Influence of Deep Learning Neural Network on Performance Evaluation of Sustainable Development of International Trade

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ABSTRACT. The objective is to enable international trade companies to understand their situation in a timely and rapid manner and make optimal sustainable development decisions. The improved balanced scorecard model is applied to the construction of the evaluation index system for the sustainable development of international trade. Through the literature survey, the causal relationship between various indexes is analyzed. Eventually, taking the performance evaluation model with 5 first-level indexes, 10 second-level indexes, and 25 third-level indexes as the finance dimension, client dimension, internal process dimension, learning and growth dimension, as well as environment dimension is formed. The COFCO International Trade Platform is selected as a case, and 300 questionnaires are issued to evaluate its performance. Then, BP (Back Propagation) neural network is used as the model. AHP (Analytic Hierarchy Process) method is combined to determine the weight of each index, further obtaining the actual evaluation model. 15 companies are selected to test the model. The results show that the application of the balanced scorecard model is conducive to improving the company's understanding of the performance evaluation management of international trade platforms. The neural network model can also accurately evaluate the performance of international trade companies, and it is highly practical, which can provide a healthy and sustainable development idea for the performance evaluation of international trade companies.

KEYWORDS: BP neural network; Balanced scorecard; Analytic hierarchy process; Performance evaluation; International trade

1. Introduction

The most direct manifestation of global economic integration in the financial field is that financial activities exceed national regulations. Through direct foreign investment, its capital and technology are transferred from domestic to foreign

countries, leading to a trend of increasing economic volume and radiation range [1]. It is due to the continuous development of the global economy. Enterprises are already saturated in the domestic market. More economic and trade exchanges between various countries have driven the development of the entire world economy [2]. But after the global economic crisis that broke out in 2008, capitalist flaws were exposed. It only focuses on its interests and vigorously promotes global trade protectionism at the political level [3, 4]. In 2019, developed countries, led by the United States, under the banner of liberalism, waved tariffs and set up many trade barriers, which led to the setback of the global economy and seriously affected the process of economic integration [5, 6]. In the current complicated international environment, international trade is the industry most affected by economic globalization. Therefore, more attention needs to be paid to the development of this industry.

There is much foreign literature on the indexes of international trade performance evaluation, and the scope is wide. But the focus is almost on reflecting the service capabilities of trade and improving trade processes efficiently. Gunasekaran (2001) analyzed the impact of multiple trade indexes on performance [7]. Wang (2016) and Armando (2012) emphasized the advantages of using the high-performance container for performance evaluation [8, 9]. Ho and Zhu (2004) used two quarters of data to analyze the advantages and disadvantages of performance evaluation in Taiwan [10]. Paddeu (2017) discussed trade performance from an angle [11]. However, the evaluation indexes are complicated and involve a wide range of contents. Therefore, each scholar has his own perspective, resulting in a large number of evaluation indexes [12]. When an enterprise makes a decision, the decision will be biased because of the complexity of the evaluation indexes. Therefore, the use of appropriate models to reflect the evaluation indexes of international trade performance is fundamental to achieve sustainable development of enterprises.

The balanced scorecard model is used to build the evaluation index system for the sustainable development of international trade. Also, the performance evaluation model with 5 first-level indexes and 25 third-level indexes as finance, client, internal process, learning and growth, as well as environment dimensions is formed. COFCO international trade platform is investigated in the form of a questionnaire, and the BP neural network model is constructed. 15 companies are selected to perform performance evaluation and model verification on the model, which provides a theoretical basis for international trade performance evaluation.

2. Method

2.1 Construction method of performance evaluation index

Literature research method: A large amount of literature on the performance evaluation of sustainable development of international trade is read. After sorting out and analyzing, the index evaluation method is obtained. Questionnaire survey

method: The method of questionnaire survey is used to analyze and investigate each index. Also, the performance appraisal is evaluated and analyzed. Comprehensive evaluation method: The improved balanced scorecard method and the causal analysis method are used to comprehensively evaluate performance indexes. Also, the AHP method and BP neural network method are used for subsequent model construction.

