Research on the valuation of City Enterprises Based on ARIMA series prediction

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Abstract. This paper studies the valuation of listed companies on the science and technology innovation board. By establishing the corresponding mathematical model, comparing the stock market valuation level of China and the United States, through multiple data screening and analysis, using factor analysis of variance, time series model and RBF neural network analysis, the paper establishes the valuation and quantitative model of China's stock market. AR. Regression analysis can accurately measure the correlation between each factor and improve the accuracy of the prediction method. Neural network has very strong nonlinear fitting ability, can map any complex nonlinear relationship, and the learning rules are simple, which is convenient for calculation and simulation. In order to quantitatively analyze the relationship between each factor and the valuation index, the significance test value of the Sino US market can be obtained by using the method of one-way ANOVA, and the ranking of the importance of each factor to the valuation index can be obtained through the analysis. The fundamental index and liquidity index of stock market have certain stability. In order to forecast and analyze the fundamental index and liquidity index of Chinese market and American market, the time series model is used to establish the prediction model for the change of index data.

Keywords: enterprise valuation, analysis of variance, multiple linear regression, AR time series, RBF neural network

1. Introduction
Science and technology innovation board enterprises are different from the existing main board market innovation sector. Therefore, the scientific and technological innovation board does not require enterprises to make profits, and the enterprises that have not made profits shall use the market sales ratio method for valuation. Because it is a new template, the valuation can refer to the average market sales rate of NASDAQ companies in similar markets in the United States. However, due to the different profitability of enterprises listed in the domestic market and the U.S. market and the structure of investors are different, there are great differences in fundamentals and liquidity, which leads to the
differences in valuation levels between the stock markets of China and the United States. Facing the innovative investment plate, it is very important for investors to master the correct valuation method.

2. Calculating the market sales rate
Market rate valuation method is mainly used for gem enterprises or high-tech enterprises. Because there is no requirement for profit performance, it is impossible to judge the value or risk of stock investment by P / E ratio. Therefore, the companies that are going to be listed on the science and technology innovation board should use the index of market sales rate to judge. Market value listed companies. It refers to the total value of a company issued shares calculated according to the market price. The calculation formula is as follows: Turnover rate refers to the frequency of stock turnover in the market within a certain period of time, which is one of the indicators reflecting the strength of stock liquidity.

Therefore, according to the above calculation formula, the market sales rate of China and the United States in 2018 are calculated respectively. The calculation results are shown in Table 1.

| market | Actual market sales rate | Calculating the market sales rate |
|--------|--------------------------|----------------------------------|
| China A-share market | 4.87 | 4.92 |
| American Nasdaq market | 181.35 | 162.28 |

3. Valuation level
Comparing the average market sales rate between China and the United States, we can see that the Chinese market is obviously lower than the United States market. According to the definition of the market rate, the investment value of the Chinese market is relatively large. If the above formula is positive, it is valuation premium; if it is negative, it is valuation discount. Through calculation, it is found that the Chinese stock market is a valuation premium, with a premium level of 1%; the US Nasdaq market is a valuation discount with a discount level of 10%. In the calculation of market sales rate, the selected index calculation method is the definition formula, which does not take into account the differences between companies. In the actual stock market, the stock price of a company will change greatly in a day or even within an hour. The result calculated here is only the average level of the whole stock market in 2018, and the influence of the data of previous years has not been considered, resulting in the valuation premium and discount of the results. In order to quantitatively analyze the relationship between each factor and the valuation index, the significance test value of the Sino US market can be obtained by using the method of one-way ANOVA, and the ranking of the importance of each factor to the valuation index can be obtained through the analysis. Secondly, a multiple linear regression model is established to quantitatively obtain the relationship between operating income, net profit attributable to parent company, return on net assets, stock trading volume, average turnover rate of stock, trading amount of stock and valuation index, and compare the differences between Chinese and American stock markets.

Considering the relationship between the indicators and the valuation level, the fundamental data and liquidity data are the first level indicators, while the operating income, net profit attributable to the parent company, return on net assets, stock trading volume, average turnover rate and trading amount of stocks are secondary indicators. According to the above analysis, the analytic hierarchy process chart as shown below is established. In order to quantitatively analyze the relationship between each factor and the valuation index and identify the effect of each factor, one-way ANOVA was used. This paper investigates and compares the effects of annual operating income and annual single stock trading volume on the valuation level. According to the method of one-way ANOVA, we run the MATLAB test program to obtain the significance test quantity of each index in the Chinese and American markets, as shown in table 2.
Table 2. F value and P value of statistics of each index

