Prediction on VLBP-based online tourism E-commerce market

Yunqian Yi

1Economic and Trade College, Shandong Management University, Jinan, 250357, China

Corresponding author and e-mail: Yunqian Yi, yiyunqian@126.com

Abstract. With the improvement of economic living standard and the development of Internet, the demand of online tourism is also growing. The increasing number of tourists and the upgrading of consumption stimulate the growth of the transaction scale of the online travel market. With the demand of accurate development of e-commerce market, a reasonable quantitative mathematical model is an effective means of resource integration. In this paper, VLBP is used to analyse the development of China's online tourism market by establishing a nonlinear relationship model between online tourism market transaction volume and various influencing factors to predict the future market transaction volume, so as to provide quantitative reference for the development of China's online tourism e-commerce marketing.

1. Introduction

Online tourism refers to the behavior that travel consumers book tickets, hotels, vacation products and other travel products or services to travel service providers through the network or telephone and pay online or offline. The development of Internet has a profound impact on the upgrading of online tourism market and e-commerce marketing has become an important benchmark of online tourism market. China's online tourism market transactions increased nearly 10 times from 48.64 billion yuan in 2008 to 478.23 billion yuan in 2017, with the annual growth rate ranging from 16.6% to 53.70%. Relatively speaking, the growth rate in the first five years was relatively high, and the growth rate in the last five years tended to be stable. Rijie Li have made in-depth analysis and Discussion on B2B and O2O modes of e-commerce work of tea enterprises in 2020 and made clear the importance of the two marketing modes [1]. Ke Liu made a comparative analysis of the development models of domestic and foreign rural e-commerce and clarified the importance of large-scale e-commerce platform and government boundary support [2]. Aiming at the development of tourism, in 2015 Jie Sun analyzed the problems existing in the development process of YiWu rural tourism e-commerce and pointed out the important influencing factors of tourism enterprises, construction, human resources, capital, etc. [3]. In 2016, Siyu Liu proposed that the factors affecting the development of tourism in Hainan include management mode, consumption mode and trade mode [4]. In the analysis of SanYa leisure tourism e-commerce, Bing Sun believes that network communication channels, sales platforms, operating costs and personalized services are important reference standards for the establishment of modern tourism business system [5]. However, at present, the impact on e-commerce and online tourism development is qualitative discussion and strategic analysis and there is no appropriate mathematical model to discuss the relationship between them quantitatively. A reasonable quantitative model can more accurately
express the influence of different tourism development factors on the application of e-commerce, further analyze its economic principles and provide important theoretical guidance and application reference for improving the development of online tourism market more efficiently.

2. Principle and algorithm
Variable learning rate back propagation (VLBP) is a new fast convergence nonlinear algorithm based on the traditional BP algorithm. Its core idea is to speed up the approach process by changing the learning rate in the reverse structure of BP. The improved learning rate formula can be divided into two situations: good convergence effect and reduced error. If the learning rate times \(k_{inc}\), \(\eta\) will increase, so the iteration speed will increase; otherwise, if the convergence effect is poor and the error increases, then the learning rate times \(k_{dec}\), \(\eta\) will decrease and the iteration speed will decrease.

\[
\eta(k + 1) = \begin{cases} 
  k_{inc}\eta(k) & \text{if good convergence effect and reduced error} \\
  k_{dec}\eta(k) & \text{otherwise}
\end{cases}
\]

\(\eta\) is the learning rate. \(k_{inc}\) and \(k_{dec}\) are rate changing parameters. In this paper, VLBP algorithm is used to build a model to predict the online tourism e-commerce market (Figure 1). The process is as follows:

![Figure 1. Flow chart of VLBP algorithm.](image)