2.2 Validity test of performance evaluation index

The RST method is used to test the validity of performance evaluation indexes. It is judged by the redundancy degree (RD) and sensitivity degree (SD). RD stands for the independence and redundancy of each index. When RD≤0.5, it means the index is valid, and the smaller the value, the higher the validity. SD is the adaptability of different evaluation systems to evaluation indexes. When SD≤5, the index is valid.

2.3 Data collection

The operating capacity data of the enterprises in the financial data comes from the COFCO analysis database. The economic data comes from the company's macroeconomic database. Other data comes from the questionnaire collection of enterprises. The questionnaire design is based on the three-level indexes in performance evaluation. Each item has 5 options: "Excellent", "Good", "General", "Poor", and "Extremely Poor", corresponding to 1, 0.8, 0.6, 0.4, and 0.2 points, respectively. A total of 300 questionnaires are issued and 292 are recovered. Among them, 280 questionnaires are valid, and the recovery rate is 97%, and the effective rate is 93%. The statistical software is used to analyze the credibility and validity of all questionnaires for further analysis.

2.4 Normalization and consistency check

There is a large degree of difference between each third-level index. Therefore, before modeling, all data are first normalized. The calculation method is that the weighted average is adopted for all the results to calculate the final score of each index. The normalized interval is [0,1]. The specific calculation equation is as follows.

$$X = \frac{x - x_{min}}{x_{max} - x_{min}} \tag{1}$$

To effectively reduce errors, all the matrices are checked for consistency. The specific calculation equation is as follows.

$$CI = \left(\lambda_{max} - n \right) / \left(n - 1 \right) \tag{2}$$

Where: λ_{max} is the largest eigenvalue, which is the mean value of Aw_i/w_i. w_i is the sub-vector of each row of the matrix multiplied by the weight W and summed.

Aw_i/w_i is the divisor of the matrix and its corresponding sub-vector. N is the number of data. The average random consistency index RI is used to determine the approximate range of inconsistency.

The consistency ratio CR (CR = CI/RI) is used to determine whether the matrix is consistent (when CR <0.1, the matrix is consistent).

2.5 Construction of BP neural network

The BP network neural model (input layer, hidden layer, and output layer) is selected to establish the model of sustainable development performance of international trade. The construction of the BP network neural model needs to calculate the number of each neural node. The specific calculation equation is as follows.

$$n=\sqrt{u+v}+z \tag{3}$$

Where: n is the number of hidden layer nodes. u and v are the number of input and output layer nodes. The value range of z is a constant between [1,10].

The other important thing is the selection of functions. The function from the input layer to the output layer adopts the S-type corresponding TANSIG function. The output layer uses PURELIN linear function. The learning rule uses the TRINGDX function. The performance evaluation uses MES function. The model times are set to 1000 times, and the accuracy is set to 0.0001. The rest are system default parameters.

2.6 Data processing and statistics

Excel 2019 software is used for data statistics. SPSS 20.0 is used to analyze the credibility and validity of the data. The drawing adopts Visio 2013 software. Matlab 7.0 is used to calculate the weights.

3. Results and discussion

3.1 Construction and validity test of the performance index system for international trade

According to the balanced scorecard, through the literature review and the causal relationship between the various indexes analyzed in the previous period, the index system for performance evaluation of sustainable development of international trade as shown in Table 1 is obtained. It includes 5 first-level indexes, 10 second-level indexes, and 25 third-level indexes. The first-level indexes are divided into five dimensions, namely finance, client, internal processes, learning and growth, as well as environment.

The finance dimension can reflect the current operating status of the international trade company and provide guidance for the company's future development. It can also reflect the environment in which the international trade company is located at a macro level. The client dimension reflects the consumer's recognition of enterprise services. At the same time, the client can directly provide improvement solutions for enterprises. International trade enterprises should track consumer's consumption and grasp consumer recognition of the company's service level. The internal process dimension can reflect the operation quality of the entire supply chain of the enterprise, and can also demonstrate the competitiveness of the enterprise from all aspects. Meanwhile, it enables enterprises to have a clear understanding of their capabilities and improve them in a targeted manner in future development. The dimension of learning and growth is an important factor for international trade enterprises to achieve long-term development. To achieve sustainable development, international trade enterprises not only need continuous innovation at the technical level but also need to increase investment in education to attract excellent international trade talents. The environment dimension means that international trade enterprises will be affected by multiple environments during the development process. They are restricted and guided by the social environment and policy environment, as well as they need to pay attention to the protection of the ecological environment.

