Correlation Analysis of Financial Indicators and Stock Price Fluctuation via BP Neural Network

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Abstract. This paper uses BP neural network model as an analysis tool, the annual financial reporting indicators of listed companies and the following year in April Correlation analysis of stock price fluctuations. From the 20 possible correlation indicators, 13 highly relevant financial indicators are selected. Through these 13 indicators, the stock price fluctuations in April of the following year are explained and analyzed, and the company’s operators are proposed to share interests, business operations, Suggestions for solvency and other aspects.

Introduction
The reasons for stock price fluctuations have always been a hot issue for people to study. China’s stock market started later than foreigner’s, but in the past decade or so, with the deepening of research, the results of analysis and research about China’s market situation have emerged. Many scholars have used different ways to explain the changes for stock price \[1-4\]. From the initial linear analysis to the later nonlinear analysis, people gradually find that nonlinear analysis can better explain and predict the stock price and stock price fluctuations. BP neural network is used to analyze the stock price. As a listed company, the root cause of stock prices changes is its business performance \[5-8\]. This paper takes the Shanghai stock market as a sample and considers the situation of stock volatility in recent years.

Financial Indicator System
(1) Earnings per share
Earnings per share (EPS), reflects the ratio of corporate after-tax profits to total corporate equity. The share of profit or loss that each common share is entitled to during a certain period of time. It lists in the financial report the important indicators used to reflect the profitability of the target company's shareholders, which can provide important reference for investors and policy makers. People often use it to measure the business opportunities of the target company, the future competitiveness and many other possibilities.

\[
Earnings \ per \ share = \frac{Current \ net \ profit \ attributable \ to \ ordinary \ shareholders}{Weighted \ average \ number \ of \ ordinary \ shares \ outstanding} \tag{1}
\]

(2) Undistributed profit per share
Undistributed profit per share is the balance of the net profit of the enterprise in the course of operation, after being distributed by the shareholders' meeting, leaving a balance for future use. Many investors pays special attention to this indicator, because the more undistributed profits per share, the more likely the company will pay dividends in the future, and the dividends will be sent. In addition, it can be said that the company has strong profitability and is in a state of steady development.
Accumulated undistributed profit in the year
Undistributed profit per share = \frac{\text{Weighted average number of ordinary shares outstanding} \text{ net profit realized in the current year}}{\text{Weighted average number of ordinary shares outstanding} \text{ profit distributed in the current year} - \text{Weighted average number of ordinary shares outstanding} \text{ profit distributed in the current year}}. \tag{2}

(3) Surplus reserve per share
The surplus reserve per share means the reserve fund drawn by the target company in a certain ratio in the current profit during the production and operation. Its role is to make up for possible losses in future years or to use it by the board of directors. According to China's current "Enterprise Law", enterprises can draw statutory surplus reserve according to 10%. When they reach 50% of registered capital, they can make their own decisions. The discretionary surplus reserve is decided by the board of directors of each enterprise. The use of surplus reserves must be in accordance with the articles of association. The earnings per share is based on the surplus reserve. Considering the total number of shares of the company, the ratio is obtained.

\begin{align*}
\text{Earnings per share} &= \frac{\text{Current surplus reserve} + \text{initial surplus reserve} - \text{surplus reserve used}}{\text{Weighted average number of ordinary shares outstanding} \text{ profit distributed in the current period}} \tag{3}
\end{align*}

(4) Return on equity
Return on equity (ROE) is also known as the return on equity. It refers to the current net profit and current shareholders’ equity. It uses the indicator parameters of the company's post-tax net profit and net assets ratio, reflecting the level of shareholders' income and return on investment. This indicator is positively related to the level of income of the company.

\begin{align*}
\text{Roe} &= \frac{\text{Current net profit realized by the enterprise}}{(\text{net assets at the beginning of the year} + \text{net assets at the end of the year}) / 2} \tag{4}
\end{align*}

(5) Management's annual compensation
The indicator shall be the total annual salary of the listed company's management disclosed in accordance with the disclosure requirements of the listed company's statements.

