Analysis of influencing factors of regional import and export trade based on an artificial neural network

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Abstract. In the post-epidemic era, the global political and economic pattern has accelerated the evolution, and regional imports and export tr[ade has become an important way of political and economic communication between countries. As the research area, this paper selects Shanghai, China, establishes a comprehensive evaluation index system of influencing factors of regional import and export trade, and constructs a high-precision artificial neural network (ANN) model to quantitatively evaluate import factors and export trade in Shanghai, China. The results show that freight capacity, science, technology level, and exchange rate change have a greater impact on the import and export trade in the region. Improving the level of transportation, science, and technology in Shanghai is significant to the sustainable development of Shanghai's foreign trade. The Chinese government can appropriately expand the geographical distribution of import and export business, establish a particular currency portfolio, and disperse foreign exchange risks in international trade and investment, and financing. The Chinese government can consider providing cash flow support for enterprises, which promotes consumption investment and vigorously improves the VAT retention and rebate system. It can focus on solving the problem of tax retention and rebate in scientific research, technical services, and transportation industries to improve market confidence and promote the development of China's import and export trade.

Keywords: ANN; regional import and export trade; comprehensive evaluation; shanghai, China.

1. Introduction

With the further development of economic globalization, regional import and export trade has become one of the important ways for countries to communicate politically and economically. Shanghai is a developed city for China's foreign trade, which reflects the typical characteristics of China's import and export trade. Due to the spread of the epidemic, the world economic recession, and the decline of international trade, in today's complex international environment, the comprehensive multi-factor study of regional import and export trade factors related research is not rare.

With the evolution of the world political and economic structure, regional import and export trade is facing the test of multilateral factors. The global business environment of Covid-19 has caused a chain blow to the whole world value chain and caused great losses to import and export trade at the same time as global political and economic fluctuations[8]. However, the global value chain is closely related to the import and export trade balance. The political and economic turmoil in some regions causes frictions in the commodity market, which breaks the overall equilibrium dynamics of international trade. In economic chaos, tariffs and exchange rate fluctuations between countries greatly impact import and export trade. For regional import and export trade, FDI, total capital formation, information technology exports, and trade openness have an impact on economic growth. At the same time, the impact of different trade cost components such as infrastructure quality and transportation cost on import and export trade volume cannot be ignored. Foreign exchange, monetary and restrictive policies have a similar impact on import and export trade. Elena et al. can evaluate and

predict regional import and export trade volume and trade behavior through time series models. Kacou et al. studied the relationship between import and export trade structure and labor productivity based on the VAR model. Reasonable import and export structure will promote domestic production efficiency, and productivity improvement will promote import and export trade. However, for the comprehensive and comprehensive consideration of regional import and export trade, the evaluation of import and export trade levels has significantly changed compared with the past. In the new international political and economic environment, regional import and export trade factors need to be studied in depth.

Most of the influencing factor evaluation models established by many scholars lack consideration of accidental events, the evaluation index system is not comprehensive, or the model algorithm is obsolete. Therefore, this study aims to establish a comprehensive evaluation model of import and export trade influencing factors based on data mining and machine learning. Firstly, based on the literature review, the comprehensive evaluation index system of regional economic influencing factors is constructed, and then the accidental events are transformed into quantitative evaluation value. This paper selects Shanghai, China, as the research object. The artificial neural network (ANN) model is highly scientific and reasonable because of its good self-learning and adaptive characteristics. Finally, the validity of the model is verified by the actual data, and conclusions and suggestions are put forward. This study will play an essential role in interpreting the characteristics of China's international trade.

The arrangement of this paper is as follows. The second part constructs the evaluation index system and introduces the data source, index selection, and construction. The third part introduces the ANN model and construction; the fourth part is the definition and test of indicators; the fifth part is the benchmark results and analysis of empirical test; the sixth part is the conclusion.

