Academic Journal of Computing & Information Science
ISSN 2616-5775 Vol. 3, Issue 3: 34-42, DOI: 10.25236/AJCIS.030305

Prediction of port logistics demand based on BP neural network -- a case study of Nantong Port

Weize Lu*, Likun Wang

College of Transport & Communications, Shanghai Maritime University, Shanghai, China
**Corresponding author e-mail: 372577731@qq.com*

ABSTRACT. *China city's rapid economic development one after another and one belt, one road strategy is being put forward and pushed forward. The construction and planning of coastal cities' ports are becoming more and more important. The prediction of port logistics demand can provide some reference for port construction and planning. This paper analyzes the factors affecting the logistics demand of Nantong port, constructs the BP neural network model to forecast the port logistics demand of Nantong port from 2019 to 2021, and puts forward some suggestions for reference.*

KEYWORDS: *Port logistics demand, BP neural network, Port, forecast*

1. Background

One belt, one Road Silk Road Economic Belt and the maritime Silk Road vision and action document of twenty-first Century were formally put forward in China in April 2015. One is the "Silk Road Economic Belt" and the other is the "21st century Maritime Silk Road". The maritime Silk Road is mainly composed of two key directions. One is mainly westward, from China's coastal ports through the South China Sea to the Indian Ocean, and finally to Europe; the other is mainly southward, from China's coastal ports through the South China Sea to the South Pacific, reaching Southeast Asia and Oceania [1].

Nantong is one of the 13 prefecture level cities in Jiangsu Province. It is located in the North Bank of the Yangtze River Estuary and the intersection of the "T" structure productivity distribution of the coastal economic belt. It is the first batch of 14 coastal port cities open to the outside world [2]. With China's one belt, one road ahead, Nantong has gradually become an ideal hub for cargo transportation between China and other countries, thanks to its advantages such as prominent location advantages and convenient internal and external radiation. Due to its good

ISSN 2616-5775 Vol. 3, Issue 3: 34-42, DOI: 10.25236/AJCIS.030305

geographical location, Nantong port has also developed rapidly in recent years. For the previous research of Nantong port, Wang Xia established the prediction model of Nantong port container throughput by using the grey prediction model, and obtained the forecast value of Nantong port's container throughput in the next four years [3]. Combining one belt, one road and one Yangtze River, the Wen Pengfei has built a combined model to predict the container throughput of Nantong port. It provides a reference for Nantong port's construction and planning and better docking of the "one belt and one road" and the Yangtze River Economic Belt strategy [4]. The above scholars only forecast the container throughput over the years without considering other factors affecting the port throughput and port logistics demand. In this paper, we consider and forecast the port logistics demand from various influencing factors. Combined with the economic development of Nantong City, and collect relevant data from Nantong Statistical Bureau, establish the index of port logistics demand prediction, and forecast the port logistics demand by establishing BP neural network model, so as to provide some data reference for the development of the port and future planning.

2. Analysis on demand factors of Port Logistics

The forecast of port logistics demand needs to be considered from many aspects, including the economic development of the city and the operation of the port. There are many factors that affect the demand of port logistics, such as the economic development scale of the city where the port is located, and the economy of various industries.

2.1 Selection of influencing factors

From Nantong statistical yearbook 2019, this paper collects Nantong's GDP, the output value of three major industries and the influencing factors of total import and export related to port production and operation in recent 10 years. The specific data are shown in Table 1.

Table 1 Statistics of influencing factors of Port Logistics

Year	GDP (100 million yuan)	Primary industry (100 million yuan)	Secondary industry (100 million yuan)	Tertiary industry (100 million yuan)	Total import and export (US $100 million)
2009	2904.2	236.47	1632.12	1035.58	162.59
2010	3510.6	266.22	1941.95	1302.39	210.96
2011	4138.9	287.21	2263.55	1588.10	258.44
2012	4630.3	319.09	2464.74	1846.47	263.01
2013	5235.4	322.31	2715.32	2197.78	298.14
2014	5748.6	339.57	2873.97	2535.07	316.47
2015	6256.1	354.90	3043.04	2858.16	315.79
2016	6885.2	366.66	3239.86	3278.63	308.59
2017	7734.6	382.69	3639.80	3712.14	348.20
2018	8427.0	397.77	3947.88	4081.35	385.91