| Index                        | F value | P value | Index                        | F value | P value |
|------------------------------|---------|---------|------------------------------|---------|---------|
| China stock market           |         |         | American Nasdaq market       |         |         |
| Business income              | 1495.01 | 0.021   | Business income              | 31.49   | e^{-28} |
| Net profit attributable to parent company | 663.24  | 0.031   | Net profit attributable to parent company | 81.49   | e^{-37} |
| Return on net assets         | 435.5   | 0.038   | Return on net assets         | 42.18   | e^{-31} |
| Stock trading volume         | 311.92  | 0.045   | Stock trading volume         | 40.78   | e^{-31} |
| Average turnover rate of stock | 25.36   | 0.157   | Average turnover rate of stock | 3.91    | e^{-8}  |
| Stock trading amount         | 9676.03 | 0.008   | Stock trading amount         | 122.6   | e^{-32} |

By ranking the significance test f value of Chinese and American markets, we can find that the factors influencing the valuation index of Chinese stock market are: stock trading amount > operating income > net profit attributable to parent > net asset income > stock trading volume. Because the p value of the average turnover rate of the stock is greater than 0.05, it does not pass the p value test, so it is not included in the ranking. By observing the ranking, the liquidity index has a greater impact on the valuation index of China stock market. The factors influencing the valuation index of American Nasdaq market are: stock trading amount > net profit attributable to parent > return to net assets > stock trading volume > operating income > average turnover rate of stocks. By observing the ranking, the fundamental indicators have a greater impact on the valuation indicators of the U.S. Nasdaq market.

4. Multiple linear regression model

Due to the quantitative analysis of the relationship between valuation indicators, fundamental indicators and liquidity indicators, the operating income, net profit attributable to parent company, return on net assets, stock trading volume, average turnover rate of stock and trading amount of stock are recorded respectively. Therefore, multiple linear regression model can be established as shown in the formula.

\[
\begin{align*}
    y &= \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_6 x_6 + \epsilon \\
    \epsilon &\sim \mathcal{N}(0, \sigma^2)
\end{align*}
\]

The average data of Chinese stock market from 2009 to 2018 are brought into the fitting equation and solved to get the fitting equation.

\[
y = 10.81 - 1.78 \times 10^{-9} x_1 + 1.92 \times 10^{-8} x_2 + 4.99 x_3 - 3.25 \times 10^{-9} x_4 - 1.22 \times 10^{-2} x_5 + 3.95 \times 10^{-10} x_6
\]
Figure 1. Fitting chart of average market sales rate of Chinese stock market

The average value of the data from 2009 to 2018 in the U.S. Nasdaq market is brought into the fitting equation and solved to obtain the fitting equation.

\[ y = -310.27 + 1.87 \times 10^{-3} x_1 - 2.61 \times 10^{-3} x_2 + 9.65 \times 10^{-2} x_3 + 4.18 \times 10^{-5} x_4 + 0.20 x_5 + 1.94 \times 10^{-5} x_6 \]

Figure 2. Fitting chart of average market sales rate of American Nasdaq market

Matlab program is used to calculate the relative error of market fitting between the two countries, and table 3 is obtained. We found that the stock market of China and the United States tends to 1. According to the relevant laws, the closer the value is to 1, the better the fitting is. It seems that the average market sales rate of China and the United States is well fitted. And the relative error of fitting is less than 10, and the error value is small.
Table 3. Fitting error table

| country                     | $R^2$ | relative error |
|-----------------------------|-------|----------------|
| China A-share market        | 0.99  | 9.72           |
| American Nasdaq market      | 0.95  | 4.48           |

In view of the stability of the fundamental indicators and liquidity indicators of the stock market, and have certain relevance with the data of previous years, in order to forecast and analyze the fundamental index and liquidity index of China A-share market and American Nasdaq market in 2019, the time series model is used to establish the prediction model for the change of index data. According to the prediction results, the multiple linear regression model can be used to calculate the valuation indexes of the two markets in 2019. Then, using the neural network model, according to the known index data of 2009-2019, we predict the valuation level in 2019, and compare it with the time series model to compare the relative error.

In order to forecast the index values of China market and Nasdaq market in the United States in 2019, the index data from 2009 to 2018 are respectively cleaned and transformed. After eliminating the invalid data, we calculate the average value of each index in each year, so as to forecast and analyze the fundamental index and liquidity index of China A-share market and American Nasdaq market in 2019. The calculation results are shown in Table 4.

