



Market revenue prediction and error analysis of products based on fuzzy logic and artificial intelligence algorithms

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Abstract

Neural networks can approximate the neuron information of all quantitative or qualitative nonlinear relationship, any complex is stored in the potential distribution in the network. It has strong robustness and fault tolerance, using the parallel distribution processing method, making quick lots of computing is possible. The mature prediction method in artificial intelligence, or the neural network method to forecast, this kind of algorithm has theoretical support to mature, reliable predictions of the information. In this paper, the authors analyze the market revenue prediction and error analysis of products based on fuzzy logic and artificial intelligence algorithms. The results of this paper can be concluded that the neural network algorithm has a high accuracy in predicting the future sales of the product, and the prediction error can be controlled within 4%. Through the establishment of the neural network model of future product sales forecast, we can predict the future product sales, can grasp the market direction, and make the enterprise get the maximum profit.

Keywords Fuzzy algorithm · Neural network · Revenue prediction · Intelligent system

1 Introduction

Forecasting is the basis of objective cognition of the essence and law of things. It describes the development of things in the future or judges the attributes of things through science and technology or experience. For sales forecasting, it is based on historical sales data of products, through analysis and research of various factors affecting the sales industry, and using reasonable methods and models, it is analyzed and predicted that the trend of sales, supply and demand changes and development law in the future period of time, so as to make a scientific evaluation of the situation of the sales industry and products. Estimate and budget, and show the trend of sales volume and sales amount of a specific product in a specific period of time in the future by time series. For sales forecasting, it is mainly divided into fashion products in the market share forecasting, sales target forecasting, product price forecasting, sales forecasting and so on.

At present, our country is in the era of vigorous development of the Internet era. The development of e-commerce

is entering a new stage of intensive innovation and rapid expansion. It has increasingly become an important engine to stimulate our consumption demand, promote the upgrading of traditional industries and develop modern service industries. Throughout the current e-commerce industry, due to the popularity of mobile smart terminals and the continuous improvement of network infrastructure, coupled with the e-commerce platform to provide fast payment means and insurance, funds, micro-loans and other services, people's online shopping demand has been greatly increased, and thus promoted the rapid development of the online retail market. Businessmen are facing some major challenges while acquiring more convenient product sales channels and a broader market environment. Usually, merchants need to formulate reasonable sales plans according to market conditions to avoid overstock or supply–demand imbalance, which will affect their sales interests and even the survival of enterprises. However, this sales plan is usually based on sales forecast. Therefore, whether the sales forecast of commodities is accurate or not is closely related to all aspects of the enterprise, which will directly affect the profit and loss of the enterprise and its survival and development (Aytac and Gurcan 2011).

With the development of technology forecasting in Mathematics in recent years, enterprises have gradually introduced

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some mathematical and statistical prediction technology: from past sales data for a product to predict future short-term or long-term product sales (Zhang et al. 2014). More and more traditional marketing to the relationship marketing, marketing solutions to change the concept of service is more and more important (Zhu et al. 2014). Master the mature forecasting technology, for the enterprise to solve problems and take the initiative to serve the customer has a huge role in promoting (Shu and Zhang 2016). For a product sales forecast is mainly based on the current business and sale rate, in considering the future of all sorts of factors, using mature prediction method, mathematical statistics, judge (Zhang 2013) on sales situation of the products in the future. The forecasting methods used in enterprises are mainly qualitative prediction and simple linear regression in traditional statistics. The main weakness of the qualitative prediction is that the subjectivity is too strong, the lack of data support (Chang et al. 2014). But in the traditional statistics, the multiple regression method is fixed, the flexibility is poor, and the prediction precision is not very good. There are also carried out some research, such as the Wang Wenhua method of nonstationary random signal processing (Wang and Wang 1997), Liu Changming method using linear prediction and nonlinear Qiu Runzhi model to predict such problems, they are using traditional methods of mathematics, statistics, poor flexibility (Liu and Long 1994). At the same time, there are other scholars in this area (Gong et al. 2018; Notani et al. 2019)