3. Experimental results and discussion

3.1. Experiment design
This paper collects the transaction volume of China's online tourism market from 2008 to 2017 as the output neuron vector to evaluate the development of e-commerce market. At the same time, the factors that may affect the online tourism market of our country, such as the number of online tourism service coverage, the ratio of mobile online tourism visits, the ratio of mobile device reservation, the ratio of vertical search engine, the ratio of outbound tourism, the number of travel agencies and so on are taken as the input layer neuron vector. Through comparative analysis, a three-layer 6-6-1 topology VLBP
neural network is established and the model is trained. The basic learning rate is 0.01, the maximum training times is 500, the training accuracy is 1e-5, the increase of learning times is 1.2 and the decrease of learning times is 0.8. See Table 1 for input neuron vector and output neuron vector data. At the same time, after normalizing all the data, a line chart of six different influencing factors and tourism foreign exchange income is established (Figure 2). The abscissa is China's online tourism market trading volume (100 million yuan) and the ordinate is six different influencing factors respectively. It can be seen from the figure that there is a good linear positive correlation between the transaction volume of China's online tourism market and various influencing factors. At the same time, with the increase of the year, the number of people covered, the mobile access ratio, the mobile reservation ratio, the vertical search engine ratio, the outbound travel ratio and the number of travel agencies have increased. The difference is that the ratio structure of the increase of each influencing factor is different. In 2011, 2012, 2013, 2016 and 2017, there was a nonlinear transition between some influencing factors and the annual market turnover.

Table 1. Online tourism market information from 2008 to 2017.

| Year | Trading volume (100 million YUAN) | Unique visitor (100 million) | Mobile access ratio (%) | Mobile reservation ratio (%) | Vertical search engine ratio (%) | Outbound travel ratio (%) | Number of travel agencies |
|------|----------------------------------|-----------------------------|-------------------------|-----------------------------|-----------------------------|-------------------------|--------------------------|
| 2008 | 486.4                            | 0.288                       | 35.9                    | 38.6                        | 28.1                        | 1.4                     | 20691                    |
| 2009 | 617.6                            | 0.465                       | 36.8                    | 42.0                        | 42.4                        | 10.0                    | 21649                    |
| 2010 | 948.9                            | 0.671                       | 40.0                    | 49.2                        | 52.8                        | 14.2                    | 23690                    |
| 2011 | 1313.9                           | 0.863                       | 42.7                    | 55.5                        | 65.0                        | 16.9                    | 24944                    |
| 2012 | 1703.7                           | 1.080                       | 60.4                    | 63.7                        | 66.6                        | 18.3                    | 25636                    |
| 2013 | 2180.3                           | 1.311                       | 67.9                    | 66.7                        | 73.1                        | 18.1                    | 26707                    |
| 2014 | 3166.6                           | 1.531                       | 72.3                    | 79.9                        | 74.6                        | 20.3                    | 27199                    |
| 2015 | 4737.7                           | 1.775                       | 70.9                    | 83.3                        | 70.9                        | 22.9                    | 28540                    |
| 2016 | 6138.0                           | 2.130                       | 83.8                    | 83.1                        | 70.5                        | 25.7                    | 29044                    |
| 2017 | 7384.1                           | 2.799                       | 83.6                    | 86.0                        | 74.6                        | 20.3                    | 27199                    |

Figure 2. The relationship between each influencing factor and online market trading volume.
3.2. VLBP results and discussion

For the established VLBP neural network, the matrix analysis of weights and thresholds is carried out. It is found that the number of people covered is highly correlated with the online tourism market and the linearity is good. It shows that the user base of online tourism is huge and continuously increasing, which is the natural combination advantage of e-commerce market and mobile tourism service. Under the support of the Internet, there will also be internal relations with other relevant factors. The correlation between vertical search engine ratio and mobile reservation ratio is weak, but it also contributes to the prediction results. This shows that the frequency of online tourism accelerates to move to the mobile end and the higher the degree of standardization, the better the product will achieve in the mobile end. The number of travel agencies has a weak impact on the online tourism market, which also shows that offline tourism products lack the online operation ability and promotion ability. Such restrictions allow the market to be distributed to online travel. However, it is undeniable that there is still a linear correlation between online tourism and traditional travel agencies (local agencies), because they complement each other and further cover the service population.