ISSN 2616-5775 Vol. 3, Issue 3: 34-42, DOI: 10.25236/AJCIS.030305

2.2 Index selection

Transportation is the most basic behavior in logistics activities. The transportation demand of port can reflect the logistics demand of port to a great extent. Therefore, cargo throughput and container throughput are selected as indicators to reflect the level of port logistics demand. The port logistics demand of Nantong port is shown in Table 2.

Table 2 2009-2018 port logistics demand index

Year	Cargo throughput (10000 tons)	Container(TEU)
2009	13641.4	350579
2010	15069.8	462322
2011	17330.6	539812
2012	18526.4	504306
2013	20494.5	600559
2014	22019.4	711043
2015	22077.4	758548
2016	22613.8	826862
2017	23572.0	1007150
2018	26702.1	967890

3. BP Neural Network Model

3.1 Introduction to the model

Back propagation network was proposed by Rumelhart and McClelland in 1980s. As a traditional neural network, the network can automatically obtain the "reasonable rules" between the data through learning, and memorize the content learned from the data into the weight of the network, with high self-learning and adaptive ability [5]. The number of hidden layers and the number of neurons of BP neural network should be set according to the actual situation of the research problem, and different structure will bring different performance [6]. Different layers of BP neural network are fully connected, but neurons in the same layer are not connected. The multi-layer network structure can make BP neural network dig out the information between the data from the input data and find the potential rules in the data, so as to complete some complex work. Most BP neural networks use sigmoid function as transfer function. A simple log sigmoid function can be determined by the following formula:

$$Log - Sigmoid = \frac{1}{1 + e^{-x}}$$

ISSN 2616-5775 Vol. 3, Issue 3: 34-42, DOI: 10.25236/AJCIS.030305

In BP neural network, the data is input from the input layer first, then transferred to the hidden layer by adjusting the weight, and then gradually propagated to the later layer. When training weights, it is transmitted in the opposite direction, that is, to first reach the hidden layer from the output layer and adjust the weight of the network layer by layer. Through repeated training, the error between the output value and the actual value of the network becomes smaller and smaller. When the error reaches the acceptable range of users, the network training is successful.

3.2 Modeling process

1) Data description and input

In this paper, X1 is the GDP, X2 is the primary industry output value, X3 is the secondary industry output value, X4 is the tertiary industry output value, X5 is the total import and export. Y1 is the throughput of port cargo and Y2 is the throughput of container. The structure of BP neural network model established in this paper is shown in Figure 1.The Kn represents hidden layer neurons.

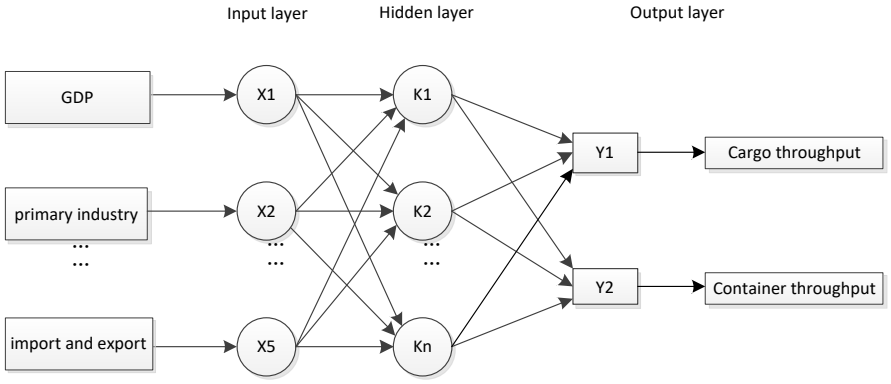

Figure. 1 Structure of BP neural network

After inputting data, it is necessary to normalize the original data so that the original data can be transformed linearly, and the data results can be mapped to the range of [0, 1] to realize the scaling of the original data. The main purpose of normalization is to speed up the convergence speed of the network, so as to facilitate the learning of BP neural network. The normalization formula is: $X_{norm} = \frac{X-X_{min}}{X_{max}-X_{min}}$, Where X_{max} is the maximum value of data, X_{min} is the minimum value of data.