Table 4. Average value of each index in China A-share market from 2009 to 2018

| Year | $\bar{x}_1$ | $\bar{x}_2$ | $\bar{x}_3$ | $\bar{x}_4$ | $\bar{x}_5$ | $\bar{x}_6$ |
|------|-------------|-------------|-------------|-------------|-------------|-------------|
| 2009 | 1.19×10^9   | 1.17×10^9   | 1.09        | 3.80×10^9   | 394.78      | 3.95×10^10  |
| 2010 | 1.57×10^9   | 1.60×10^9   | 8.58        | 2.85×10^9   | 267.03      | 3.36×10^10  |
| 2011 | 1.94×10^9   | 1.80×10^9   | 5.63        | 2.27×10^9   | 199.46      | 2.57×10^10  |
| 2012 | 2.06×10^9   | 1.79×10^9   | 10.93       | 1.96×10^9   | 155.02      | 1.72×10^10  |
| 2013 | 2.24×10^9   | 2.04×10^9   | 2.87        | 2.74×10^9   | 170.14      | 2.38×10^10  |
| 2014 | 2.27×10^9   | 2.07×10^9   | -6.22       | 4.23×10^9   | 231.73      | 3.74×10^10  |
| 2015 | 2.13×10^9   | 1.93×10^9   | -0.02       | 9.31×10^9   | 455.60      | 1.22×10^11  |
| 2016 | 2.08×10^9   | 1.85×10^9   | 5.42        | 3.75×10^9   | 304.44      | 4.18×10^10  |
| 2017 | 2.09×10^9   | 1.89×10^9   | 5.64        | 3.12×10^9   | 329.22      | 3.63×10^10  |
| 2018 | 2.20×10^9   | 1.92×10^9   | -3.37       | 2.57×10^9   | 477.02      | 2.77×10^10  |

5. Time series forecasting model

Spearman correlation coefficient is a kind of rank correlation coefficient. Let is a sample with a capacity of from a unitary population, and its order statistic is. If then it is called the rank in the sample, which is recorded as the rank statistic for each one. They are called rank statistics. For the sample observation data of two-dimensional population, we can get the univariate sample data of each component and. Let the rank statistic of is; the rank statistic of is. When, the two groups of rank statistics are closely related. The correlation coefficient is defined as the correlation coefficient of the two groups of rank statistics Spearman.
Because the time series of the data given is too short, the AR time series forecasting model is selected to forecast the index values of the Chinese and American markets. Taking China market revenue as an example, this paper uses SPSS software to draw its autocorrelation coefficient and cross correlation coefficient diagram, as shown in Figure 3 and figure 4, so as to intuitively see its tailing and truncation.

\[
q_{XY} = \frac{\sum_{i=1}^{n} (Y_i - \bar{Y})(S_i - \bar{S})}{\sqrt{\sum_{i=1}^{n} (Y_i - \bar{Y})^2 \sum_{i=1}^{n} (S_i - \bar{S})^2}}.
\]

**Figure 3.** Autocorrelation coefficient diagram

**Figure 4.** Cross correlation coefficient diagram
In the long run, the stock market follows certain rules, while in the short run, due to the influence of uncertain factors, such as macro policy and market demand changes, it is difficult to predict the data of each index. In the process of economic forecasting, the autoregressive model not only considers the dependence of economic phenomena on time series, but also considers the interference of random fluctuations. It has a high accuracy rate for the short-term trend of economic operation, and is a widely used method. As an important index of stock market operation, fundamental index and liquidity index have certain stability, and have certain relevance with the data of previous years. Therefore, we can use time series method to establish prediction model for the change of index data.

1. China A-share market

Taking the operating revenue as an example, the relative error of the above model is shown in Table 5 for the known data. It can be seen that the prediction accuracy of the model is high. Using MATLAB software to draw and analyze the actual data and forecast data from 2009 to 18 years, and get Figure 5. According to the graph trend, the gap between the two will gradually decrease with the passage of time, so the fitting situation is relatively good.

![Figure 5. Trend of operating revenue in China A-share market](image)

**Table 5. Predicted values and relative errors of known data**

| particular year | actual value | Estimate | relative error |
|-----------------|--------------|----------|----------------|
| 2009            | 1.19×10^10   | 1.19×10^10 | 0              |
| 2010            | 1.57×10^10   | 1.57×10^10 | 0              |
| 2011            | 1.94×10^10   | 1.95×10^10 | 0.005          |
| 2012            | 2.06×10^10   | 2.08×10^10 | 0.010          |
| 2013            | 2.24×10^10   | 2.12×10^10 | 0.054          |
| 2014            | 2.27×10^10   | 2.30×10^10 | 0.013          |
| 2015            | 2.13×10^10   | 2.28×10^10 | 0.070          |
| 2016            | 2.08×10^10   | 2.08×10^10 | 0              |
| 2017            | 2.09×10^10   | 2.06×10^10 | 0.014          |
| 2018            | 2.20×10^10   | 2.10×10^10 | 0.045          |

According to the above method, we forecast the indicators of China A-share market in 2019, and the forecast results are shown in Table 6.

