

Analysis and Research on Internal Factors of Stock Price Fluctuation of Chinese Listed Companies Based on ANN-RBF Model

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Abstract. Affected by the new corona epidemic, China ' s stock market fluctuates frequently, and stock price fluctuations lead to obstacles to corporate financing, which is not conducive to establishing a good corporate image. In order to provide ideas for enterprises to stabilize the stock price, this paper establishes the influence of internal financial factors on the stock price fluctuation of listed companies based on the artificial neural network-radial basis function (ANN-RBF) model. Based on grounded theory, this paper constructs an index system of stock price fluctuation factors, including 14 indicators from four aspects from the perspective of internal enterprises. Based on the financial data of the Lingnan Pharmaceutical Industry from 2008 to the third quarter of 2021, this paper integrates the financial index system into ANN to explore the impact of corporate financial indicators on stock prices. The results show that net asset growth rate (0.87), retained earnings (0.68) and speed ratio (0.929) are the leading financial indicators affecting stock prices. In addition, this paper helps to study the accuracy of RBF neural network in predicting stock prices of listed companies.

Keywords: RBF neural network; Financial indicators; Stock price fluctuation.

1. Introduction

In China's financial market development, more and more investors enter the stock market, injecting new vitality into financial development. Since the outbreak of the new corona epidemic, China's stock market has repeatedly experienced major turmoil, which will inevitably impact China's immature financial markets and even further affect long-term economic development. For enterprises, stock price turbulence is not conducive to their production and operation, financing. While monetary policy stabilizes the economy macroscopically, enterprises need to stabilize stock prices by regulating internal factors.

At present, there are few studies on the influencing factors of stock price. Han et al. ^[1] obtained that the number of information negatively correlates with stock price volatility through descriptive statistics and regression analysis, and the moderating effect of institutional investors. Wang et al. ^[2] conducted regression after differential adjustment of macroeconomic indicators, and found that improving accounting comparability can inhibit stock price volatility and explain the signal effect of monetary policy. Starting from the margin financing and securities lending business of their own company, they set up a regression model, thinking that good news will increase the volatility of stock price. Conversely, it will inhibit the volatility of the stock price. Zhang et al. ^[3] established a regression model from the company's margin trading business, thinking that positive news will increase stock price volatility. Conversely, it will inhibit the volatility of the stock price. Most scholars use descriptive statistics, multiple regression analysis, autoregressive analysis and other research methods. Chai et al. ^[4] used the weekly data from July 01, 2011, to July 09, 2021, to construct a time-varying parameter vector autoregressive model (TVP-VAR) to examine the dynamic nonlinear

relationship between green bonds, clean energy, and stock prices before and after the outbreak of COVID-19 in the global market. Wan et al.^[5] established the ARIMA model and ARCH model by using the autocorrelation of the Hong Kong stock index and its mean equation disturbance term to predict the Hong Kong stock index. Taking 70 stocks in the Shenzhen A-share market from 2014 to 2018 as the research object, Gao et al.^[6] further portrayed the combination group image to establish an ARMA model to predict the fluctuation trend of stock price. Some scholars combined the computer field method to study the influencing factors of stock price volatility. Xu and other scholars^[7] studied the law of stock price movement through self-regulation of the generative adversarial network, effectively reducing the randomness and overfitting of stock price and financial text information. Sun et al.^[8] established SV-VOL model for the trading volume of stock market and exchange market through SMC algorithm, which provided a new idea for predicting stock price. Xie et al.^[9] took the Shanghai index, Shenzhen index and other six main indexes as the research object, and by establishing an integrated learning model of long-short memory neural network, they realized the prediction of stock price fluctuation with computer algorithm.

Most of the existing studies have established a linear regression relationship for the influencing factors as the research model. The traditional time-series research is a comprehensive analysis of the general information, which can only study the local relationship, ignoring the nonlinear impact of variables on stock price changes on the whole. In addition, investors are more concerned about the autocorrelation of stock price volatility and the accuracy of stock price prediction, while listed companies are more concerned about how to stabilize and improve stock prices. Therefore, it is necessary to study how enterprises improve their stock prices by enhancing their own financial indicators. In order to explore the influence degree and influence path of enterprise financial indicators on stock price, this paper proposes to establish the influence of internal financial factors on the stock price fluctuation of listed companies based on the ANN-RBF model, and integrate financial indicators into an artificial neural network to further clarify the black box of influence path. The marginal contribution of this paper is to break through the locality and theory of multiple linear regression, as well as the endogenous explanatory variables of the traditional ARIMA model and GARCH mode. The ANN-RBF model is established to describe the impact of internal financial indicators on stock price volatility, and the impact path is dynamic and nonlinear. This study is conducive to the impact of internal financial indicators on stock price fluctuations, and provides a theoretical basis for enterprises to stabilize and improve stock prices by adjusting financial indicators. At the same time, it verifies the applicability of artificial neural networks in studying stock price changes.

