 2. Descriptive statistical results

Indicators (units)	Mean	Std.	Min	Max
Y(billion yuan)	482,339.90	351,935.50	64,978.00	1,208,460.00
$X_{11(billion\ yuan)}$	6,995.78	5,511.48	1,133.27	17,826.56
$X_{12(billion\ yuan)}$	6,591.67	6,419.06	536.01	18,862.75
$X_{13(Previous\ year\ =\ 100)}$	102.40	2.14	98.72	107.59
$X_{14(billion\ yuan)}$	839.71	659.05	99.75	1,786.80
$X_{21(US\ \$\ /\ 100)}$	712.82	79.84	614.28	827.70
$X_{22(million\ dollars)}$	37,713.40	32,268.14	2,829.00	107,155.00
$X_{23(million\ dollars)}$	110,930.30	138,516.00	9,383.00	448,582.00
X_{31}	2,497.45	2,152.95	184.52	7,352.13
X_{32}	0.31	1.04	-0.88	3.27
$X_{33(million\ yuan)}$	491,446.10	476,148.80	53,486.00	1,617,090.00

5.2 Test result

In this paper, the RBF neural network learning algorithm is constructed based on SPSS software. The model is trained by adjusting the number of hidden layer neurons from 10 to 20 (setting the step

size to 1), and the training results are tested by using the test indicators R^2 and *MAPE* constructed above. The training parameters are shown in table 3 [20]:

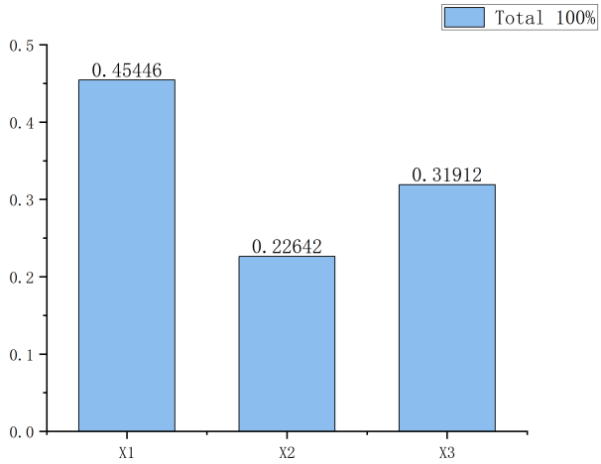
Table 3. trainning parameter

number of hidden layer nodes	R^2	*MAPE*
10	0.5866	0.5450
11	0.7139	0.1161
12	0.7127	0.1128
13	0.7142	0.1000
14	0.7005	0.0834
15	0.7005	0.0834
16	0.7005	0.0834
17	0.7005	0.0834
18	0.7005	0.0834
19	0.7005	0.0834
20	0.7005	0.0834

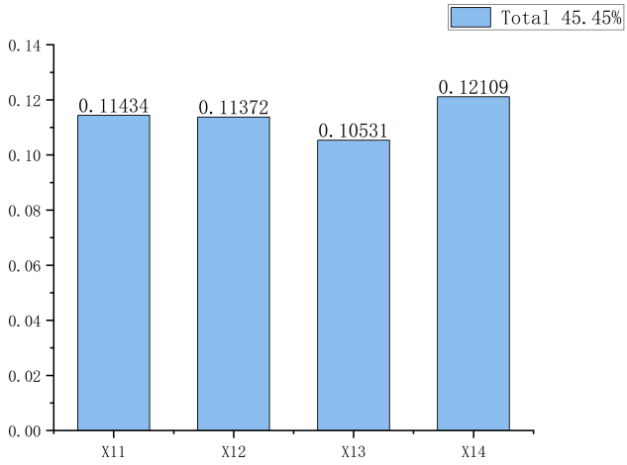
Based on the above analysis results, this paper finds that when the number of neuron nodes in the hidden layer reaches 14 and above, the model will converge to a fixed result. At this time, the accuracy of the model reaches the highest. The value of the test indicator R^2 is 0.7005, and the value of *MAPE* is only 0.0834. The value of R^2 shows that the model can accurately fit the real value and better explain the reason for the change of the dependent variable. The value of *MAPE* indicates that the model has high accuracy and good evaluation effect.

