Prediction of international Chinese liquor market based on convolution neural network

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Abstract. In view of the low market share of Chinese liquor in the international market, domestic liquor export strategies are mostly analyzed from the qualitative aspect, while the reasonable quantitative mathematical model is seldom studied. In this paper, the Convolutional Neural Network (CNN) was used to analyze the current development of Chinese liquor export market by establishing the nonlinear relation model between liquor export amount and various influencing factors, so as to forecast the future market export volume and provide quantitative reference for the development of Chinese liquor export industry.

1. Introduction
As one of the traditional Chinese alcoholic drinks, baijiu has a long history and is very popular among Chinese consumers. With the development of economic globalization, the export of liquor has become the intersection of the industry's attention. Unfortunately, compared with the extensive domestic market, its market share in foreign countries is low, far from opening up the North American and European markets with a large number of potential consumers. For example, in terms of liquor export, according to the data of the National Statistics Network, the export amount of China in 2016, 2017 and 2018 was USD 469 million, USD 470 million and USD 655 million respectively, which was on the rise year by year. Even so, Chinese liquor exports accounted for only 0.19% of the annual domestic liquor output in 2018. Meanwhile the international share of 0.76% was not consistent with Chinese status as a major liquor producer [1]. In 2015, Jing Ma made an analysis on the major challenges of Chinese liquor export and put forward corresponding countermeasures and suggestions [2]. In 2019, Tieyuan Cheng discussed the main characteristics and problems of Chinese liquor export through combing and analyzing the destination of liquor export to the international market, and provided suggestions for the selection of export market [3]. In 2018, Wei Qingqing expounded the inherent compatibility between the development of liquor industry and China's open and inclusive initiative under the background of the new normal economy, and clarified the opportunities and challenges faced by China's liquor foreign trade [4].

2. Principle and algorithm
Convolutional Neural Networks (CNN) is composed of input layer, convolutional layer, pooling layer, full connection layer and output layer. Compared with BP Neural Network, it is improved that the nodes of two adjacent layers are partially connected, which significantly reduces the number of parameter weights and improves the speed of model construction. The calculation process is to input the data into the input layer and then calculate the hidden layer to get the output layer. The error
between the output value and the target value is calculated again to reach the desired threshold value, and the operation is finished. If not, the error is input from the output layer to the input layer, and the error is distributed to each layer of neuron nodes. In the process of error backward propagation, the weights between each layer of neuron nodes will be constantly modified until the operation process is completed. In this paper, CNN algorithm is used to establish a model to predict the export amount of liquor, and the process is shown in Figure 1:

![Figure 1. Forward and backward propagation in CNN algorithm.](image-url)

### 3. Experimental results and discussion

#### 3.1. Experimental design

This paper collects the export amount of Chinese liquor from 2010 to 2018 as the output neuron vector to evaluate the development of liquor export trade. The production of liquor industry, the number of large-scale enterprises, the output of sorghum, wheat and corn, the cumulative value of domestic sales of liquor and other factors that may affect the export of liquor in China are taken as the input layer neuron vector. Through experimental comparison, the maximum training times of the CNN model are 500 times and the training accuracy is 1e-5. One input layer, two convolution layers, two pooling layers, two full connection layers and one output layer are set. Among them, the convolution kernel size of the first convolutional layer is 2*2, and the number is 20. The pooling layer adopts maximum sampling, and the kernel size is 2*2. The second convolutional layer and the pooling layer are set in the same way. The activation function is Relu function, and the number of neurons in the full connection layer is 30.

See Table 1 for input neuron data and output neuron data. Then, establish the scatter diagram of six different influencing factors and the amount of liquor export (see Figure 2). The vertical coordinate is the amount of liquor export in China ($100 million), and the horizontal coordinate is six different influencing factors. It can be seen from the figure that there is basically no linear relationship between the export amount of Chinese liquor and various influencing factors, and the multiple linear regression analysis will not be applicable at this time. At the same time, with the increase of years, there is a non-linear transition between some years. It is speculated that on the one hand, it is due to the change of national policies or the reform of industrial planning (such as “the 13th five years plan”). On the other hand, it may be due to the many market influencing factors, and the selected influencing factors are not fully considered.