2. Construction of Stock Price Influencing Factors System

2.1 Corporation growth capability

Growth ability refers to enterprises' development prospect and speed, including the continued growth of enterprise-scale and the continuous increase of profit. Enterprises that want to speed up the development speed to improve the industry's competitiveness must have good growth ability. Higher growth ability is the symbol of an enterprise's comprehensive strength and can attract investors to stabilize and further improve the stock price.^[10]

This paper selects net profit growth rate (X11), total asset growth rate (X12) and retention rate of return (X13) to reflect the growth ability of enterprises. The growth of net profit reflects the ability of enterprises to create profits and expand the business scale. Total assets reflect the business scale of enterprises. The retained earnings reflect the accumulation level, accumulation ability, and ability to cope with catastrophe risks.

2.2 Enterprise profitability

Profitability refers to the ability of enterprises to obtain profits. Profit embodies the manager's operating results, the basis of investors' income, and the guarantee of creditors' interest. The

profitability of an enterprise is closely related to its owner's return on investment, so the stock price will also be affected by it.

This paper selects return on net assets (X21), return on assets (X22), operating net profit rate (X23), and earnings ratio (X24) as the embodiment of corporate profitability. The growth rate of net profit is the growth rate of net profit in the current period compared with that in the previous period. Return on assets reflects the effect of assets used to create profits. The operating net profit rate can reflect the efficiency of enterprise operation. The P/E ratio is usually used to measure the quality of stocks.

2.3 Corporate solvency

Corporate solvency means the ability of a company to repay its current and non-current liabilities by expected liquidation of assets before the maturity of the debt.^[11] Good solvency means that enterprises can quickly obtain cash flow at reasonable costs, an important guarantee for enterprises to repay maturing debt. Debt solvency affects stock prices by influencing investor expectations through signal effects.

This paper selects the current ratio (X31), speed ratio (X32), asset-liability ratio (X33), and equity multiplier (X34) as indicators to describe the solvency of enterprises. Flow ratio is the concrete embodiment of enterprise liquidity. Speed ratio removes inventory on the basis of the current ratio, and more accurately depicts the ability of enterprises to repay short-term debt. Asset-liability ratio measures the ability of enterprises to use creditors to provide funds for business activities. Equity multiplier is an important indicator of financial leverage.

2.4 Enterprise operational capability

Operational capability reflects the ability of an enterprise to operate its assets. It is a direct reflection of the ability of an enterprise to create cash flow, and is also an important basis for stimulating its business vitality and improving its value creation.^[12] Good operational capability means that enterprises can allocate assets rationally for production and operation, and stabilize stock prices by enhancing investor confidence.

Table 1. System of stock price influencing factors

First index	Second index	Computing formula	Unit
Corporation growth capability X1	Net profit growth rate X11	$(\text{Current net profit} - \text{prior period net profit}) / \text{prior period net profit} * 100 \%$	%
	Growth rate of total assets X12	$(\text{End-to-initial total assets}) / \text{initial net assets} * 100\%$	%
	Rate of return on retention X13	$(\text{Net profit} - \text{profit allocated to shareholders}) / \text{net profit} * 100 \%$	%
Profitability indicator X2	ROE X21	$\text{Net profit} / \text{average net assets} * 100\%$	%
	Return on assets X22	$(\text{Total profit} + \text{interest expenditure}) / \text{average total assets} * 100 \%$	%
	Operating net profit rate X23	$\text{Operating profit} / \text{total business income} * 100 \%$	%
	P/E X24	$\text{Per share price} / \text{earnings per share}$	Times
Corporate solvency X3	Current ratio X31	$\text{Current assets} / \text{current liabilities} * 100 \%$	%
	Speed ratio X32	$(\text{Current assets} - \text{inventory}) / \text{current liabilities} * 100\%$	%
	Asset-liability ratio X33	$\text{Liabilities} / \text{assets} * 100 \%$	%
	Equity multiplier X34	$\text{Asset} / \text{equity} * 100 \%$	%
Enterprise operational capability X4	Total assets turnover rate X41	$\text{Net operating income} / \text{average total assets} * 100 \%$	%
	Inventory turnover rate X42	$\text{Operating income} / \text{average inventory turnover} * 100 \%$	%
	Accounts receivable turnover rate X43	$\text{Net credit income} / \text{average accounts receivable turnover} * 100 \%$	%