In order to verify the reliability of the model, the number of online travel service coverage in 2018 and 2019, the ratio of mobile online travel visits, the ratio of mobile device reservation, the ratio of vertical search engines, the ratio of outbound travel and the number of travel agencies are taken as the input vectors of the prediction sample set. The transaction volume of online tourism market is predicted by the model and the prediction results are shown in Table 2. The results show that in 2018 and 2019, the VLBP forecast value of online tourism market turnover is 819.95 billion yuan and 1174.71 billion yuan respectively and the relative errors with the actual market turnover published by the National Tourism Administration are 6.72% and -7.50% respectively, which are less than 10% relative errors (table 3).

**Table 2.** Comparison of actual transaction and VLBP prediction of online tourism market in 2018 and 2019.

| Statistical time | Actual online travel market turnover (100 million YUAN) | VLBP-estimated turnover of online travel market (100 million YUAN) | Relative error (%) |
|------------------|--------------------------------------------------------|---------------------------------------------------------------|-------------------|
| 2018             | 8750.3                                                 | 8199.5                                                       | 6.72              |
| 2019             | 10866.5                                                | 11747.1                                                      | -7.50             |

At the same time, in order to compare the accuracy of prediction data horizontally, the same data was analyzed by multiple linear regression model. From the previous data, it can be seen that the online tourism market transaction volume is significantly linearly related to some of the influencing factors, and is affected by multiple independent variables. At the same time, there are some weak correlations that will change the prediction results to a certain extent. Therefore, each variable in the model is independent, so as to establish the system of equations:

\[
\begin{align*}
y_1 &= a_1x_{11} + a_2x_{12} + a_3x_{13} + a_4x_{14} + a_5x_{15} + a_6x_{16} \\
y_2 &= a_1x_{21} + a_2x_{22} + a_3x_{23} + a_4x_{24} + a_5x_{25} + a_6x_{26} \\
y_3 &= a_1x_{31} + a_2x_{32} + a_3x_{33} + a_4x_{34} + a_5x_{35} + a_6x_{36} \\
y_4 &= a_1x_{41} + a_2x_{42} + a_3x_{43} + a_4x_{44} + a_5x_{45} + a_6x_{46} \\
y_5 &= a_1x_{51} + a_2x_{52} + a_3x_{53} + a_4x_{54} + a_5x_{55} + a_6x_{56} \\
y_6 &= a_1x_{61} + a_2x_{62} + a_3x_{63} + a_4x_{64} + a_5x_{65} + a_6x_{66}
\end{align*}
\]

After the parameters are solved by the least square method, the online tourism market transaction volume of two years is calculated by taking the data of relevant influencing factors in 2018 and 2019 and the data are 7736.8 and 9434.5 respectively. Compared with the prediction results and actual transaction volume of VLBP, figure 3 shows that the accuracy of the prediction results of VLBP is more accurate than that of multiple linear regression model.
Figure 3: Comparison between the transaction of online tourism market and the two prediction models.

4. Conclusions
Based on the data of online tourism market turnover and its influencing factors from 2008 to 2017, this paper trains VLBP neural network, and analyzes the market turnover in 2018 and 2019. The results show that the relative error of VLBP forecast value is less than 10%. At the same time, multiple regression linear model is added to carry out regression forecast analysis under the same conditions, and the results have certain settings. However, VLBP has higher accuracy and smaller error, which is more suitable for the prediction of transaction volume in online tourism market. It provides important reference for improving online tourism market and provides direction for optimizing e-commerce marketing.

References
[1] Rijie Li, E-commerce marketing model of tea enterprises, Fujian tea, 2020, 2:37.
[2] Ke Liu, Comparative analysis of rural e-commerce development mode, Rural economy, 2020, 1:81-87.
[3] Jie Sun, E-commerce strategy of rural tourism development in Yiwu, Modern industrial economy and informatization, 2015, 8: 85-87.
[4] Siyu Liu, The influence of tourism e-commerce on the development of Hainan Tourism, 2016, 35: 69-70.
[5] Bing Sun, E-commerce creates a new development model of leisure tourism in Sanya, Modern business, 2011, 30: 63-64.