

# Research on the analysis of financial risk contribution within stocks based on artificial neural networks

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**Abstract.** Since the late 1980s, as stock markets have faced a variety of challenges, the assessment and management of financial risk within stocks has become increasingly important. The management of financial risk within stocks is an important part of modern portfolio investment theory. In order to study the internal influencing factors and risk transmission mechanism of stock price in China, this paper selects a system of 13 indicators from 4 aspects, conducts contribution analysis by constructing ANN (Artificial Neural Network) algorithm, and uses  $R^2$ , MSE indicators to test the indicators, and the results show that the growth ability and profitability of enterprises have the most influencing factors on stock price. The research in this paper is beneficial to further explore the internal influencing factors and their intrinsic relationships of Chinese firms' stocks.

**Keywords:** stock financial risk, ANN algorithm, decision error, mean square error.

## 1. Introduction

In recent years, the stock market has long been a popular and integral part of the financial sector, and there are many factors that affect it. Today's stock market is growing in size and stock price movements are always unpredictable, up and down and very volatile. In order to explore the patterns of change and to make stock selection more informed, it is important to further explore the factors influencing stock prices and their underlying mechanisms.

A large number of studies have been conducted to analyze the internal financial risk of equities, and the current studies have focused on the impact of external and internal factors on share prices. For example, Ma et al.[1] selected four financial indicators related to solvency, operating capacity, profitability and development capacity and conducted a factor analysis, selecting only three factors for regression. Xiang et al.[2] selected eight indicators of profitability, growth capacity, cash flow and operating capacity on this basis and conducted a linear regression, the results were that financial indicators of profitability and growth capacity had a greater correlation with stock price, while operating capacity and cash flow indicators had a smaller impact on stock price and were not highly valued by investors. In contrast, Meng et al.[3] selected five indicators of profitability, growth capacity, operating capacity, solvency and special capacity. Using factor analysis, four factors were extracted for regression. The results showed that total asset turnover ratio, capital adequacy ratio, cost margin and equity ratio did not have a significant effect on share price, while the rest of the indicators were shown to be significant.

In addition to this, many experts and scholars have also conducted extensive analysis in external influencing factors: Xing et al.[4] used company fixed effects for regressions, while 12 indicators such as company size, gearing ratio and return on net assets were used as control variables, and found that corporate green innovation could improve capital market pricing efficiency; green innovation of companies with good internal control environment and companies in heavy pollution industries had a The effect of synchronization is weaker. In contrast, Cheng et al.[5] established a relationship model

between operating performance and share price volatility and analyzed it for A-share listed banks. The results found that there was a significant positive relationship between the two, and profitability and growth ability had a significant contribution to share price volatility, asset security had a significant inhibiting effect on share price volatility, while loan management ability was not relevant.

Previous studies have addressed the factors influencing share prices in a large number of ways and have made certain contributions. Common models used abroad in the assessment of financial risk using data mining techniques include: logit analysis models, multivariate discriminant analysis models, classification tree methods, etc. And this paper constructs ANN algorithm and uses decision error and mean square error for algorithm testing to complete the analysis of the contribution to financial risk within stocks. However, the methods of existing studies are some econometric models and the accuracy and data are often not reasonable. In this paper, we propose an ANN-based approach to ANN regression and contribution analysis of internal stock price influencing factors, and use  $R^2$ , MSE for accuracy measurement, through the ANN algorithm to analyse the internal factors affecting stock price, and measure the factors that have a greater impact, and thus provide some reference value for the research approach of stock price influencing factors.

## **2. The construction of a system of indicators of internal influences on stocks**

### **2.1. Business growth capability**

Growth capacity refers to a company's ability to grow in the future and reflects the speed of its development and its growth potential. Three indicators have been selected for growth capacity: growth rate of total assets ( $X_{11}$ ), growth rate of operating income ( $X_{12}$ ) and growth rate of net profit ( $X_{13}$ ).