This paper selects the turnover rate of total assets (X41), inventory turnover rate (X42), and accounts receivable turnover rate (X43) as indicators to measure the operational capacity of enterprises. The total asset turnover rate measures the relationship between investment scale and sales revenue, reflecting the transfer speed of assets from input to output during enterprise operation.

Inventory turnover rate reflects the efficiency of inventory operation in production. The turnover rate of accounts receivable reflects the efficiency of enterprises in recovering funds and turning them into cash. In summary, the stock price influencing factors system constructed in this paper is shown in table 1.

3. Model

3.1 Introduction of artificial neural network

The concept of artificial neural network (ANN) originated in 1943. Based on mathematics and threshold logic algorithm, psychologist Warren McCulloch and logician Walter Pitts created a neural network calculation model, called the M-P model. This model describes the mathematical theory and network structure of artificial neurons by simulating the principle and process of neural cells in biology, and proves that a single neuron can achieve logical function, thus initiating the theoretical research of ANN model.^[13] ANN has the advantages of good robustness, strong self-adaptability, strong self-organizing and self-learning ability, strong generalization ability and association ability, strong parallel collaborative processing ability and fault tolerance ability, which makes the nonlinear fitting ability of the network stronger. It can accurately process and analyze the nonlinear system through continuous training and learning, and has high prediction accuracy.^[14]

3.2 Artificial neural network architecture

The typical artificial neural network model (ANN) is shown in Fig. 1. The model is divided into three layers in structure: input layer, hidden layer and output layer. The input layer is responsible for receiving external information and data; The hidden layer is responsible for processing information and constantly adjusting the connection properties between neurons, such as weight, feedback, and so on. The output layer is responsible for outputting the calculated results. Where, the weight reflects the connection strength between units; feedback reflects the positive and negative correlation between units. In the connection relationship between units, information processing is reflected through this information. Due to the unknown of the overall results, it is necessary to constantly adjust the weights and feedback in the hidden layer to achieve the best fitting results.^[15]

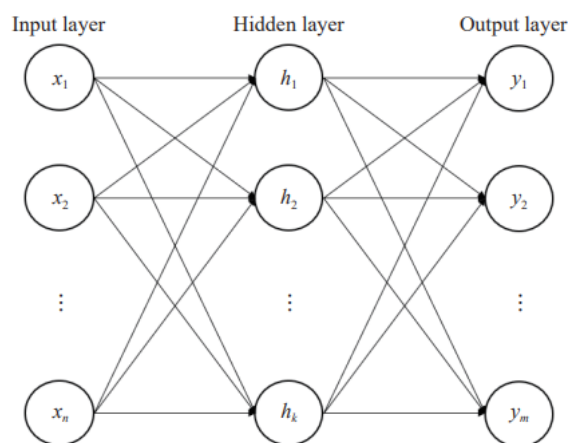


Figure 1. Schematic diagram of neural network model

3.3 Radial basis function neural network model

Radial basis function (RBF) neural network model is a feedforward neural network using the radial basis function as an activation function. Compared with MLP neural network, this model has the advantages of simple structure, simple training, optimal approximation, global optimization, strong generalization ability, faster learning convergence rate, and easy adjustment of network structure. It has higher processing efficiency and accuracy for data, and can better excavate and reveal the actual

structure of complex nonlinear systems. [16] Therefore, in this paper, RBF is used to fit the nonlinear mapping relationship between the sample structure parameters and the measurement accuracy index. The approximate steps of RBF are as follows:

Set the input sample data as X' ; $R_i(X')$ is RBF function. RBF neural network output is as follows:

$$f(X') = \sum_{i=1}^l W_{is} R_i(X') \quad (1)$$

Where, i represents the i th neuron node; l represents the number of neuron nodes; W_{is} represents the connection weights of the hidden layer.