2. Introduction of regional import and export trade and construction of index system of influencing factors

2.1 Introduction to regional import and export trade

Import and export trade refers to the trade between countries, for purchase, export for export, by the development of social productivity of two or more countries produced for the exchange of surplus goods, the exchange of the surplus goods between countries, that is, the international import and export trade. The high-quality development of regional import and export trade significantly improves the important position of the current region in the global economic market and plays a key role in promoting the steady development of a social economy. For regional economic development, import and export trade plays its role of transmission, which is helpful to the introduction of new technologies, the optimization of system management, the renewal of business philosophy, and the adjustment of economic structure. Import and export trade further stimulates and stimulates domestic consumption and promotes the overall development of the regional economy and society. Meanwhile, in the international economic market, to effectively improve the international supply and demand relations, effective regulation of national economic structure and factor utilization, optimize the allocation of global resources.

Therefore, this paper selects total export trade (Y_1) and total import trade (Y_2) as indicators to measure regional import and export trade.

2.2 Index system of influencing factors of import and export trade

2.2.1 Macroeconomic

This section selects GDP, consumer price index, money supply, the proportion of the tertiary industry, and fixed asset investment indicators. GDP (X_{11}) reflects a country's overall level of economic development and has different effects on the country's foreign trade. Consumer price index CPI (X_{12}) directly reflects the price changes of consumer goods and services purchased by households,

which has an impact on the total foreign trade; money supply M2 (X_{13}) affects foreign trade import and export mainly through investment and savings and price changes; the change in the proportion of the tertiary industry (X_{14}) has an important impact on the foreign trade of different countries; fixed asset investment (X_{15}) is the total amount of work and related costs for the construction and purchase of fixed assets. It is an important basis for the formulation and control of national investment plans and can promote economic growth and foreign trade exports.

2.2.2 Foreign Trade

This section selects the exchange rate, tariff rate, the use of foreign capital, foreign exchange reserves, and export trade dependence index. Generally speaking, the Exchange rate (X_{21}), when the local currency depreciates, foreign currency can convert more local currency, and the increase in product price competitiveness will be conducive to exports while the price of imported products will also be relatively higher, which is not conducive to trade imports, and vice versa; tariff rate (X_{22}) refers to the proportion of tax levied by the customs established by the government on import and export commodities. The use of foreign capital (X_{23}) means the domestic use of foreign capital by foreign borrowers and other economic organizations to finance equipment and technology in foreign countries. Foreign exchange reserve (X_{24}) refers to monetary resources with international payment capacity, which is the basis for international trade. Export trade dependence (X_{25}) refers to the proportion of a country's commodity export trade in GDP, which indicates the degree of dependence of a country's economy on foreign trade and reflects a country's economic development level. The degree of participation in the international economy to some extent.

2.2.3 Regional economic indicators

This section selected freight capacity, technological level, and human capital indicators. Freight capacity (X_{31}) can reflect a country's transportation level to a certain extent, and it is also the basic condition for a country to achieve foreign trade. To a certain extent, the trade transport capacity of a country is expressed by the sum of railway freight volume and air freight volume. The level of science and technology (X_{32}) refers to the impact of technological progress on economic growth, and the contribution of scientific and technological progress to social and economic development is measured by the total input of national science and technology funds; human capital (X_{33}) is an endogenous variable to promote economic growth and plays an increasingly prominent role in trade development. It can effectively optimize the economic structure and the international division of labor system. The number of students in higher education is used to represent human capital.

2.2.4 Other factors

This section selects epidemic factors and global economic growth rate indicators. Epidemic factor (X_{41}) refers to the socio-economic delay and stagnation caused by epidemic transmission and other factors affecting import and export trade through interaction. The 0/1 variable represents the year of special factors such as an epidemic or not. Global economic growth rate (X_{42}) refers to the index reflecting the degree of change in the level of world economic development in a certain period.

This paper constructs a comprehensive evaluation index system of influencing factors, as shown in Table 1.