At present, people's preferences for commodities and consumption habits are changing tremendously all the time. Retail industry presents a series of new characteristics, such as: increasing demand for products and increasing range of changes, accelerating the trend of product sales change. These new situations lead to the influence of many factors, such as the rapid change of market demand, popular trend, commodity price and so on, in addition to seasonal alternation factors in the process of commodity forecasting. In addition, for online merchandise sales, it is necessary to take into account the impact of marketing promotion and feedback of merchandise evaluation on various sales platforms (Brown et al. 2015). Therefore, how to predict the sales situation of products reliably and accurately, grasp the supply and demand situation, and formulate reliable strategies for enterprises' economic decision-making and marketing plans, so as to promote the occurrence of transactions and enhance economic efficiency is particularly critical and important (Tasan et al. 2014). Therefore, how to analyze all kinds of sales influencing factors and effectively use historical sales data to make accurate prediction of future product sales needs to be solved urgently (Aldhouse 2014).

The main contribution of this paper is to analyze the market revenue prediction and error analysis of products based on fuzzy logic and artificial intelligence algorithms. Through the establishment of the neural network model of future product

sales forecast, we can predict the future product sales, can grasp the market direction, and make the enterprise get the maximum profit. This paper is organized as follows: the Bp neural network component optimization algorithm set foundation in Sect. 2. Application of Bp neural network in the prediction of marketing data is presented in Sect. 3. Comparison simulation studies are stated to verify the effectiveness of the design in Sect. 4. Finally, Conclusions are given in Sect. 5.

2 Bp neural network component optimization algorithm set foundation

2.1 Basic theory of BP neural network

Bp network is a kind of feed forward network without feedback. The neurons in the network are arranged hierarchically, and the output of neurons in each layer is transmitted to the next layer. The working process is divided into two parts: the learning period and the working period. The key of the calculation is the error back propagation process in the learning period (Yao 2012).

2.1.1 Design of BP neural network

Figure 1 is the basic structure of the BP neural network. This kind of network relies on the complexity of the system, through adjusting the connection between a large number of internal nodes, so as to achieve the purpose of processing information, and has the ability of self-learning and self-adaptive.

The input layer, the hidden layer and the output layer neuron are numbered with i , j , k respectively.

The specific calculation formula is as follows:

Hidden layer and output layer of each neuron input reference formula 1.

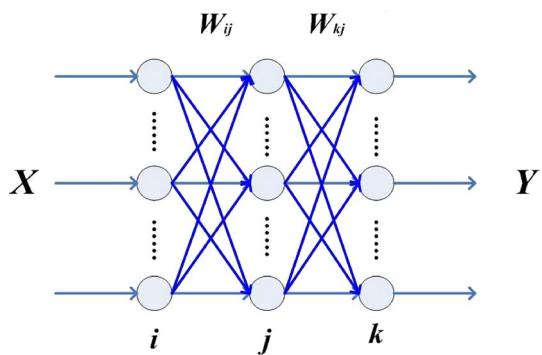


Fig. 1 Basic structure of BP neural network

$$\begin{aligned} net_j &= \sum_i w_{ji} o_i \\ net_k &= \sum_j w_{kj} o_j \end{aligned} \quad (1)$$

The output of each neuron in the hidden layer and the output layer are respectively refer to the formula 2.

$$\begin{aligned} o_j &= g(net_j) \\ o_k &= g(net_k) \end{aligned} \quad (2)$$

The activation function $g(x)$ is a unipolar *Sigmoid* function, with reference to formula 3.

$$g(x) = \frac{1}{1 + e^{-x}} \quad (3)$$

2.1.2 Calculate network error

When the output o_k of the network is not equal to the actual output y_k (expected value), there is an error in training, and the average error of the system is shown in Fig. 4.

$$e = \frac{1}{2} (o_k - y_k)^2 \quad (4)$$

The total error of the network is shown in formula 5.

$$E = \frac{1}{2} \sum_k (o_k - y_k)^2 \quad (5)$$

The formula above is the objective function of the BP neural network. In the learning period, the error back propagation process is to minimize the objective function.