Table 1 Index system for performance evaluation of sustainable development of international trade

System	First-level indexes	Second-level indexes	Third-level indexes
Index System for Performance Evaluation of Sustainable Development of International Trade	Finance	Operational Capability	Assets and liabilities
			Operating margin
			Turnover of total assets
		Economic Level	Economic extroversion
			Fixed investment in trade assets per capita
	Client	Consumer Level	Satisfaction
			loyalty
	Internal Process	Competitiveness	International trade foundation
			Resource consumption
			Corporate international reputation
		Operational Quality	International trade service capacity and quality
			International trade quality
			Emergency incident handling capability
			Customs clearance and customs declaration efficiency
	Learning and growth	Technical level	New international trade product development growth rate
			Information technology level

		Educational Level	The proportion of investment in international trade education accounted for the total investment
			International trade senior talent ratio
		Social Environment	National sustainable development thinking
			International Trade and Social Development Coordination Coefficient
	Environment	Policy Environment	Perfection of international trade policies and regulations
			Improvement of environmental impact assessment system
		Ecosystem	Total pollutant emissions
			Total investment in environmental pollution treatment
			Waste utilization

The RST method is used to test the validity of the indexes, as shown in Table 2. According to the value of redundancy and sensitivity, the index system for performance evaluation of sustainable development of international trade is valid.

Table 2 Validity test of the index system for performance evaluation of sustainable development of international trade

	Redundancy RD	Sensitivity SD
Index System for Performance Evaluation of Sustainable Development of International Trade	0.312	1.807

3.2 Establishment of the performance evaluation model of sustainable development of international trade

According to the above performance evaluation index of sustainable development of international trade and the results of the questionnaire survey, the model framework for performance evaluation of sustainable development of international trade is constructed, as shown in Figure 1. The input layer and output layer design related nodes according to specific indexes. A total of 25 indexes are contained. Therefore, the design has 25 input nodes and 1 output node, which is the final comprehensive evaluation score. The hidden layer calculates the number of related neuron nodes as 6 according to equation (3).
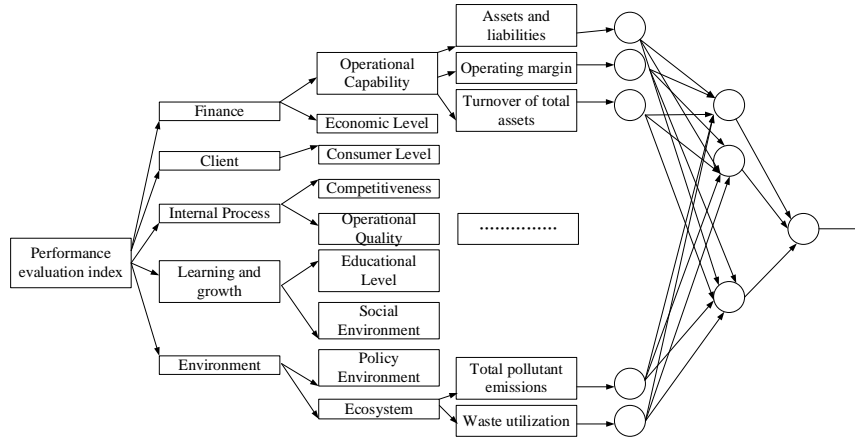
Figure. 1 Model framework for performance evaluation of sustainable development of international trade

3.3 Weighting results of the performance evaluation model of sustainable development of international trade

For the above performance model of sustainable development of international trade and questionnaire survey data, the weights need to be checked first. The calculation of weights needs to determine the appropriate matrix, as shown in equations (4)-(7). The following results are the judgment matrix obtained by the first-level indexes through the scoring results of experts. Among them, A represents the first-level index judgment matrix, and B represents the second-level index judgment matrix, and C represents the third-level index judgment matrix.