Table 1 Comprehensive evaluation index system of influencing factors

First-grade indexes	Second-grade indexes	unit	References
Macroeconomics (X1)	GDP (X11)	Hundred million Yuan	[7]
	CPI (X12)	--	[7]
	Money supply (M2) (X13)	Hundred million Yuan	[6]
	The proportion of tertiary industry (X14)	--	[7]

	Fixed asset investment (X15)	Hundred million Yuan	[6]
Foreign trade (X2)	Exchange rate (X21)	--	[3]
	Tariff rate (X22)	--	[3]
	The use of foreign capital (X23)	Hundred million US Dollars	[4]
	Foreign exchange reserves (X24)	Hundred million US Dollars	[6]
	Export trade dependence (X25)	--	[4]
Regional economics (X3)	Freight capacity (X31)	Ten thousand tons	[5]
	The level of science and technology (X32)	Hundred million Yuan	[4]
	Human capital (X33)	Ten thousand people	[1]
Other factors (X4)	Epidemic factors (X41)	--	[1]
	Global economic growth rate (X42)	--	[2]

3. Construction and Introduction of ANN Model

ANN (artificial neural network) is a network model constructed artificially to achieve certain functions based on the cognition of the brain neural network, which is composed of a large number of artificial neurons and can be used for large-scale calculation. Overall, the artificial neural network has the following advantages: First, fault tolerance is good. Second, it has self-organizing, self-learning, reasoning, and other aspects of adaptive capacity; the third is the nonlinear connection to ensure that the system has higher performance [9].

The structure of an artificial neural network includes an input layer, one or more hidden layers, an output layer, and the connection relationship between each layer. Different connections can connect neurons into neural networks with different topological structures. This paper uses a feedforward neural network structure, and its topology is shown in Figure 1.

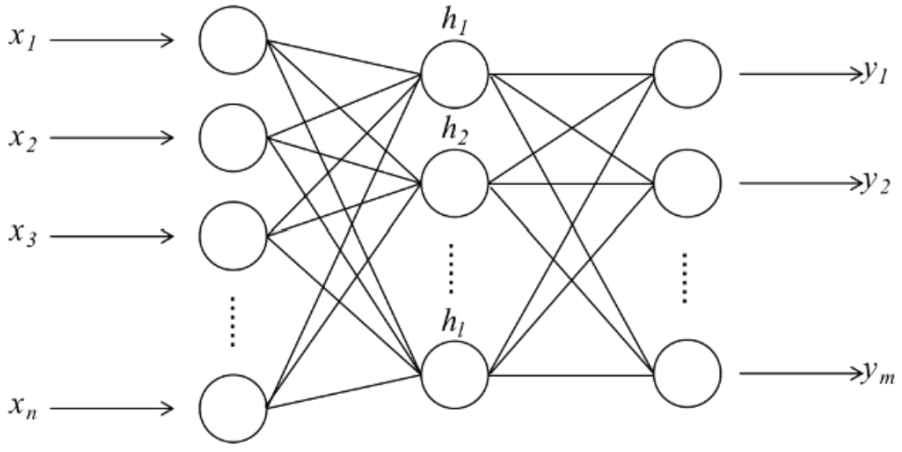

Figure 1. The topological structure of the feedforward neural network

The input layer contains N neurons (corresponding to N index influencing factors), and its input vector is $x=[x_1,x_2,x_3,...,x_n]^T$; the hidden layer contains L neurons, and its output vector is $h=[h_1,h_2,h_3,...,h_l]^T$. The connection weight w_{ij} between the input layer and the hidden layer represents the connection weight between the i neurons in the input layer and the j neurons in the

hidden layer and $x_j = \sum_i^n x_i w_{ij}$ is the total input received by the j neurons in the hidden layer. Then, the total input x_j is linearly processed with the threshold θ_i, and the neurons in the hidden layer generate the output signal h_j through the activation function $f(x)$ [10]. Figure 2 shows the working mechanism of neurons in a typical ANN structure.