2) Determine the number of neurons in the hidden layer

Firstly, the number of neurons in the hidden layer is determined by the empirical formula, and the value obtained by the empirical formula is taken as an initial value

ISSN 2616-5775 Vol. 3, Issue 3: 34-42, DOI: 10.25236/AJCIS.030305

of the network model, and then the training situation of the network is observed during the training process. If the performance of the neural network is poor, the number of hidden layer neurons is gradually modified until the number of hidden layer neurons that can make BP neural network perform well is found. At this time, the number of hidden layer neurons is the optimal number of the neural network. Empirical formula: $M = \log_2 N$, where m is the number of neurons in the hidden layer and N is the number of neurons in the input layer.

3) Create neural network

Input the normalized sample data, take the data from 2009 to 2017 as the training set sample, and the data from 2018 as the test set sample. Use Matlab to create BP neural network, and set the parameters of each layer, such as transfer function, training function, maximum training times, training objectives and learning rate, and then train the BP neural network. The hidden layer transfer function of the model is set to Tansig. The number of neurons in the hidden layer was 13, and the transfer function of output layer was purelin..The training function uses trainlm, the training target is 10^{-6}, the learning rate is 0.05, and the maximum training times is set to 1000 times.

4. Forecast of Nantong Port logistics demand

Taking the data from 2009 to 2017 as training set samples and 2018 data as test set samples, the BP neural network prediction model is established through the above steps. After many times of training, the training result curve is shown in Figure 2.

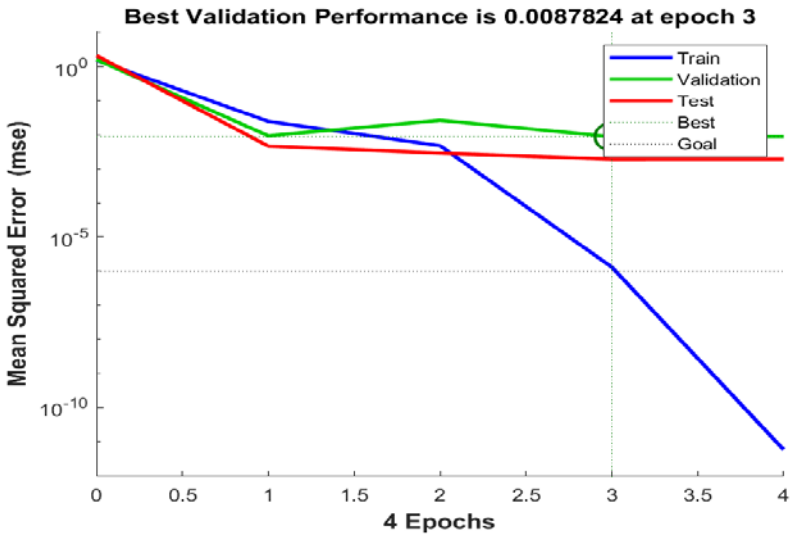

Figure. 2 Network training diagram

ISSN 2616-5775 Vol. 3, Issue 3: 34-42, DOI: 10.25236/AJCIS.030305

In order to further reflect the prediction effect of BP neural network, the performance of the network is observed by comparing each output index with the actual value, as shown in Figure 3 and Figure 4.