2.1.3 Adjustment of each layer weight

Each layer of the weights of the adjustment is a reverse process, that is, the actual output value of y_k and the actual error signal δ_k compared to the hidden layer and the output layer between the weights of w_{kj} adjustment, as shown in Eq. 6.

$$\begin{aligned} \delta_k &= (y_k - o_k)o_k(1 - o_k) \\ w_{kj}(n) &= w_{kj}(n-1) + \eta\delta_k o_j + \alpha\Delta w_{kj}(n-1) \end{aligned} \quad (6)$$

Then the error signal δ_k is transmitted back to the input layer, and the input layer error signal δ_j is obtained, and the weight adjustment between the input layer and the hidden layer is played as shown in Eq. 7.

$$\begin{aligned} \delta_j &= o_j(1 - o_j) \sum_k \delta_k w_{kj} \\ w_{ji}(n) &= w_{ji}(n-1) + \eta\delta_j x_i + \alpha\Delta w_{ji}(n-1) \end{aligned} \quad (7)$$

η is the learning rate, α is the momentum term, so as to improve the training speed of BP neural network, and can maintain a certain stability.

Through the network training, to meet the requirements, the interconnection weights between the nodes of the network is completely determined, it is said that the entire BP network has a good learning (Tao et al. 2016).

2.2 Model building

2.2.1 Determining the parameters of BP neural network

The common BP neural network has three layers: input layer, hidden layer and output layer. The input layer, the output layer neuron number is determined based on the actual, and the number of neurons in hidden layer can still determine the principle: the cell number of hidden layer is larger than the half of the input and output neurons, and less than the input and output layer neuron number. The learning rate $\eta \in (0, 1)$ and the momentum term affecting the learning efficiency of training $\alpha \in (0, 1)$.

2.2.2 Network training to get the connection weights between each layer

When the parameters of the model are determined, the training samples are trained. When all the training samples are trained, the connection weights between the input layer and the hidden layer, the hidden layer and the output layer are obtained (Hu et al. 2017). The training process is shown in Fig. 2. BP algorithm is one of the most effective learning methods of multilayer neural network. Its main feature is the forward transmission of signal, and the backward transmission of error. By continuously adjusting the weight value of the network, the final output of the network is as close as possible to the expected output, so as to achieve the purpose of training (Petersen et al. 2015).

2.2.3 Calculation weight

The correlation coefficient is shown in formula 8.

$$\begin{aligned} r_{ij} &= \sum_{k=1}^P W_{ki}(1 - e^{-x})/(1 + e^{-x}) \\ x &= w_{jk} \end{aligned} \quad (8)$$

The correlation index is shown in formula 9.

$$\begin{aligned} R_{ij} &= |(1 - e^{-y})/(1 + e^{-y})| \\ y &= r_{jk} \end{aligned} \quad (9)$$

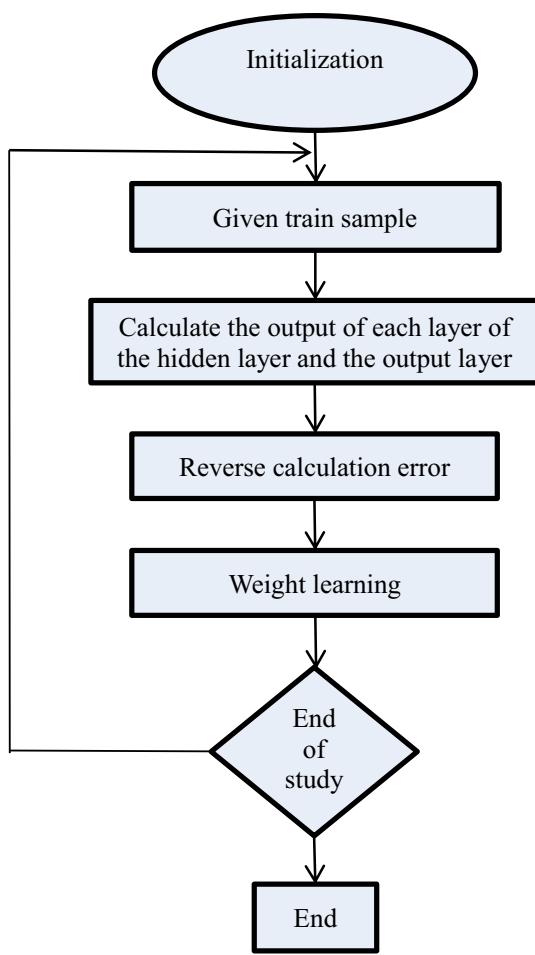


Fig. 2 Flow chart of BP algorithm training

The absolute influence coefficient is shown in formula 10.