### **2.2. Corporate profitability**

Profitability refers to the ability of a business to add value to its assets and make a profit. Profitability is one of the most important reference indicators for shareholders to assess the development of a company, and is also a guarantee for shareholders to gain income. The stronger the profitability, the more confidence shareholders have in the stock, and thus profitability will have an impact on the share price. Four indicators have been selected in this aspect of profitability: net sales margin ( $X_{21}$ ), return on net assets ( $X_{22}$ ), net total assets margin ( $X_{23}$ ) and earnings per share ( $X_{24}$ ).

### **2.3. Business operating capacity**

Operating capacity refers to a company's ability to run its operations, including a company's ability to turn over its assets and control the expenses of the operating process. Operating capacity affects the level of performance of a company and therefore the share price. Three indicators have been selected for this aspect of operating capacity: accounts receivable turnover ( $X_{31}$ ), current assets turnover ( $X_{32}$ ) and total assets turnover ( $X_{33}$ ).

### **2.4. Corporate solvency**

Solvency is the ability of a company to repay its debts, and it also has certain requirements for the liquidity of its assets. The stronger the solvency, the more resilient the company will be to risk. This will have an impact on the survival and sustainability of the company, which in turn will have an impact on the share price. Three indicators have been chosen for solvency: current ratio ( $X_{41}$ ), quick ratio ( $X_{42}$ ) and gearing ratio ( $X_{43}$ ).

In summary, the indicator system constructed in this paper is shown in Table 1.

**Table 1** System of indicators of internal stock influencing factors

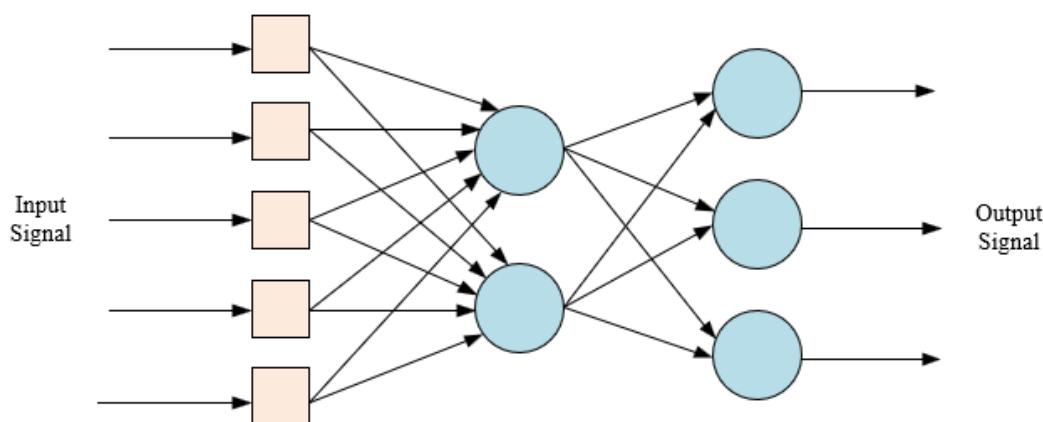
| Tier 1 indicators            | Secondary indicators                           | Indicator Unit | Indicator literature |
|------------------------------|------------------------------------------------|----------------|----------------------|
| Growth capacity ( $X_1$ )    | Growth rate of total assets ( $X_{11}$ )       | %              | [1]                  |
|                              | Operating income growth rate ( $X_{12}$ )      | %              | [1]                  |
|                              | Net profit growth rate ( $X_{13}$ )            | %              | [1]                  |
| Profitability ( $X_2$ )      | Net sales margin ( $X_{21}$ )                  | %              | [1]                  |
|                              | Return on Net Assets ( $X_{22}$ )              | %              | [1]                  |
|                              | Total net asset margin ( $X_{23}$ )            | %              | [2]                  |
|                              | Earnings per share ( $X_{24}$ )                | %              | [2]                  |
| Operating capacity ( $X_3$ ) | Accounts receivable turnover rate ( $X_{31}$ ) | %              | [2]                  |
|                              | Current asset turnover ratio ( $X_{32}$ )      | %              | [2]                  |
|                              | Total asset turnover ( $X_{33}$ )              | %              | [2]                  |
| Solvency ( $X_4$ )           | Current ratio ( $X_{41}$ )                     | %              | [3]                  |
|                              | Quick Ratio ( $X_{42}$ )                       | %              | [3]                  |
|                              | Gearing ratio ( $X_{43}$ )                     | %              | [3]                  |