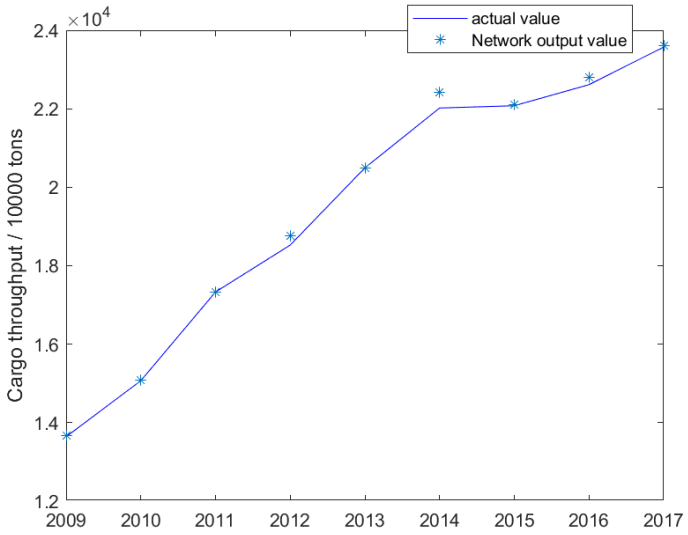

Figure. 3 Network output value and actual value of cargo throughput

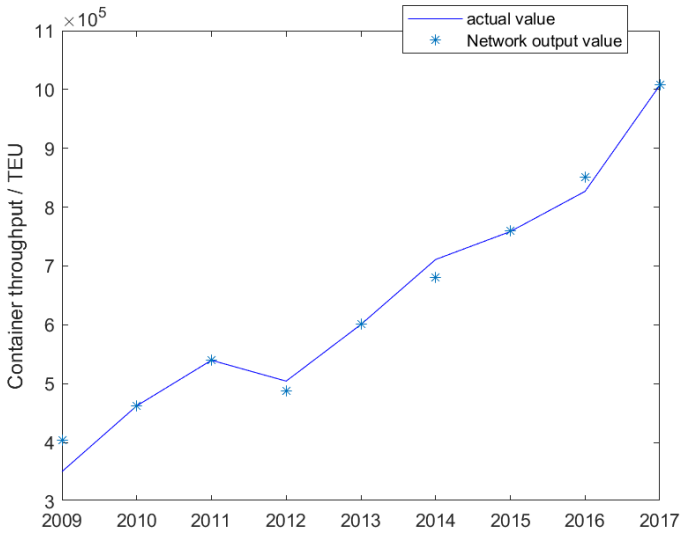

Figure. 4 Output value and actual value of container throughput network

ISSN 2616-5775 Vol. 3, Issue 3: 34-42, DOI: 10.25236/AJCIS.030305

It can be seen from Figure 4 and Figure 5 that the network fitting is good, and the output value of the network is approximately close to the actual value, indicating that the network training effect is good.

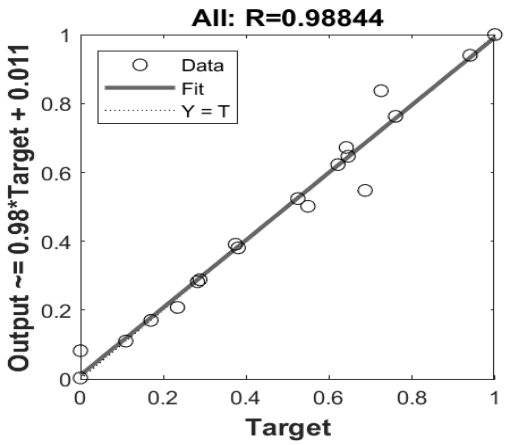

Figure. 5 Regression diagram of BP neural network

The regression graph generated at the end of network training in MATLAB, the closer value is to 1, the better the network performance is. In this model, R= 0.98844, which shows that the BP neural network training is better. Five variables of the test data in 2018 are input into the trained network to get the output value in 2018. Among them, the port cargo throughput is 267139500 tons, the container throughput is 968273.03 (TEU).The actual port cargo throughput is 267.021 million tons, and the container throughput is 967890 (TEU). The overall error is $5.82 * 10^{-7}$and the error is very small. The network can be used to predict.

The trained BP neural network model is used to predict the cargo throughput and container throughput of Nantong port from 2019 to 2021. Firstly, the values of the five independent variables in the input layer of the neural network from 2019 to 2021 are predicted. This paper uses the quadratic exponential smoothing method [7] to forecast Nantong's GDP, the output value of the primary industry, the output value of the secondary industry, the output value of the tertiary industry and the total import and export volume of Nantong city. The values of the five independent variables of the GDP, the output value of the primary industry, the output value of the secondary industry, the output value of the tertiary industry and the total amount of foreign trade import and export of Nantong City from 2019 to 2021 are as shown in Table 3.