(6) The proportion of masters
The proportion of masters refers to the proportion of incumbents who have obtained master's degrees in the enterprise. It reflects the academic structure of the enterprise and can indirectly reflect the importance attached to a professional knowledge of a company and the professionalism of its personnel.

\begin{align*}
The \text{ proportion of masters} &= \frac{\text{The number of masters in the company’s incumbents}}{\text{Number of employees in the company}} \tag{5}
\end{align*}

(7) Operating net profit margin
The operating net profit margin refers to the ratio of the net profit and operating income of the target company after the income tax deduction. This indicator can effectively reflect the profitability of the company. The larger the indicator, the greater the profitability of the company.

\begin{align*}
\text{Operating net profit margin} &= \frac{\text{Current net profit of the enterprise}}{\text{Total operating income during the corresponding period}} \tag{6}
\end{align*}

(8) Management expense rate
The management expense ratio refers to the proportion of the management expenses generated by the enterprise within the current period of the enterprise to the current operating income of the enterprise. The level of familiarity with this indicator is negatively correlated with the profitability of the firm. The annual change in the indicator reflects the contribution of the company to internal management.
**Management expense rate** = \( \frac{\text{Management expenses of current enterprises}}{\text{Total operating income during the corresponding period}} \)  

(7)

(9) Financial expense ratio
The financial expense ratio refers to the interest expenses incurred by the enterprise for the borrowing of interest-bearing capital for the normal production and operation of the enterprise, including the exchange difference, the financial institution's handling fee, etc., which accounted for the proportion of operating income in the current period. It is negatively related to corporate profitability, and reflects the impact of different structures of corporate financing on profitability in the financial statements.

**Financial expense ratio** = \( \frac{\text{Financial expenses of the current period}}{\text{Total operating income during the corresponding period}} \)  

(8)

(10) Net operating rate of operating activities
The net income generated by operating activities is the profit of a company through daily production and operation activities. Comparing this with the total amount of income can convey the ability and stability of the target company to profit, that is, the quality of the income. The larger the index number, the more profitability of the target company comes from the daily production and operation process of the enterprise, which is high and sustainable. The current profit can better reflect the efforts made by the enterprise for the market and can be used for Evaluate the performance of managers.

**Net operating rate of operating activities** = \( \frac{\text{Net income from current operating activities}}{\text{Total current income}} \)  

(9)

(11) Accounts receivable turnover rate
The account receivable turnover rate is a key indicator to measure the business capability of the enterprise. The numerical value of the indicator can effectively reflect the company's ability to control the flow of funds, and to some extent reflects the position of the target company in the market environment. The faster the turnover rate of a company's accounts receivable, indicating that the company is in a dominant position in the market. The use of this indicator can convey to investors the size of the company's economic capabilities, which is an extremely important indicator.

**Accounts receivable turnover rate** = \( \frac{\text{Current sales net income}}{(\text{accounts receivable in the beginning and at last})/2} \)  

(10)

(12) The current ratio
The current ratio is the ratio of current assets to current liabilities. As the main indicator to measure the ability of enterprises to repay their debts, they have been concerned by the people reading the report. In general, the higher the ratio, the stronger the liquidity of the company and the higher the wind resistance. However, this indicator is not as high as possible. As the indicator increases, the risk of inventory impairment of the enterprise and the cost of idle funds will increase, which is unfavorable for the good operation of the enterprise. Most companies control this indicator at around.

**Current ratio** = \( \frac{\text{Total corporate liquid assets}}{\text{Total corporate current liabilities}} \)  

(11)

(13) Cash flow interest coverage multiple
The cash flow interest coverage ratio is an important indicator used to measure the risk of corporate debt repayment. It is more worthy of attention than the interest coverage ratio, they use cash flow companies can use cash rather than other cash alternatives, not its scale factor of liquidity risk by the loss.
\[ \text{Cash flow interest cover age multiple} = \frac{\text{Operating net cash flow}}{\text{Interest expense}} \] (12)

**BP Neural Network**

The BP (Back Propagation) neural network was proposed by a group of scientists led by Rinehart and McClelland in 1986. It is a multi-layer feedforward network trained by error inverse propagation algorithm and is one of the most widely used neural network models. The BP neural network model can self-train a large number of training sets, and fit a mapping relationship by two-way propagation between input values and output values. Because of unsupervised self-learning, large amount of data parallelism, large structural flexibility, nonlinearity and other comprehensive advantages, it does not appear in the form of a specific equation, but uses weights and threshold adjustments to approximate the results. The BP neural network continuously adjusts the weights and thresholds by using the steepest descent method to minimize the sum of squared errors. The model completed by topology has three parts: input layer, hide layer and output layer. The form is shown in Figure 1.