### 3. ANN Method

ANN (Artificial Neural Network) is a complex network structure consisting of a large number of processing units (neurons) interconnected to simulate the organization and operation mechanism of the human brain [6].

The mechanism of action of ANN: each node represents a specific output function, called the excitation function. Each connection between two nodes represents a weighted value for the signal passing through that connection, i.e., a weight, which is equivalent to the memory of an artificial neural network. The output of the network is then dependent on how the network is connected and varies with the value of the weights and the excitation function.

We need to construct the ANN algorithm in our study of the analysis of the financial risk contribution within the stock, because the ANN algorithm is a powerful tool for dealing with machine learning problems and is widely used in practice in regression analysis problems, which happens to be applied in our analysis of the factors influence.



**Figure 1.** Schematic diagram of ANN

As shown in Figure 1, the original input information on the far left is called the input layer, the neurons on the far right are called the output layer, and the middle is called the hidden layer.

Numerous neurons receive a large number of non-linear input messages. The messages are transmitted, analyzed, and weighed in the neuron links to form the output results. And the hidden layers are the various layers composed of numerous neurons and links between the input and output layers. If there are multiple hidden layers, it means multiple activation functions[7].

From the principle of neural network, it is clear that neurons are the most important part of processing information and perceiving it. The single neuron model is as follows.

(1) Accept input variables. The model inputs are the independent variables in the data. The independent variables can be single or several, and the number of input variables is related to the linear model in the neuron.

(2) The linear model in the neuron is the model that accepts the input variables. model, and the basic mathematical principle is

$$f(x) = b + \sum_{i=1}^n (w_i * x_i) \quad (1)$$

Where:  $n = 1, 2, 3, \dots, n \in \mathbb{Z}$ ;  $w_i$  denotes the weight;  $b$  denotes the intercept.

(3) Activation function. Because most of the data are nonlinear in existence, a nonlinear function is introduced as the activation function in the neuron as a way to strengthen the learning ability of the network. In this paper, the modified linear unit function (ReLU) is selected as the activation function  $f(z)$ .

(4) Output. That is,  $f(\sum_{i=1}^n w_i * x_i + b)$  transmitted to the next neuron.

## 4. Algorithm test

Because in panel data and serial data, if there are unit roots, there may be serious consequences such as pseudo-regression, so it is necessary to conduct unit root test for each variable so as to ensure the smoothness of each variable and the smooth variable regression is valid. And in this paper for the regression analysis of stock internal influences, this paper chooses R2 with (coefficient of determination) and MSE (mean squared error) for the algorithm test[8].

$$R^2 = SSR / SST \quad (2)$$

SST (total sum of squares) is the total sum of squares, SSR (regression sum of squares) is the regression sum of squares, and SSE (error sum of squares) is the residual sum of squares.

R2 is an important statistic that reflects the goodness of fit of the model, and is the ratio of the regression sum of squares to the total sum of squares. The greater the goodness of fit, the higher the degree of explanation of the dependent variable by the independent variable, the higher the percentage of the total variation caused by the independent variable, and the more dense the observation points are around the regression line. R2 is the most commonly used indicator to evaluate the degree of goodness of fit of a regression model, the larger the R2 (close to 1), the better the fitted regression equation. The MSE is a convenient way to measure the "mean error", which can evaluate the degree of variation of the data.