$$S_{ij} = R_{ij} / \sum_{i=1}^m R_{ij} \quad (10)$$

The correlation coefficient of each layer is analyzed by using the method of significant correlation coefficient to analyze the influence degree of each index on the global credibility. The normalized relation can be used to obtain the relationship between input and output, that is, the weight vector of the index W . The normalization formula is shown in formula 11.

$$w = \frac{R_{ik}}{\sum R_{ik}} \quad (11)$$

The R_{ik} is the absolute influence coefficient in the significant correlation coefficient method.

3 Application of Bp neural network in the prediction of marketing data

There are many factors affecting the sales of commodities. These factors can be summarized as two main product factors and environmental factors. In terms of price, as the most direct influencing factor for consumers to buy goods, price has the most direct impact on the sales of goods. Usually, commodity prices and sales are inversely proportional, that is, the higher commodity prices, the lower commodity sales; on the contrary, the lower commodity prices, the corresponding increase in commodity sales. In addition, for online sales products, especially fashion goods, due to seasonality, popularity, consumer preferences change, often make the value of goods and marketing prices deviate. At different stages of sales, merchants will adjust prices accordingly, and sales will change accordingly to a certain extent. Therefore, the price positioning and adjustment of commodities will cause fluctuations in sales. In terms of seasonal attributes, most commodity sales will change with the seasons. The seasonal attributes of products have a great impact on the performance of product sales, such as summer T-shirts, winter down jackets and so on (Tanwar and Kumar 2015). With the changing seasonal weather, the sales situation of products will fluctuate greatly, which also makes the actual sales data used to predict and the sales data to be predicted fluctuate greatly. That is to say, there may be great fluctuation and noise in sales data. In terms of promotional activities, most e-commerce platforms will do marketing activities for the whole platform during holidays or shopping festivals created by the platform. For a large platform, promotional activities can even cover the whole e-commerce field, such as "Shuang11" activities of Taobao, Jingdong and Tianmao. This large-scale marketing campaign will have a huge impact on the sales of online goods. In the process of forecasting, this huge fluctuation and deviation of commodity sales will have a great impact on forecasting. In addition, in addition to large-scale platform promotional activities, promotional activities launched by the merchants themselves will also make the sales of goods increase rapidly, which will also have a great impact on the forecast.

In addition to its own factors, commodity sales are also affected by external market environment, such as external economic factors, external industry factors and so on. External economic factors mainly refer to the domestic and foreign economic situation, economic development trend, macro-policy and other economic conditions in the process of product sales. External economic factors may directly or indirectly affect the change of commodity sales. For example, when the overall economic environment

Table 1 Sales volume of ACB

Particular year	Sales volume per month											
	1	2	3	4	5	6	7	8	9	10	11	12
2011	16	17	16	19	18	22	25	23	19	17	18	18
2012	18	21	23	22	28	20	30	44	23	26	20	49
2013	4	7	22	14	42	107	53	58	36	45	30	29
2014	36	21	16	68	51	49	162	43	31	22	18	40
2015	52	34	35	34	53	158	75	53	68	51	121	43
2016	27	74	45	91	208	89	84	103	90	84	52	63