The specific definition of RBF function is as follows:

$$R_i(X') = \exp\left(-\frac{1}{2}\left(\frac{\|X' - c_i\|^2}{\sigma_i}\right)\right) \quad (2)$$

In the formula, c_i represents the center of RBF; σ_i represents the center point width; $\|X' - c_i\|$ is the distance between the sample and the center.

In the learning process of RBF neural network, the specific basis between different samples and centers is as follows:

$$\sigma_i(j) = \|X'(j) - c_i(j-1)\| \quad \sigma_{\min}(j) = \|X'(j) - c_{\min}(j-1)\| \quad (3)$$

The sample is continuously adjusted to the c_{\min} center of the minimum distance as follows:

$$c_{\min}(j) = c_{\min}(j-1) + \alpha(X'(j) - c_{\min}(j-1)) \quad (4)$$

In the formula, α is the learning rate.

And adjust the distance paradigm accordingly, as follows:

$$\sigma_{\min}(j) = \|X'(j) - c_{\min}(j-1)\| \quad (5)$$

Repeat the above process to determine the optimal $c_i(j)$. [17]

4. Algorithm Model Evaluation Construction

Through the evaluation index, this paper selects the analysis results, selects the suitable method, helps to check the problems existing in each link of the analysis process, and corrects them in time, accurately evaluates the prediction accuracy and model performance of the established RBF neural network, improves the confidence of the model, and provides reliable reference indexes for optimizing the model and analysis results.

This paper selects two evaluation indexes of prediction effect, sum of squares of error (SSE) and relative error (Er), for evaluation. The basic calculation formulas are as follows:

$$SSE = \sum_{i=1}^n (Y_i - \hat{Y}_i)^2 \quad (6)$$

$$E_r = \frac{\hat{Y}_i - Y_i}{Y_i} \quad (7)$$

Where, n is the number of samples, Y_i is the measured value, and \hat{Y}_i is the predicted value.

SSE and E_r are used to measure the deviation between the predicted value and the real value of the model. The closer the value is to 0, the better the model selection and fitting are, and the more successful the data prediction is.

5. Empirical Analysis

5.1 Object selection and data acquisition

Since the outbreak of COVID-19, the stock price of pharmaceutical shares has fluctuated with the epidemic situation, and has formed several rounds of cyclical fluctuations. Given that the global epidemic is still and will remain high for a long time, and the pharmaceutical industry is very sensitive, it is of practical significance to analyze the price of pharmaceutical stock. YILING PHARMACEUTICAL is the leading enterprise in the pharmaceutical industry and the focus of investors under the current epidemic situation. The company has always adhered to the development strategy of market leader and technology-driven innovation, promoted the industrialization of traditional Chinese medicine through academic innovation of traditional Chinese medicine, and used modern high-tech to develop traditional Chinese medicine, western medicine and biological medicine, forming three major business sectors of technological traditional Chinese medicine, chemical and biological medicine and health industry. As China's top 10 Chinese medicine enterprises, China's top 20 listed pharmaceutical companies, and China's top 500 listed companies, its influence in the pharmaceutical industry continues to grow, so this study selects its stock price data as the research object.

This paper uses the stock price data and various capacity indicators of YILING PHARMACEUTICAL in the past 13 years, from 2008 to the third quarter of 2021. The characteristics included net asset profit growth rate, total asset growth rate, retention rate of return, net asset yield, asset return, operating net profit margin, price-earnings ratio, current ratio, quick ratio, asset-liability ratio and equity multiplier. This paper collected a total of 44 groups of data as samples, 70 % of the data as training sample data, and 30 % as validation sample data.

The stock price of listed companies are affected by many factors, which usually have different ranges, so it is difficult to compare them directly. Therefore, these data should be standardized in advance. This experiment uses the Min-Max method to normalize the data, and the calculation method is as follows.

$$x_i = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \quad (8)$$

Where x_i is the input or output data, x_{\min} is the minimum value of a set of data, and is the maximum value. After standardization, the input and output data are mapped to the interval [0,1]. Standardization is linear, which ensures that the data is not distorted. Thirty-five groups of training samples were input into RBF neural network, and then the network began to learn and store the data.

5.2 Construction of Artificial Neural Network

SPSS (Statistical Product and Service Solution) is one of the most widely used measurement software. In this paper, the SPSS platform is used for calculation. With the above characteristic parameters as variables, the number of neurons in the hidden layer is continuously adjusted to obtain the relative error and the sum of squares of each model, as shown in Table 2.