## 5. Case study

### 5.1. Data collation

In this paper, China BYD Co., Ltd.(002594.SZ) is selected as the subject of an empirical study, and the ANN algorithm is used to investigate the influence of internal factors on the company's stock price. As a global leader in the new energy vehicle industry, BYD has a large technology research and development team and strong technological innovation capabilities, and has developed a series of global leading forward-looking technologies to establish its global leading position in the new energy vehicle field. According to data released by the China Association of Automobile Manufacturers, its market share of new energy vehicles reached 17.1% in FY2021, an increase of

nearly 8% during the year, leading the domestic new energy vehicle market and ranking among the top in the world. BYD has always adhered to the development concept of "technology is king and innovation is the foundation", and has achieved comprehensive development by virtue of its R&D strength and innovative development model, and has played a pivotal role in various fields such as batteries, electronics, passenger cars, commercial vehicles and rail transportation. Observing the price trend of BYD in the A-share market from 2011 to 2021, the overall price showed an increase, with the closing price on 31 December 2020 rising by RMB146.63, or 307.59%, compared to the same period in FY2019. In this paper, the closing prices of BYD in the A-share market from 2011 to 2021 are selected to represent the stock prices in the corresponding years, which are the explanatory variables. The intra-firm factors affecting the annual average closing price of the stock were selected as the explanatory variables. Based on Wind database, the descriptive statistics of each indicator are as follows.

**Table 2.** Descriptive statistics of indicators

| Primary Indicator                 | Secondary Indicator/Unit                                      | Max    | Min    | Mid   | Mean  |
|-----------------------------------|---------------------------------------------------------------|--------|--------|-------|-------|
| Growth capacity( $X_1$ )          | Total assets growth rate/%<br>( $X_{11}$ )                    | 55.20  | 0.55   | 21.64 | 20.54 |
|                                   | Increase rate of main business/%<br>( $X_{12}$ )              | 65.71  | -4.04  | 17.71 | 19.68 |
|                                   | Net profit growth rate<br>/%<br>( $X_{13}$ )                  | 324.16 | -86.65 | -7.46 | 59.60 |
|                                   | Net profit margin on sales/%<br>( $X_{21}$ )                  | 5.30   | 0.45   | 2.67  | 2.75  |
| Profitability( $X_2$ )            | Net Return on Assets/%<br>( $X_{22}$ )                        | 12.09  | 0.38   | 4.53  | 5.37  |
|                                   | Net increase rate of total asset/%<br>( $X_{23}$ )            | 4.21   | 0.32   | 1.76  | 2.01  |
|                                   | Earning per share/Yuan<br>( $X_{24}$ )                        | 1.88   | 0.03   | 1.00  | 0.89  |
| Operating Capability<br>( $X_3$ ) | Turnover rate of accounts receivable<br>/time<br>( $X_{31}$ ) | 5.09   | 1.57   | 4.47  | 4.16  |
|                                   | Turnover rate of current asset/time<br>( $X_{32}$ )           | 2.51   | 0.86   | 1.56  | 1.59  |
|                                   | Turnover rate of total asset/time<br>( $X_{33}$ )             | 0.87   | 0.47   | 0.72  | 0.72  |
| Solvency<br>( $X_4$ )             | Current ratio<br>( $X_{41}$ )                                 | 1.05   | 0.61   | 0.91  | 0.86  |
|                                   | Quick ratio<br>( $X_{42}$ )                                   | 0.72   | 0.39   | 0.57  | 0.57  |
|                                   | Debt liability ratio/%<br>( $X_{43}$ )                        | 69.29  | 61.81  | 67.70 | 66.73 |

## 5.2. ANN calculation

In this paper, based on SPSS software, using the ANN algorithm, bringing in the collected historical data, the MSE of the model constructed by adjusting the parameters, the accuracy of the results of several groups is calculated as shown in Table 3 in particular.