5.3 Contribution analysis

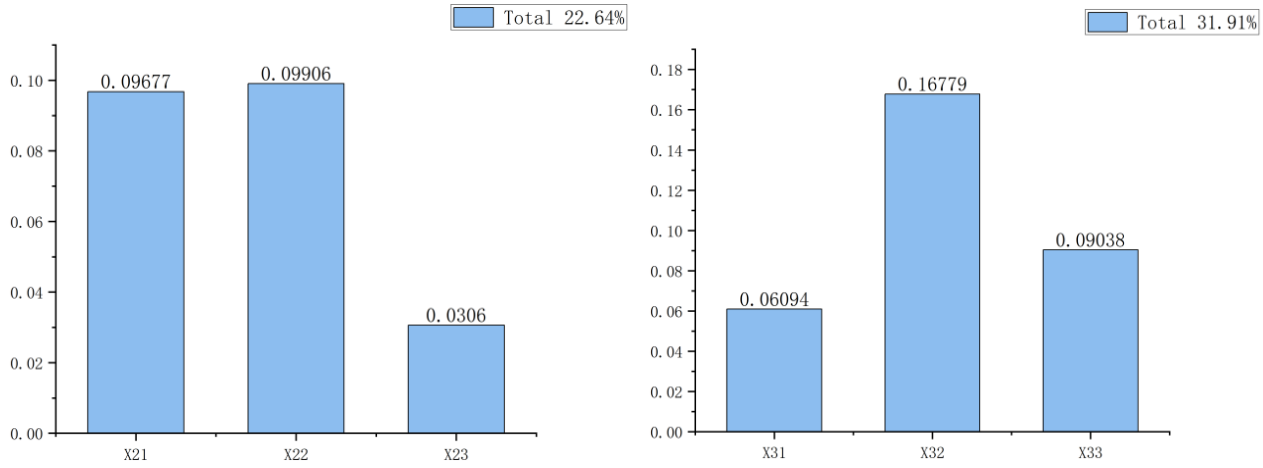
Based on the ANN model constructed above and the parameter adjustment of 5.2, combined with the ANN contribution analysis, when the number of hidden layers is 14 or more, the model accuracy reaches the highest, and the importance analysis of each indicator is shown in Figure 2 [21]:



(a) First-level indicators



(b) Regional internal economic situation(X_1)



(c) Regional External Economic Situation(X_2)

(d) Regional Science and Technology Development Level(X_3)

Figure 2. Importance analysis results

The importance analysis results show that in the first-level indicators, the regional internal economic situation (45.4%) has the greatest impact on import and export, followed by the regional science and technology development level (31.9%) and the regional external economic situation (22.6%). This shows that the development of import and export trade in a region depends largely on the economic development of the region itself and the various economic policies of the region. With the continuous expansion of the regional economy, regional import and export will continue to develop. In addition, the improvement of regional science and technology development level will promote the development of core technologies in the region, thus improving the core competitiveness of enterprises, which also strengthens the import and export trade to a certain extent. The regional foreign economic situation changes the regional import and export by external investment, which is less important than the other two indicators.

In the internal economic situation of the region, the four second-level indicators of GDP (11.4%), total fixed asset investment (11.4%), CPI (10.5%), and fiscal revenue (12.1%) have little difference in the impact on import and export. Among them, the importance of fiscal revenue is slightly larger than the other three second-level indicators, indicating that the government decision-making government occupies a very important position in regional import and export trade. In addition, the consumption, investment, production and other behaviors of residents or enterprises will have an important impact on import and export.

In the regional foreign economic situation, the exchange rate of RMB against the US dollar (9.68%) and foreign direct investment (9.90%) have a greater impact on import and export, while the actual use of foreign capital (3.06%) is less important. This shows that the pegged exchange rate has a greater impact on China 's foreign exchange transactions. Foreign direct investment will flow capital and also reflect the level of regional opening up, which will affect import and export. The actual use of foreign capital indirectly affects the investment behavior of investors, so the impact on import and export is small.

At the level of regional science and technology development, technological progress (16.78%) has the greatest impact on import and export, followed by R&D expenditure (9.04%), and labor productivity (6.01%). This is because technological progress represents the improvement of social production level, which has a direct role in promoting regional economic development, thus affecting import and export trade. R&D expenditure reflects the development of science and technology in the region, and also affects the import and export to a certain extent. Labor productivity reflects the production efficiency of the region and indirectly reflects the level of regional economic development, so it also has an impact on import and export.

6. Conclusion

(1) When the number of neurons in the hidden layer of RBF neural network is 14 or more, the accuracy of the model is the highest. At this time, the value of the test indicator R^2 is 0.7005, and the value of *MAPE* is 0.0834, which indicates that the RBF neural network model can explain 70 % of the change of the dependent variable and accurately reflect the importance of each influence indicator, which provides an important reference for the development of regional import and export.

(2) Among the first-level indicators, the economic situation within the region has the greatest impact, accounting for 45.4 %, followed by 31.9 % of the regional science and technology development level, and the lowest level of regional external development, only 22.6 %. Among all the second-level indicators, technological progress has the greatest impact on import and export, accounting for 16.78 %, followed by 12.1 % of fiscal revenue; the total actual utilization of foreign capital has the least impact, accounting for only 3.06 %.

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