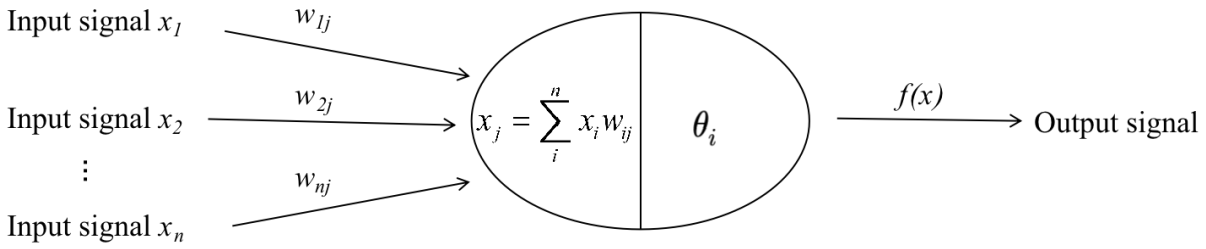

Figure 2. The working mechanism of typical ANN neurons

Figure 2 shows that the input-output correspondence between the output layer and the hidden layer of the artificial neural network is:

$$h_j = f(\sum_i^n x_i w_{ij} + \theta_i) \tag{1}$$

The activation function embodies the mapping relationship, which is an essential component of a neural network. Different neural network models have different neuron activation functions. At present, the most mainstream activation function is the Sigmoid function:

$$f(x) = \frac{1}{1+e^{-x}} \tag{2}$$

Then, the output signal of the hidden layer is transmitted to the next layer of neurons by weighting. The process is shown in formula (5). Where w_{jk} is the connection weight between j neurons in the hidden layer and k neurons in the output layer; $h_k = \sum_j^l h_j w_{jk}$ is the total input signal received by the output layer neurons; γ_j is the threshold; y_k is the prediction data of the output layer. Finally, the output vector of the output layer is.

$$y_k = f(\sum_j^l h_j w_{jk} + \gamma_j) \tag{3}$$

4. Construction of test indicators

In order to analyze the influencing factors of regional trade import and export, it is necessary to continuously optimize the parameters through ANN learning until the calculation error meets the requirements. The learning process has two stages: signal forward propagation and error backward propagation. The signal forward propagation stage aims to calculate the global error. If the output value of the output layer cannot be satisfied, the parameter conditions initially set for the network to finish learning will then step into the error backpropagation stage. This stage transmits the error signal in the direction opposite to the forward propagation of the signal and constantly adjusts the weights until the error meets the conditions. This paper uses root mean square error (RMSE) and correlation coefficient (R2) as error functions for analysis.

$$\text{RMSE}=\sqrt{\frac{1}{\text{m}}\sum_k^m (d_k - y_k)^2} \tag{4}$$

$$R^2 = 1 - \frac{\sum_k (d_k - y_k)^2}{\sum_k (d_k - \overline{d})^2} \tag{5}$$

In the formula, d_k is the actual import and export trade volume collected, y_k is the ANN prediction value obtained by the influence index as the input data, and $\overline{d}$ is the average value of the actual import and export trade volume. For RMSE, its range is (0, ∞). The closer to 0 indicates that the smaller the prediction error is, the better the performance of the constructed artificial neural network is. The range of correlation coefficient R^2 is [0,1]. The closer the value of R^2 is to 1, the better the network performance is. Conversely, the smaller the value of R^2, the worse the performance. If the total error does not meet the requirements, the weight coefficient and the threshold are adjusted in the good direction of the error function.

5. Empirical analysis

5.1 Research object determination and data collection

Local conflict events accompany the post-epidemic era, and the world political and economic pattern is accelerating. The economies of each country are greatly affected, which will increase international trade friction to some extent. In recent years, the epidemic has become more serious in various countries. Compared with the impact of the epidemic on China's economy, it is gradually weakening, and China 's economy as a whole is stable. Shanghai is one of the four municipalities directly under the central government of China's provincial administrative regions, and its urban GDP has been ranked first in mainland China for a long time. The national central city is China's international economic, financial, trade, shipping, science, and technology innovation center, and it is the largest city in China's economic volume. Shanghai can remain in the top ten in the list of major cities globally and has a profound cultural heritage of modern cities and many historical monuments. In order to explore the characteristics of China's import and export trade under the current international background, this paper selects Shanghai as the target area and empirically analyzes the influencing factors of its import and export trade.