#### Table 1. Data of Chinese liquor export volume and influencing factors in 2010-2018.

| Year | Export Value ($100 million) | Industrial output (ten thousand liters) | Number of large-scale enterprises | Sorghum output (10000 tons) | Wheat output (10000 tons) | Corn production (10000 tons) | Liquor sales volume (ten thousand liters) |
|------|----------------------------|------------------------------------------|----------------------------------|----------------------------|----------------------------|-------------------------------|------------------------------------------|
| 2010 | 0.9                        | 890.8                                    | 1607                             | 193.31                     | 11609.34                   | 19075.18                       | 2087.5                                   |
| 2011 | 2.43                       | 1025.6                                    | 1223                             | 189.16                     | 11856.95                   | 21131.6                        | 2420                                     |
3.2. Results and comparison

Based on the matrix analysis of weights and thresholds of the established CNN neural network, it is found that the industry output, the number of large-scale enterprises and the export amount are highly correlated and the linearity is good between some years, which indicates that the liquor produced by large-scale enterprises had more chances to be produced and sold abroad. The correlation between yields of individual grains is weak, but it also contributes to the forecast results.

This paper makes a prediction of the international liquor market, and the relative error is used to judge the prediction results. The predicted results are shown in Table 2 and Figure 3. The results show that CNN has a good forecast effect, and the forecast deviation of some years is not more than 12.68%.
Table 2. Comparison between the actual export amount of 2010-2018 liquor and the predicted value of CNN.

| Year | Actual export amount ($100 million) | Predicted export amount ($100 million) | Relative error |
|------|------------------------------------|----------------------------------------|----------------|
| 2010 | 0.9                                | 0.919458                               | 2.16%          |
| 2011 | 2.43                               | 2.2646385                              | 6.81%          |
| 2012 | 3.5                                | 3.295495                               | 5.84%          |
| 2013 | 2.54                               | 2.862072                               | 12.68%         |
| 2014 | 3.27                               | 3.4735902                              | 6.23%          |
| 2015 | 3.9                                | 3.468621                               | 11.06%         |
| 2016 | 4.69                               | 4.6153821                              | 1.59%          |
| 2017 | 4.7                                | 4.507535                               | 4.10%          |
| 2018 | 6.55                               | 6.4621645                               | 1.34%          |

Figure 3. Comparison curve between actual export amount of 2010-2018 liquor and predicted value of CNN.

The forecast results for some years are not satisfactory, possibly due to the following reasons: first, the quantity of data, the data taken in this paper are obtained from the national statistical network, and other aspects are not taken into account, for example, liquor export countries, foreign countries per capita liquor consumption, national import and export policies, liquor sales costs and other factors affecting the volume of liquor export; Second, at present, the application of convolutional neural network in image recognition is relatively mature, but there are few researches on its application in prediction, which need to be developed. It also has disadvantages: it cannot clearly explain the influence of each input data on the predicted data.

Among them, $Y$ represents the export amount of liquor, $X_1$–$X_6$ represent six different influencing factors, $\alpha_0$–$\alpha_6$ represent the regression coefficient of the model, $\mu$ is the random error term. At the same time, in order to compare the accuracy of the forecast data laterally, the data of 2010-2017 are selected for multiple linear regression model analysis. The specific model is as follows: $Y = \alpha_0 + \alpha_1X_1 + \alpha_2X_2 + \alpha_3X_3 + \alpha_4X_4 + \alpha_5X_5 + \alpha_6X_6 + \mu$. After regression by using the least square method, the significance test is made for the regression equation and regression coefficient, in which the determined coefficient $R^2 = 0.999938$. The fitting effect is good and the P value is 0.014748, which passed the significance test. The final model of liquor export amount is: $Y = -4.45297 - 0.00084X_1 - 0.00117X_2 - 0.00791X_3 + 0.000641X_4 - 0.0007X_5 + 0.007397X_6$. 
Compared with CNN's prediction results and actual trading volume, as shown in Figure 4, it can be seen that the prediction value error of multiple linear regression in 2018 is large, so the accuracy of CNN's prediction results is more accurate than that of multiple linear regression model.

**Figure 4.** Comparison between the export amount of liquor and the two prediction models in 2010-2018.

4. Conclusions
In this paper, a convolutional neural network is trained based on the data of liquor export volume and six influencing factors from 2010 to 2018. Then, the annual volume of liquor export from 2010 to 2018 is predicted and analyzed, and compared with the multiple linear regression analysis model, the results show that the prediction effect of CNN is mostly good, which provides an application reference for the development of liquor export industry. For example, large-scale enterprises are encouraged to provide one-to-one assistance to small and medium-sized liquor enterprises, so as to promote liquor sales and increase liquor export volume. In addition, like multiple linear regression analysis, the accuracy of CNN prediction also depends on the quantity and quality of data. Further research and improvement are needed in the selection and processing of variable data.

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