![Figure 1. Schematic diagram of BP neural network structure.](image)

As shown in Figure 1, the \( n \) nodes of \( n \) hidden layers are given, which mainly refer to the three functions of biological neurons: weighting, summation, and transfer. \( X_1, X_2, X_3, \ldots \) represent several neurons, \( W_{1i}, W_{2i}, W_{3i}, \ldots \) represent the connection strength with the i-th neuron, \( b \) is the threshold, \( f(x) \) is the transfer function, \( S_j \) input value, \( z \) is the hidden layer and \( y \) is the output value.

\[
S_j = \sum_{i=1}^{n} w_{ji} \times x_i + b_j = W_j \times X + b_j
\] (13)

Specially, \( X = [x_1 x_2 \ldots x_i \ldots x_n] \), \( W_j = [w_{j1} w_{j2} \ldots w_{ji} \ldots w_{jn}] \)

\[
z_k = f_i \sum_{i=1}^{n} \omega_i x_i
\] (14)

When the neuron completes the summation process, the \( S \) value is input into the transfer function \( f(x) \), and the output value of the \( j \)-th neuron node can be obtained.

\[
y_j = f_j = f(\sum_{i=1}^{n} w_{ij} \times x_i + b_j) = fW_j \times X + b_j
\] (15)

Besides, the function \( f(x) \) acts as a monotonous rising function, and both upper and lower bounds. After completing the forward propagation process of the BP neural network, the next step is the back propagation, that is, the self-learning process, which reduces the error by degrading the learning, and continuously adjusts the parameters for back propagation. First, the error is defined. The error of this study is squared error. If there are \( t \) input values, the whole training error can be obtained:
\[ E_j = \frac{1}{2} \sum (E_j - y_j^2) \]

\[ E_j = \frac{1}{2} \sum \sum (E_j - y_j^2) \] (17)

The back propagation of BP neural network adopts the cumulative error algorithm to adjust, gradually reduce the global error expectation value, and use the partial derivative to solve the above-mentioned expected value.

\[ \Delta \omega_y = -\varphi \frac{\partial E}{\partial \omega_y} = -\varphi \frac{\partial}{\partial \omega_y} \frac{1}{2} \sum \sum E_j - y_j^2 \] (18)

Define the error signal:

\[ \delta_y = \sum_{j=1}^{n} E_j - y_j f S_j \times z_i \] (19)

Re-adjust the weight parameters of each layer:

\[ \Delta \omega_y = \sum \sum \varphi E_j - y_j f S_j \times z_i \] (20)

The hidden layer weight changes in each layer:

\[ \Delta \gamma_{ij} = -\varphi \frac{\partial E}{\partial \gamma_{ij}} = -\varphi \frac{\partial}{\partial \gamma_{ij}} \sum E_f \] (21)

Define this part of the error, according to the chain theorem:

\[ \delta_y = \frac{\partial}{\partial z_i} \frac{1}{2} \sum_{j=1}^{n} E_j - y_j^2 \times f_i z_i \] (22)

Thus, the weighted value adjustment formula of the hidden layer neurons is obtained:

\[ \Delta \gamma_{ij} = \sum_{i=1}^{m} \sum_{j=1}^{n} \varphi \left( E_j - y_j^2 \right) f_2(s_j) \omega_{ij} f_i(s_i) x_i \] (23)

**Correlation Analysis**

This topic takes the stocks of listed companies in Shenzhen and Shanghai as the selection range, according to the industry type as the classification standard, and the information technology listed companies as the main research object, randomly selected 100 information technology listed companies for training. Using Wind software to select the financial indicators of the 2017 annual report of listed companies of information technology and the stock price changes of the whole month of April 2018 as the analysis object.

Self-training is completed through the BP neural network, and the training results are output. According to the results, the input item is 13 items, the final output item is 1 item, the hidden layer 1 layer contains 6 hidden links, the learning step number is 40000 steps, the processor calculation rate is 1000/second, the learning rate is 0.01, the training set sample The content is 80 and the test set sample content is 20. According to this parameter model, the BP network correlation analysis model is established to obtain the final error of 1.586256. According to the training results, the weight of each node is obtained.
Table 1. Weight1 & biases1.