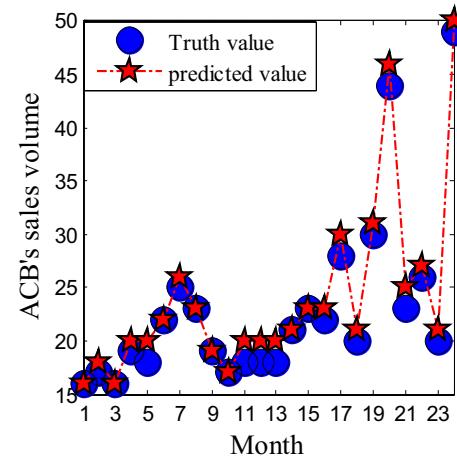
Table 2 Sales volume of MCCB

Particular year	Sales volume per month											
	1	2	3	4	5	6	7	8	9	10	11	12
2011	35	18	186	144	619	503	409	97	124	155	63	126
2012	134	315	325	613	1636	770	773	740	289	338	233	370
2013	232	710	581	595	1314	3407	1777	3776	1036	1339	1114	1383
2014	1029	648	783	1510	3805	1691	1623	1191	1541	3905	1289	1711
2015	642	689	1118	916	1356	1014	1416	1108	1511	966	1170	2893
2016	1394	1244	2474	2748	2300	2066	1989	1832	1659	2034	1850	1748

continues to be depressed, there may be a large number of unsalable commodities, manifested by the continued decline or decline in commodity sales. For example, when the average profit in the industry is low, it means that the market competition is fierce, or the market is saturated, the supply exceeds the demand, and the sales will be reduced.

On the consumer side, the most important core issue of product sales is how to meet and cater to the needs of consumers. For consumers with different characteristics, their corresponding purchasing behavior also has its own unique laws. Taking clothing as an example, consumers' height, weight, age, preference, education level, social status, occupation, lifestyle and so on will have a greater impact on clothing sales, and the impact is complex, and has been in a dynamic process of change. With the change of the mainstream trend and personal factors, the sales volume of commodities will change greatly, and the sales data will fluctuate at the same time. In terms of industry factors, it refers to the industrial categories formed according to the characteristics of enterprises' products and their different roles in the national economy. Industry factors include the number of competitors, competitors' business strategy, market size, market growth rate and so on. Usually these factors will indirectly affect product sales, market share and profitability in the coming period or years.

Source data is Moulded Case Circuit Breaker (MCCB) and Automatic Circuit Breaker (ACB) these two products in a region 2011–2016 sales records. As shown in Tables 1 and 2.

**Fig. 3** 2011–2012 neural network prediction results

As a set of data for every 2 years to train a neural network, MCCB and ACB can train a total of 6 network structure.

The neural network is used as the input of the neural network, and the real value of the corresponding month is regarded as the output of the neural network. Here is a comparison of the predicted and true values (Figs. 3, 4, 5, 6, 7, 8):

By the above prediction results can be seen, the prediction results of neural network are in good agreement with the true value can be calculated, the error control in less

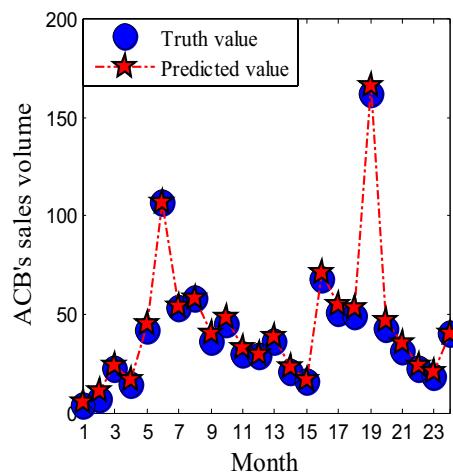


Fig. 4 2013–2014 neural network prediction results

than 4%, so using neural network algorithm to predict the MCCB and ACB is very suitable.

4 Sales model and management optimization of commercial enterprises

In China, the level of information development of sales management in commercial enterprises is still relatively low. With the comprehensive development of informationization, large domestic commercial enterprises have also made preliminary achievements in sales management informationization, which has also led some small and medium-sized commercial enterprises to improve the level of sales management informationization. At present, some small and medium-sized commercial enterprises are actively building sales information platform. With the rapid development of economy, commercial enterprises gradually realize the importance of information for enterprises, especially information with high accuracy and authority, which can provide strong support for business decision-making.