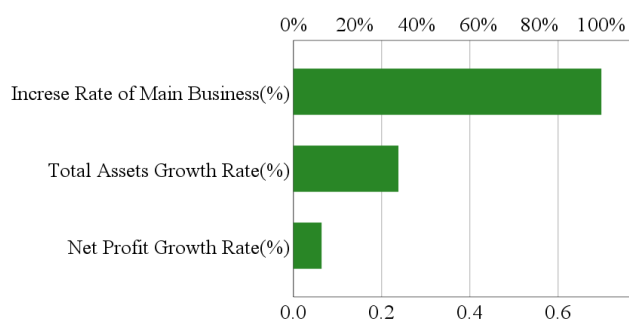
**Table 3.** Accuracy of different parameter models Table

| Model parameters | MSE       | $R^2$   |
|------------------|-----------|---------|
| 10               | 54.2266   | 0.9934  |
| 11               | 1618.2634 | 0.6775  |
| 12               | 83.6554   | 0.9900  |
| 13               | 783.9235  | 0.8706  |
| 14               | 1526.8716 | 0.8533  |
| 15               | 146.0078  | 0.9798  |
| 16               | 667.5424  | 0.9018  |
| 17               | 918.4786  | 0.8415  |
| 18               | 33.7403   | 0.9959  |
| 19               | 1330.5829 | 0.8685  |
| 20               | 974.1196  | 0.8549  |
| 21               | 595.7700  | 0.9203  |
| 22               | 260.6672  | 0.9654  |
| 23               | 907.6965  | 0.8922  |
| 24               | 8411.9674 | -2.8640 |
| 25               | 2321.3628 | 0.5647  |
| 26               | 1254.6130 | 0.8371  |
| 27               | 904.7868  | 0.8897  |
| 28               | 712.7429  | 0.8914  |
| 29               | 683.3390  | 0.8959  |
| 30               | 275.0057  | 0.9638  |

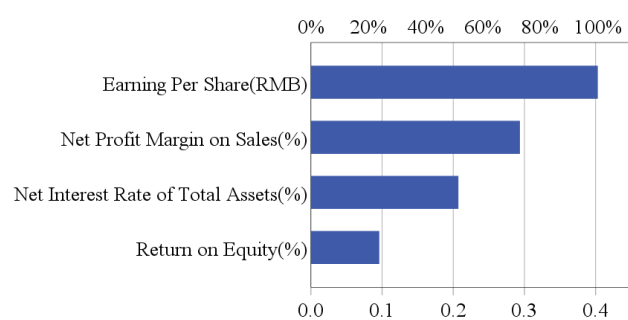
From Table 3, we can see that when the model parameters are 18, the model accuracy is the highest at this time and the model converges, at this time the MSE,  $R^2$ , are 33.7403 and 0.9959 respectively

## 5.3. Contribution analysis

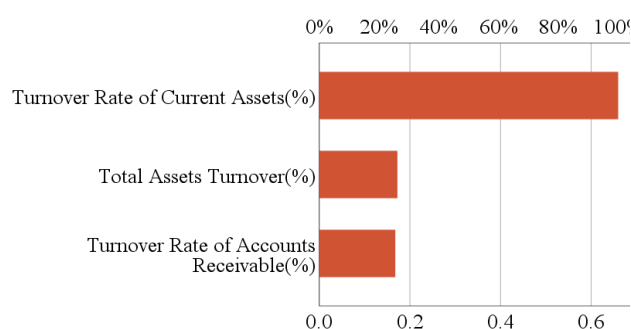
Based on the previous calculation and analysis in 5.2, we selected the results of the parameter adjustment to 18 for contribution analysis, and the results are shown in bar charts 2 to 5.