$$A=\begin{bmatrix} 1 & 1/3 & 1/2 & 2 & 1/3 \\ 3 & 1 & 2 & 4 & 1 \\ 1 & 1/2 & 1 & 3 & 1/2 \\ 1 & 1/3 & 1/2 & 2 & 1/3 \end{bmatrix} B1=\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} B2=\begin{bmatrix} 1 \end{bmatrix} B3=\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} B3=\begin{bmatrix} 1 & 2 \\ 1/2 & 1 \end{bmatrix} \quad (4)$$

$$B5=\begin{bmatrix} 1 & 1/2 & 1/3 \\ 2 & 1 & 1/2 \\ 3 & 2 & 1 \end{bmatrix} C1=\begin{bmatrix} 1 & 1/2 & 1/2 \\ 2 & 1 & 1 \\ 2 & 1 & 1 \end{bmatrix} C2=\begin{bmatrix} 1 & 1/2 \\ 2 & 1 \end{bmatrix} C3=\begin{bmatrix} 1 & 2 \\ 1/2 & 1 \end{bmatrix} \quad (5)$$

$$C4=5\begin{bmatrix} 1 & 1/5 & 1/2 \\ 2 & 1 & 2 \\ 2 & 1/2 & 1 \end{bmatrix} C5=\begin{bmatrix} 1 & 1/2 & 1/2 & 1/3 \\ 2 & 1 & 1 & 1/2 \\ 2 & 1 & 1 & 1/2 \\ 3 & 2 & 2 & 1 \end{bmatrix} C6=\begin{bmatrix} 1 & 3 \\ 1/3 & 1 \end{bmatrix} \quad (6)$$

$$C7=\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} C8=\begin{bmatrix} 1 & 3 \\ 1/3 & 1 \end{bmatrix} C9=\begin{bmatrix} 1 & 1/2 \\ 2 & 1 \end{bmatrix} C10=\begin{bmatrix} 1 & 3 & 5 \\ 1/3 & 1 & 2 \\ 1/5 & 1/2 & 1 \end{bmatrix} \quad (7)$$

The calculation results of the weights for performance indexes of sustainable development of international trade are shown in Table 3. Among them, the first-level indexes: finance, client, internal processes, learning and growth, as well as environment account for 0.1093, 0.3192, 0.1840, 0.0683, and 0.3192. It indicates that the performance indexes of sustainable development of international trade are more important.

Table 3 Calculation results of the weights for performance indexes of sustainable development of international trade

System	First-level indexes	Weights	Second-level indexes	Weights	Third-level indexes	Weights
Index System for Performance Evaluation of Sustainable Development of International Trade	Finance	0.1093	Operational Capability	0.5000	Assets and liabilities	0.2000
					Operating margin	0.4000
					Turnover of total assets	0.4000
			Economic Level	0.5000	Economic extroversion	0.3333
					Fixed investment in trade assets per capita	0.6667
	Client	0.3192	Consumer Level	1.0000	Satisfaction	0.6667
					loyalty	0.3333
	Internal Process	0.1840	Competitiveness	0.5000	International trade foundation	0.1283
					Resource consumption	0.5954
					Corporate international reputation	0.2764
			Operational Quality	0.5000	International trade service capacity and quality	0.1223
					International	0.2270

					trade quality	
					Emergency incident handling capability	0.2270
					Customs clearance and customs declaration efficiency	0.4236
	Learning and growth	0.0683	Technical level	0.6667	New international trade product development growth rate	0.7500
					Information technology level	0.2500
			Educational Level	0.3333	The proportion of investment in international trade education accounted for the total investment	0.5000
					International trade senior talent ratio	0.5000
			Social Environment	0.1634	National sustainable development thinking	0.7500
					International Trade and Social Development Coordination Coefficient	0.2500
	Environment	0.3192	Policy Environment	0.2970	Perfection of international trade policies and regulations	0.3333
					Improvement of environmental impact assessment system	0.6667
			Ecosystem	0.5396	Total pollutant emissions	0.6483
					Total investment in environmental pollution treatment	0.2297
					Waste utilization	0.1220

3.4 Consistency check of the performance model of sustainable development of international trade

For the above performance model of sustainable development of international trade and questionnaire survey data, the consistency needs to be checked. First, normalization is required, and the results are shown in Table 4. The sample data is eventually obtained. Among them, the horizontal is the number of 15 sample companies, and the vertical is 25 indexes. The results show that the sample data results of the 15 companies are all consistent and the deviations are relatively small.