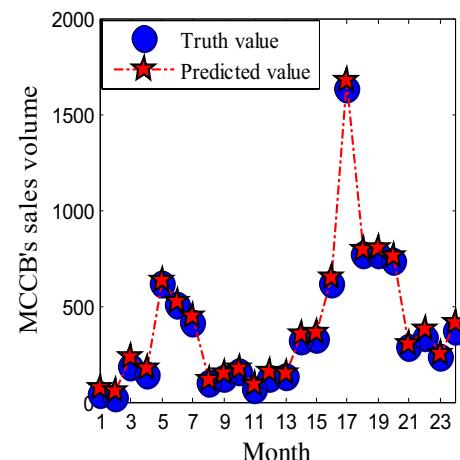


Fig. 6 2011–2012 neural network prediction results

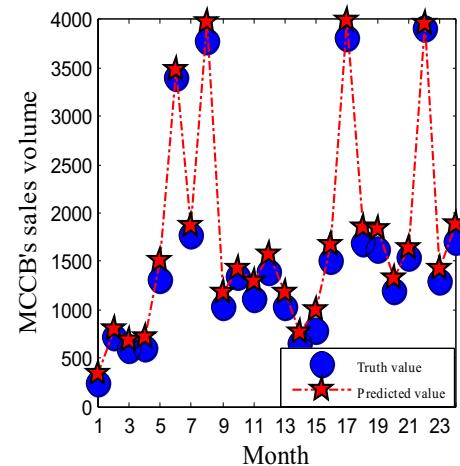


Fig. 7 2013–2014 neural network prediction results

In recent years, according to the sales management mode of international commercial enterprises and combined with the actual sales situation of our country, large commercial enterprises in our country have established their own product sales business system successively, and

Fig. 5 2015–2016 neural network prediction results

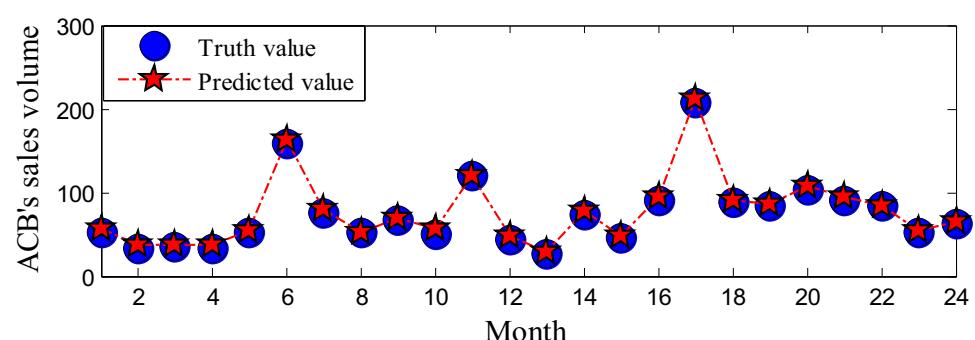
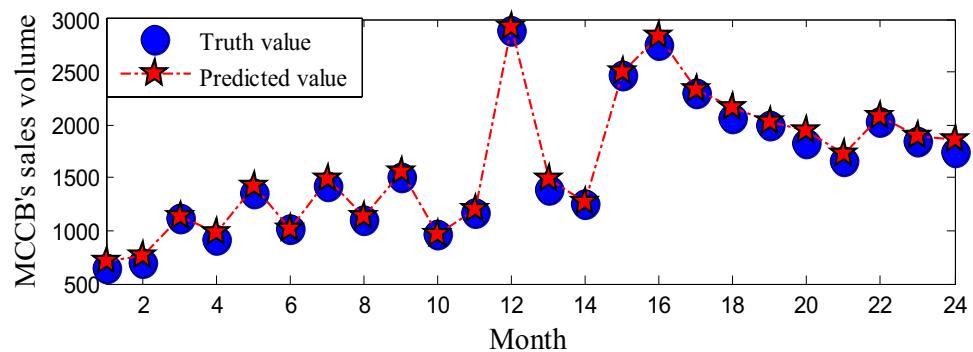


Fig. 8 2015–2016 neural network prediction results



have taken the road of “combining unified marketing with specialization” sales system. Throughout the current state of commercial enterprises in China, some commercial enterprises have developed and put into use sales management information system, while some enterprises have just planned and started late. Different enterprises apply different sales management systems, with different levels and different levels. Most of the systems are developed by enterprises alone. China’s commercial enterprises are still in the primary stage on the road of sales management informationization, all aspects are immature, and there is still a considerable gap with the true meaning of sales management informationization. It is not difficult to imagine that the market tracking ability of commercial enterprises at this level is certainly not strong. In the current competitive market, if the market can not be accurately judged, sales will inevitably be greatly discounted, affecting the growth of sales. Therefore, China’s commercial enterprises should make full use of advanced technology, establish market information prediction system, and provide accurate decision-making information for the long-term development of commercial enterprises.