Table 3 Input variables of port logistics demand forecast

Year	GDP	Primary industry	Secondary industry	Tertiary	Total import and

ISSN 2616-5775 Vol. 3, Issue 3: 34-42, DOI: 10.25236/AJCIS.030305

	(100 million yuan)	(100 million yuan)	(100 million yuan)	industry (100 million yuan)	export (US $100 million)
2019	8688.78	409.91	4035.64	4243.08	390.22
2020	9215.65	423.90	4248.93	4543.39	408.15
2021	9743.08	437.88	4462.21	4843.71	426.08

The input variables in 2019 are: 868.878 billion yuan, 40.991 billion yuan, 403.564 billion yuan, 424.308 billion yuan and 39.022 billion US dollars respectively. By inputting these five independent variables into the network, the cargo throughput in 2019 is predicted to be 286.7364 million tons and the container throughput is 968616 (TEU). Similarly, the predicted cargo throughput in 2020 is 304.5768 million tons, the container throughput is 979668 (TEU), and the cargo throughput in 2021 is 315.278 million tons, and the container throughput is 985624 (TEU). The forecast results of Nantong port logistics demand are shown in Table 4.

Table 4 Forecast results of port logistics demand

Year	Cargo throughput (10000 tons)	Container (TEU)
2019	27174.26	988614
2020	27975.16	1015294
2021	28346.52	1039579

5. Conclusion

This paper uses BP neural network model to analyze and forecast the logistics demand of Nantong port. The error between the output value of the network and the actual data is small, which shows that it is feasible to use the model to forecast the logistics demand of Nantong port. From the forecast data, it can be seen that the cargo throughput of Nantong port will continue to grow slowly, while the container throughput will grow faster. Compared with 967890 (TEU) in 2018, it will increase more in the next three years. One belt, one road, will not only provide a great opportunity for Nantong port development but also a challenge, which will lead to a steady growth in the logistics demand of the port of Nantong in the future. The increasing demand of logistics puts forward higher requirements for the port operation of Nantong port. This requires Nantong port to increase investment in modern logistics system, port industry, port construction and port information construction, automation management and other aspects, and constantly introduce high-quality talents, so as to create a good environment for the logistics development of Nantong port and attract more resources.

BP neural network can predict the logistics demand of the port. Taking Nantong port as an example, it realizes the prediction of BP neural network. Scholars who use other methods to predict the port logistics demand can try to join this method for comparison. The next work will try to use other neural networks and compare them with BP neural networks.

ISSN 2616-5775 Vol. 3, Issue 3: 34-42, DOI: 10.25236/AJCIS.030305

References

[1] Cheng Bing. One belt, one road strategy, Nantong logistics, boosting foreign trade development strategy [J]. Logistics engineering and management, 2019, 41 (03): 10-11.
[2] Yang Wei. The mechanism and path of the participation of the local city in building the "one belt and one way"taking Nantong as an example. [J]. Yili State Party school, 2018 (04): 68-72.
[3] Wang Xia. Prediction and analysis of container throughput of Nantong Port Based on grey theory [J]. Shopping mall modernization, 2017 (07): 19-20.
[4] Wen Pengfei, Wang Tong. Prediction of container throughput of Nantong port by combined model [J]. China business theory, 2016 (08): 138-141.
[5] Liu Hangfei, Chen Changping, Zheng Yanna, Chen ronggeng. Application of BP neural network in the prediction of fishing cargo unloading capacity [J]. Journal of Dalian University, 2017, 38 (06): 42-46.
[6] Wei Hui. Prediction of port logistics demand based on BP neural network [J]. Decision making exploration (middle), 2019 (09): 86-88.
[7] Liu Meilian, Zhu Meihua. Prediction model of Port Throughput Based on BP neural network [J]. Journal of systems science, 2012, 20 (04): 88-91.