Table 4 Index weight values

Order	1	2	3	4	5
RI	0	0	0.58	0.90	1.12

According to the CR calculation method, Matlab7.0 is used to calculate the CR values of 16 judgment matrices, as shown in Table 5. The code takes only first-level indexes as an example, where x_{max} is λ_{max} , and all values are less than 0.1. Therefore, it is judged that the data results are reasonable, and the model has the consistency.

Table 5 Consistency check results of the judgment matrix

Judgment matrix	A	B1	B2	B3	B4	B5	C1	C2
CR	0.0018	0	0	0	0	0.0079	0	0
Judgment matrix	C3	C4	C5	C6	C7	C8	C9	C10
CR	0	0.0048	0.0038	0	0	0	0	0.0032

3.5 Operation result of BP neural network model

According to the above results, the performance model of the sustainable development of international trade is relatively complete. Thus, 1-10 are used as training samples and 11-15 are used as test samples for BP neural network training. The actual output, expected output and error value of the training samples are shown in Table 6. It can be seen from the table that the mean error is 1.55%, indicating that the BP neural network model has a relatively high evaluation effect and the error is relatively small. It can be applied to the performance evaluation of the sustainable development of international trade enterprises.

Table 6 Expected output and error of training samples

Sample	1	2	3	4	5	6	7	8	9	10
Expected output	0.5477	0.6292	0.4922	0.5658	0.5292	0.5820	0.5441	0.4853	0.5067	0.5539
Actual output	0.5391	0.6327	0.4736	0.5698	0.5203	0.5790	0.5588	0.4829	0.5190	0.5596
Absolute	0.0086	0.0035	0.0186	0.004	0.0089	0.003	0.0147	0.0024	0.0123	0.0057

error										
Relative error	1.57%	0.56%	3.78%	0.71%	1.68%	0.52%	2.70%	0.49%	2.43%	1.03%
Mean absolute error	0.0082									
Mean relative error	1.55%									

The trained BP neural network model is called and the software is used for the simulation test. The results are shown in Table 7. All the error values are low, indicating that the evaluation results of the model are indeed in line with the actual situation. It can be widely used in the performance evaluation of the sustainable development of international trade.

Table 7 Expected output and error of training samples

Sample	1	2	3	4	5
Expected output	0.5207	0.5400	0.4982	0.4881	0.4824
Actual output	0.5200	0.5257	0.4925	0.4925	0.4974
Error	0.13%	2.65%	1.14%	0.90%	3.11%
Performance level	General	General	General	General	General

4. Conclusion

The balanced scorecard model is used to build the evaluation index system for the sustainable development of international trade. COFCO international trade platform is investigated in the form of a questionnaire, and the BP neural network model is constructed. Also, 10 groups of sample data from 15 companies are selected for network training. Finally, the performance evaluation and model verification are performed on the model.

The results show that after referring to the literature of many scholars and the analysis of the causal relationship between the indexes, the index system for performance evaluation of sustainable development of international trade with the five dimensions of finance, client, internal processes, learning and growth, as well as the environment as the first-level indexes, 10 second-level indexes, and 25 third-level indexes is formed. The results of the questionnaire construct the BP neural network as the basic model. The result of each variable weight is better. All the indexes of the model are important, and all have passed the consistency check. The evaluation effect is relatively high, and the relative error is 1.55%. It proves the rationality and accuracy of the model. Furthermore, it indicates that the model has wide application value and can be used in the performance evaluation of the sustainable development of international trade enterprises.

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