Table 2. Output of Error Results Based on Different Numbers of Neurons

Number of hidden layer units	Sum of error square	Relative error	Number of hidden layer units	Sum of error square	Relative error
5	8.037	1.284	14	0.273	0.385
6	0.273	0.412	15	14.283	0.962
7	6.571	0.789	16	6.187	1.185
8	13.065	2.607	17	3.588	0.707
9	6.358	0.964	18	3.392	0.606
10	1.597	0.483	19	5.359	0.495
11	11.446	2.624	20	3.190	1.053
12	11.407	1.104	50	18.044	3.515
13	0.452	0.154			

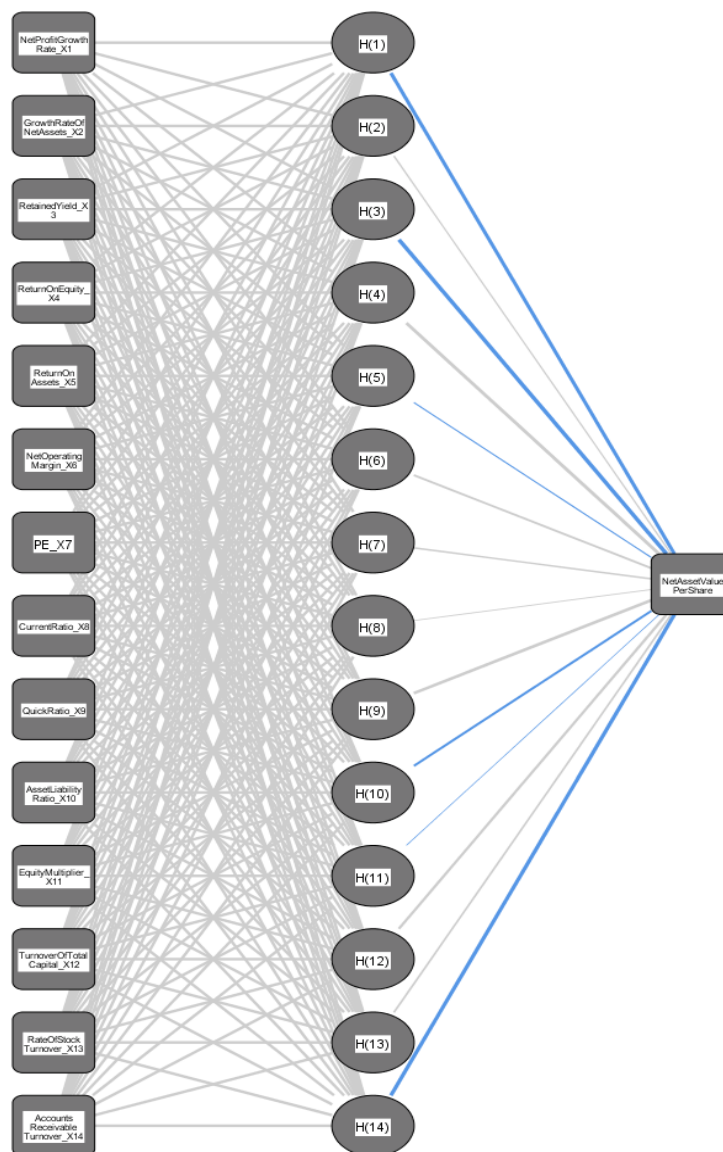


Figure 2. Neural network model

It can be seen from Table.2. that the error relative error is small when the number of hidden layer units is 14, and the performance of the neural network is the best. The results of the neural network model are shown in Figure.2.