Based on the official website of the Shanghai Statistics Bureau, this paper collects the indexes of import and export trade of Shanghai from 2021 to 2002, such as total export trade of Shanghai, total import trade of Shanghai, gross domestic product, consumer price index, money supply, the proportion of the tertiary industry, investment in fixed assets, utilization of foreign capital, foreign exchange reserves, export trade dependence, freight capacity, scientific and technological level, human capital, epidemic factors, and exchange rate. China's tariff rates from 2021 to 2002 were collected in WITS. The report ' World Economic Situation and Prospects 2021 ' collected global economic growth rates from 2021 to 2002.

5.2 ANN Operation and Model Checking

In this paper, based on SPSS software, the neural network model is calculated and tested, and the data of each index are substituted as the input value of the ANN algorithm. Through the distributed iteration, the range and threshold of the hidden layer parameters of the neural network are modified. From 2002 to 2021, the predicted value is constantly closed to the actual value, and R^2 and RMSE are used as the judgment standards. Through dozens of iterations, R^2 and RMSE are calculated as shown in Figure3 and Figure4.

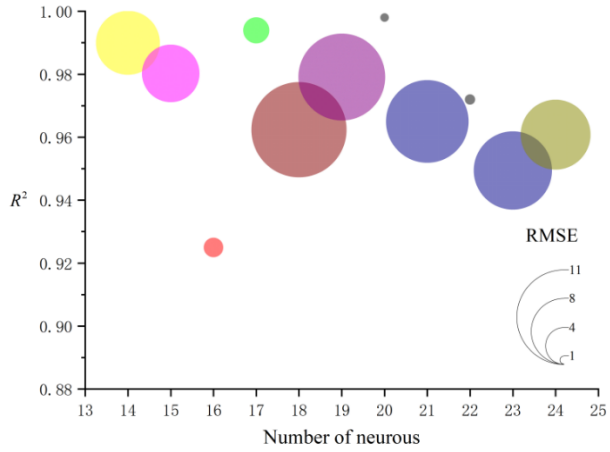

Figure 3 Model Test of Total Export Trade

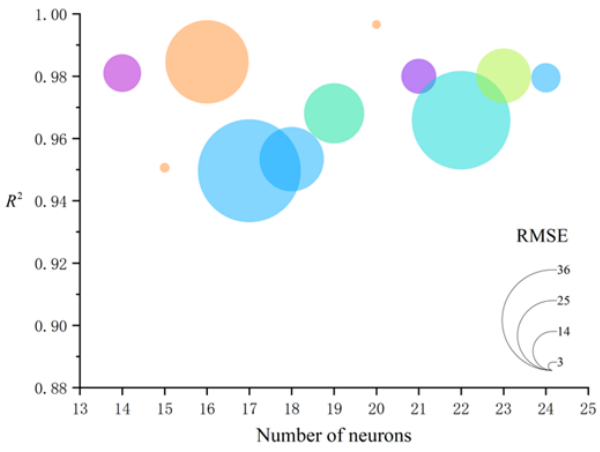

Figure 4 Model test of total import trade

It can be seen from Figure 3 that when the number of neurons is 20, R^2 and MRSE are 0.997 and 0.557, respectively, the export trade model has confidence. It can be seen from Figure 4 that when the number of neurons is 20, R^2 and MRSE are 0.997 and 3.512, respectively, the import trade model has confidence.

5.3 Index importance analysis

The above training and analysis found that when the number of hidden layer neurons is 20, the accuracy is the best, and the robustness of the model can reach the optimal solution. According to the sensitivity of the input layer to the output layer in the ANN algorithm, the synaptic weight of the neural network is calculated. Then, the influence of imports and export is analyzed. Get the importance analysis of the index based on ANN neural network analysis, as shown in Figures 5 and 6.