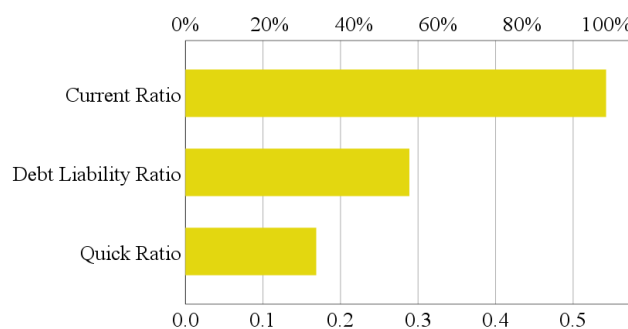
**Figure 2.** Growth capacity



**Figure 3.** Profitability



**Figure 4.** Operating Capability



**Figure 5.** Solvency

Through ANN analysis of BYD's financial indicators from 2011 to 2022 and the average stock price on the last day of the corresponding year, the optimal fit results are as follows when adjusting the number of hidden layers to 18. In terms of corporate growth capability, the normalised importance of net profit growth rate is 9.2%, the normalised importance of total assets growth rate is 34.1% and the normalised importance of operating income growth rate is 100%. Generally speaking, a high revenue growth rate indicates that the business is expanding rapidly, and the market share and influence will also increase, which is a reflection of the company's good development trend. For BYD's profitability, the normalised importance of total net asset margin, return on net assets, net sales margin and earnings per share are 23.9%, 51.4%, 72.8% and 100% respectively, meaning that earnings per share most affects BYD's profitability.

Earnings per share, which divides a company's net profit by its total share capital, reflects the current profitability of each share of the company and is one of the most important indicators that investors pay attention to when conducting financial financial analysis of the company. In this paper, the accounts receivable turnover ratio, total asset turnover ratio and current asset turnover ratio are selected to study BYD's operating capacity, where the normalised importance of the current asset ratio is 100%, far exceeding the accounts receivable turnover ratio of 25.4% and the total asset turnover ratio of 26.2%. The higher the current asset turnover of a company, the more efficient the company is in using its current assets, which is conducive to higher profitability. On the other hand, current assets show the management level of corporate management, and companies with high current asset turnover can generate more profits while effectively reducing the risk of bankruptcy. Finally, this paper looks at the solvency of a company with the help of current ratio, quick ratio and gearing ratio. The most influential factor on BYD's solvency is the current ratio, with a normalised importance of 100%, exceeding the quick ratio of 31.3% and gearing ratio of 53.2%. The current ratio is used to measure the ability of a company's current assets to be turned into cash to service its liabilities before short-term debt maturity. Although the higher the current ratio, the more liquid the company's assets are, a ratio that is too large indicates that more current assets are tied up, which can affect the efficiency of operating capital turnover and profitability.

## 6. Conclusion

This paper is an analysis of the contribution of financial risk within stocks. Firstly, firstly, we constructed the index system construction of stock internal influence factors, and constructed 4 primary indicators and 13 secondary indicators. Secondly, China BYD Co., Ltd. was selected as the object of empirical research and ANN algorithm was used to study the influence of intra-firm factors on corporate stock prices; the closing prices of BYD in the A-share market from 2011 to 2021, representing the stock prices in the corresponding years, were selected as the explanatory variables, and intra-firm factors affecting the annual average closing prices of stocks were chosen as the

explanatory variables. Finally, decision error and mean square error were used for algorithm testing. The conclusions drawn in this paper are as follows.

(1) The most influential factors on the growth, profitability, operating capacity and solvency of enterprises are: operating income growth rate, earnings per share, current asset turnover ratio and current ratio, respectively.

(2) The highest accuracy of the model is when the model parameter is 18, at which time the model converges with MSE and  $R^2$  of 33.7403 and 0.9959 respectively, indicating that the model constructed in this paper has strong robustness and generalizability, and the model and method are reasonable.

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