5.3 Contribution analysis

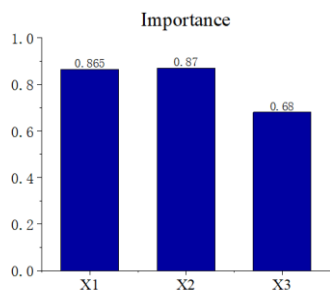


Figure 3. Contribution of growth capacity index

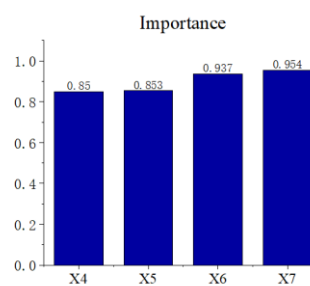


Figure 4. Contribution of profitability index

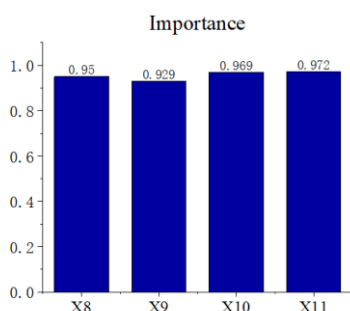


Figure 5. Contribution of solvency index

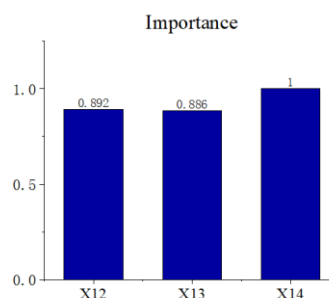


Figure 6. Contribution of operational capability index

From the test results of the neural network model, the model test data are good, so the model enjoys a good prediction effect. The contribution of each variable is normally standardized. The histograms are drawn according to growth capacity index, profitability index, solvency index and operational capacity index, respectively. The results are shown in Figure 3 to 6. The following is a specific analysis of the contribution of each indicator.

Among the growth capacity indexes, the growth rate of net asset (87.0%) has the greatest impact on stock prices. This indicator reflects the expansion speed of enterprise capital scale and the value of enterprise assets. Higher return on net assets represents a strong vitality of business. If the return on net assets and the growth rate of net assets is high, it means that the future development of enterprises is stronger, so this indicator has a great impact on stock prices. The second is the net profit growth rate x_1 (86.5%), which is the final result of enterprise management. If the net profit is high, the operating benefits of enterprises are good; The other is poor. x_1 is also an important indicator of investors' attention, so it has a high contribution to the stock price.

The P/E ratio (95.4%) contributes the most among the profitability index. The cash flow obtained by shareholders mainly comes from dividends, and dividends are further derived from profits. Therefore, the two most important financial data for stocks are dividends and profits. The price-earnings ratio is the ratio of the stock price to the dividend per share, indicating that the price of stocks purchased by the market is how many times the current earnings. In other words, how many years of corporate earnings are reflected in the stock price, so the price-earnings ratio has become an important indicator affecting the stock price. In addition, the operating net profit rate x_6 also has an important impact on stock prices (93.7%), which can comprehensively reflect the operational efficiency of an enterprise or an industry.

Among the solvency index, the three indicators contribute almost equally to stock prices, with a current ratio of 95.0 percent, a speed ratio of 92.9 percent, an asset-liability ratio of 96.9 percent, and an equity multiplier of 97.2 percent. The solvency index reflects the ability of an enterprise to quickly cash its assets into current liabilities, namely, the liquidity of the enterprise. There are risks in the operation of enterprises, and liquidity is the embodiment of the ability of enterprises to resist risks.

Therefore, the contribution of solvency indicators to stock prices is higher than other indicators on average.

The contribution of normal standardization of accounts receivable turnover rate in operational capacity indicators reached 100 %. The accounts receivable of a company play a decisive role in current assets. If the company's accounts receivable can be recovered in time, the company's capital utilization efficiency can be greatly improved. Suppose the number of days the company actually recovers the account exceeds the stipulated. In that case, it indicates that the debtor has long arrears and low creditworthiness, which increases the risk of bad debt losses. If the assets form bad debts, resulting in current assets not flowing, it is very unfavorable for the company's normal production and operation. Mobility of capital is the lifeline of a company, so this indicator contributes most to stock prices.

Securities can be defined as a legal right certificate that accepts the expected future return under the declared conditions. The value of stocks mainly comes from the company's future earnings. Stock is valuable because it has potential cash flow, that is, the stockholder expects from the ownership of the company to obtain dividends and shareholders' equity appreciation (capital gains and losses), which in essence is the future cash flow. It can be seen that the stock income is affected by the company's incentive policy and the company's profitability. The above indicators analyze the impact of their variables on stock prices from different dimensions.

6. Conclusion

This paper establishes an RBF-based neural network model to predict the stock price parameters of listed companies. The calculation results based on this model are consistent with the actual stock price, proving the effectiveness and rationality of this model. The specific experimental conclusions are as follows.

(1) RBF neural network is a one than the BP neural network in terms of approximation ability, classification ability and learning speed, so it is significantly superior to use RBF neural network to predict the stock price of listed companies.

(2) The stock value is uncertain, and it is a random variable of specific state dependence. All the estimations of stock are actually based on certain information.

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