|     | x     | x     | x     | x     | x     | x     |
|-----|-------|-------|-------|-------|-------|-------|
|     | 50.55162 | 12.89424 | 36.83414 | -10.7269 | 12.90816 | -85.8044 |
|     | 1.880257 | 26.50318 | 31.52094 | 20.01391 | 113.748 | 12.72194 |
|     | -139.967 | 292.7787 | 105.6192 | 132.7431 | -137.431 | 292.5174 |
|     | 17.08682 | -17.5633 | 36.03869 | 8.01427 | 12.88264 | -5.5828 |
|     | -85.8044 | 1.880257 | 26.50318 | 31.52094 | 20.01391 | 113.748 |

Table 2. Weight2 & biases2.

|     | x     | Bia2  |
|-----|-------|-------|
|     | 11.6002 | 3.638506 |
|     | -20.871 | 1.97089 |
|     | -16.167 | 3.159892 |
|     | -30.416 | 1.994359 |
|     | 21.7535 | -0.22579 |
|     | 29.7004 | 3.638506 |

Digital analysis of the above training results. The training weights are treated as two matrices. A first set of weights as matrix, a second set of weights as B. The two groups of weights are processed for data, and the weights of each indicator parameter affecting the stock price fluctuation are calculated.

1) correlation significance coefficient

\[ r_{ij} = \sum_{k=1}^{p} W_{ik} \left( 1 - e^{-e_{k}} \right) \left( 1 + e^{-e_{k}} \right) \]

(24)

2) correlation coefficient

\[ R_{ij} = \frac{1 - e^{-e_{k}}}{1 + e^{-e_{k}}} \]

(25)

3) Absolute influence coefficient

\[ S_{ij} = \frac{R_{ij}}{\sum_{i=1}^{n} R_{ij}} \]

(26)

In the above formula, i is the input unit of the neural network, \( i = 1, 2, \ldots, m \); j is the output unit of the neural network, \( j = 1, 2, \ldots, n \); k is the hidden unit of the neural network, \( k = 1, 2, \ldots, p \); \( W_{ki} \) is the weight between the input layer and the hidden layer, and \( W_{jk} \) is the weight between the hidden layer and the output layer. The medium absolute influence number \( S \) of the above three correlation coefficients is the comprehensive weight. See Table 4-3 for calculation results.
Table 3. Indicator weights.

| First-level indicator name | Secondary indicator name          | Comprehensive weight |
|----------------------------|-----------------------------------|----------------------|
| Shareholder return index   | $X_{11}$ Earnings per share       | 0.084120             |
|                            | $X_{12}$ Undistributed profit per share | 0.084120          |
|                            | $X_{13}$ Earnings per share       | 0.084120             |
|                            | $X_{14}$ Return on equity         | 0.066432             |
| Operational management     | $X_{21}$ Management annual salary | 0.075821             |
| performance                | $X_{22}$ The proportion of masters | 0.070720             |
|                            | $X_{23}$ Operating net profit margin | 0.049729          |
|                            | $X_{25}$ Management expense ratio | 0.084032             |
|                            | $X_{26}$ Financial expense ratio  | 0.084120             |
|                            | $X_{27}$ Operating income net rate of return | 0.065855          |
|                            | $X_{28}$ Account receivable turnover | 0.084119           |
| Risk resistance            | $X_{31}$ The current ratio        | 0.084120             |
|                            | $X_{32}$ Cash flow interest coverage multiple | 0.082693          |

Conclusion

In this paper, a total of 13 financial statement indicators are selected, and the sum of weights is 1. According to the mean method, it can be considered that when a certain index weight is greater than 0.07692307, the index occupies a large proportion in the whole, which is an influential indicator. When the indicator is smaller than the value is numerical, it indicates that the influence of the indicator is weaker than other test indicators. According to the data processing results, the Shareholder return index is a key first-level indicator among the selected 13 indicators, which shows that the investors are most concerned about the company's profitability and dividends to shareholders in the stock market. It shows that many investors are still rational. When the company has good operating performance, the stock price will maintain steady growth. In terms of corporate management and operation performance, investors are more concerned about the use of financial expenses and management fees. These two financial indicators responding to the efforts of the managers of the company in internal management and business operations, a company with a sound and effective operating system, its management costs tend to be stable and lower than other companies at the same level, indicating that senior managers are in the corporate culture and internal control system. The management methods adopted are correct and effective, and the energy is good to promote the development of the company; the anti-risk ability has become a major concern factor. Most investors are still stable investors, and are unwilling to accept high-risk and high-return investment models. We prefer to invest in listed companies with sound financial positions and good solvency.

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