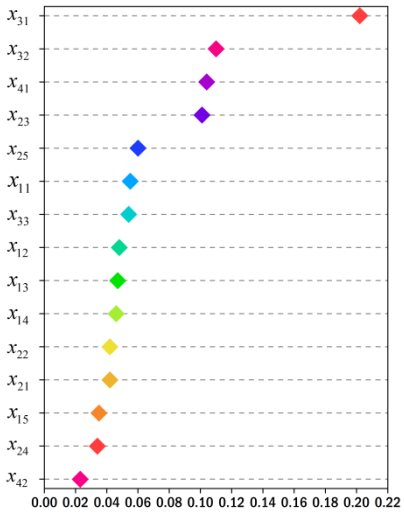

Figure 5 Importance Analysis of Export Trade Variables

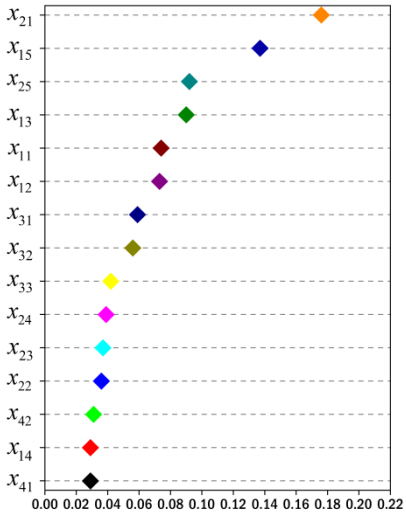

Figure 6 Importance Analysis of Import Trade Variables

5.4 Analysis and discussion

As can be seen from Figure 3, Shanghai freight capacity x_{31} (0.202) and technological level x_{32} (0.112) have a great impact on export trade. To some extent, freight capacity reflects the level of transportation in the region and the basic conditions for the region to achieve foreign trade, so the freight capacity of Shanghai will affect the region's export trade. The technological level reflects the

investment of science and technology to export trade and reflects the structure of Shanghai's export commodities to some extent. Most of Shanghai's exports are high value-added new products, the use of technology into technology, and then product production, so such high value-added products are currently exported more.

It can be seen from Figure 4 that the indicator x_{21}(0.176) has the greatest impact. It reflects the exchange rate between China and other countries. Exchange rate changes have a direct regulatory effect on a country's import and export trade. Under certain conditions, depreciating the foreign currency, i.e., increasing the exchange rate, will play a role in restricting imports. On the contrary, the appreciation of the domestic currency, that is, the decline of the exchange rate will increase imports.

According to the above analysis, some suggestions are given:

(1) Shanghai's policies can include transportation structure adjustment policies and related transit measures, bringing new opportunities to develop Shanghai's freight volume. At the same time, it should continuously improve the level of science and technology and reduce the adverse impact of world economic fluctuations on Shanghai's foreign trade environment.

(2)The Chinese Government may appropriately expand the geographical distribution of import and export operations, which diversifies the sources and locations of raw materials at the international level. It raises funds in multiple capital markets in multiple currencies. It establishes a particular monetary portfolio by exchange rate trends and the international trade situation so foreign exchange risks in international trade and investment and financing can be primarily dispersed.

(3)the Chinese government can consider providing cash flow support for enterprises, promoting consumer investment, and vigorously improving the VAT retention and tax rebate system, which focuses on supporting research and technical services and transportation industries. Value-added tax rebates have increased significantly to boost market confidence and promote China's import and export trade.

6. Conclusion

With economic globalization, the development of import and export trade has become an essential guarantee for national and regional economic growth. As a top-tier city in China, Shanghai's import and export trade plays an essential role in China's economic growth. Therefore, the study of the influencing factors of Shanghai's import and export trade is significant to the development of Shanghai's import and export trade and China's economic growth.

(1) In this paper, Shanghai, China, is selected as the evaluation region from the four aspects of foreign trade, regional economic indicators, the macroeconomy, and other factors, and the comprehensive evaluation index system of regional economic influencing factors is constructed. The contribution analysis is carried out by using ANN. It has high calculation speed, strong adaptability, strong fault tolerance, and self-organization ability, which is conducive to studying the influence of import and export. On this basis, corresponding countermeasures and suggestions are put forward to reference the development of import and export trade in Shanghai.

(2)In terms of total export trade in Shanghai, freight capacity (0.202), science and technology level (0.112), epidemic factors (0.104), the use of foreign capital (0.101) have a great influence on export trade, and the RMSE error is only 0.557. In terms of total import trade in Shanghai, the exchange rate (0.176) and fixed asset investment (0.137) greatly influence import trade, and the RMES error is only 3.157. The import and export trade volume error is small, and the results are credible within the prediction range.

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