Compared with the relatively mature sales management situation of foreign commercial enterprises, there are many unreasonable aspects in the formulation of sales strategies of Chinese commercial enterprises. Since the reform and opening up, Chinese commercial enterprises have never solved a major problem in sales management, that is, the deviation between strategic decision-making of enterprise development and short-term behavior of enterprise managers. Most commercial enterprises fail to put the overall situation of market competition together with the long-term trend of change in business decision-making. Consider. Commercial enterprises have not established a comprehensive and long-term sales strategy system.

Based on the above analysis of sales model and management status quo, commercial enterprises must adopt sales forecast to improve their own enterprise development. Specifically, the necessity for commercial enterprises to adopt sales forecasting is as follows:

- (1) Develop an efficient marketing plan: The marketing plan specifically involves many problems, such as the change of anticipated commodities, the means of promotion of products and the pricing of products. The focus of marketing is whether the products and their series launched by enterprises are welcomed by consumers. Marketing plan can be adjusted by sales forecast. Enterprises should consider many problems when making plans. By adjusting the sales forecast, enterprises should consider many problems of the battalion when making plans. By adjusting the sales forecast, enterprises should consider many problems of the battalion when making plans. Therefore, it can be said that sales forecasting and business planning are mutually complementary.
- (2) Reduce the phenomenon of loss of sale: In the process of business operation, enterprises should not ignore the cost of product loss. The loss-of-sale cost of products is reflected in the loss of customers and the reduction of customer service quality, which can not be accurately calculated by enterprises. When making sales forecast, enterprises will analyze and compare the previous sales data of enterprises. At the same time, enterprises will also pay attention to the number of customers and the level of service. In this way, to some extent, it can prevent enterprises from losing their products and indirectly recover their losses.
- (3) Reasonable arrangements for production and procurement: Enterprise production must pay attention to long-term forecast and short-term forecast. Long-term forecasts help companies build new factories or buy new equipment. At the same time, the production plan of an enterprise is determined by the short-term forecast made
- (4) Reducing Inventory Costs: In order to maintain the normal operation of enterprises, each commercial enterprise has its own warehouse, which stores all kinds of commodities for sale. However, the amount of inventory is very difficult to grasp, if the inventory is too small,

it will cause the loss of the enterprise because of the outage; and if the inventory is too large, it may cause a huge backlog of goods, making the enterprise invest very high inventory costs. At this time, sales forecasting is particularly important. If the forecasting is accurate, it can keep the enterprise's inventory in a reasonable range and make the maximum use of the enterprise's funds.

5 Conclusion

The enterprise product sales forecast for the future, the qualitative forecast theory, excessive human intervention, can not reflect the actual situation of all kinds of unexpected objective, so the error is large, there are some wrong information included, so we can use mathematical statistics, the mature prediction method in artificial intelligence, or the neural network method to forecast, this kind of algorithm has theoretical support to mature, reliable predictions of the information. Neural networks can approximate the neuron information of all quantitative or qualitative nonlinear relationship, any complex are stored in the potential distribution in the network, it has strong robustness and fault tolerance, using the parallel distribution processing method, making quick lots of computing is possible, but do not know or learning and adaptive system not sure, can handle both quantitative and qualitative knowledge of the five major advantages. The results of this paper can be concluded that the neural network algorithm has a high accuracy in predicting the future sales of the product, and the prediction error can be controlled within 4%. Through the establishment of the neural network model of future product sales forecast, we can predict the future product sales, can grasp the market direction, and make the enterprise get the maximum profit.

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