![Image]
Table 6. Forecast of various indicators of China A-share market in 2019

| business income | Net profit attributable to parent company | Return on net assets | annual turnover rate | Annual turnover |
|-----------------|------------------------------------------|----------------------|---------------------|----------------|
| 2.23×10^13     | 1.92×10^12                              | -3.03                | 2.84×10^8          | 3.24×10^8      |

Establish multiple linear regression model

\[ y = 10.81 - 1.78 \times 10^{-9} x_1 + 1.92 \times 10^{-8} x_2 + 4.99 x_3 - 3.25 \times 10^{-9} x_4 - 1.22 \times 10^{-2} x_5 + 3.95 \times 10^{-10} x_6 \]

From the above formula, the valuation level of China A-share market in 2019 is 5.39.

② American Nasdaq market

Taking the operating revenue as an example, the relative error of the above model is shown in Table 7 for the known data. It can be seen that the prediction accuracy of the model is high.

![Figure 6. Trend of operating revenue in the US Nasdaq market](image)

Table 7. Predicted values and relative errors of known data

| particular year | actual value | Estimate | relative error |
|-----------------|--------------|----------|----------------|
| 2010            | 1.28×10^5    | 1.28×10^5| 0              |
| 2011            | 1.46×10^5    | 1.46×10^5| 0              |
| 2012            | 1.46×10^5    | 1.65×10^5| 0.13           |
| 2013            | 1.51×10^5    | 1.43×10^5| 0.053          |
| 2014            | 1.58×10^5    | 1.56×10^5| 0.013          |
| 2015            | 1.61×10^5    | 1.66×10^5| 0.031          |
| 2016            | 1.63×10^4    | 1.62×10^5| 0.006          |
| 2017            | 1.82×10^5    | 1.65×10^5| 0.093          |
| 2018            | 2.21×10^5    | 2.04×10^5| 0.077          |
According to the above method, we forecast the indexes of NASDAQ market in the United States in 2019, and the prediction results are shown in Table 8.

**Table 8. Forecast of various indicators of the US Nasdaq market in 2019**

| business income | Net profit attributable to parent company | Return on net assets | annual turnover | turnover rate | Annual turnover |
|-----------------|------------------------------------------|---------------------|----------------|--------------|----------------|
| $2.63 \times 10^5$ | $2.08 \times 10^4$ | -29.67 | $2.34 \times 10^8$ | 110.07 | $1.37 \times 10^6$ |

Establish multiple linear regression model

\[
y = -310.27 + 1.87 \times 10^{-3} x_1 - 2.61 \times 10^{-3} x_2 + 9.65 \times 10^{-2} x_3 + 4.18 \times 10^{-7} x_4 + 0.20 x_5 + 1.94 \times 10^{-5} x_6
\]

According to the above formula, the valuation level of US Nasdaq market in 2019 is 136.58.

6. **RBF neural network model**

   (1) Determination of network parameters

   RBF The neural network is composed of input layer, hidden layer and output layer, as shown in the figure.

![Figure 7. Neural network](image)

   (2) Network training

   Using Matlab toolbox, the prediction results are shown in Table 9.

**Table 9. Average market sales rate of Sino US market in 2019**

|                     | Market sales rate (1) | Market sales rate (2) | relative error |
|---------------------|-----------------------|-----------------------|----------------|
| China A-share market| 4.73                  | 5.39                  | 0.11           |
| American Nasdaq market| 125.42              | 136.58                | 0.08           |

Among them, the market sales rate (1) is the prediction value of neural network, and the market sales rate (2) is the prediction value of the established regression model. The comparison shows that the prediction error between the models is small, indicating that the prediction results are relatively good. By analyzing the market sales rate of China and America stock markets, it is found that the market sales rate of China market is significantly lower than that of the United States market, indicating that the investment prospect of China market is better. In order to predict the valuation level of China first batch of science and technology innovation board enterprises after listing, we first calculate the average value of the fundamental indicators of 93 known companies. Secondly, with reference to the valuation
quantitative model of NASDAQ market in the United States, the annual fitting regression equation is obtained according to the multiple linear regression model, and the average value of each index from 2016 to 2018 is brought into the fitting equation according to the liquidity index of China A-share market. We can get the annual valuation level, and then predict the valuation level of the first batch of enterprises listed on the science and technology innovation board.

7. Conclusion
Regression analysis can accurately measure the correlation between each factor and improve the accuracy of the prediction method. The use of time series model is simple and easy, can make full use of the original time series of each data, the calculation speed is fast, so the model parameters have the ability of dynamic determination, very accurate. Neural network has very strong nonlinear fitting ability, can map any complex nonlinear relationship, and the learning rules are simple, which is convenient for calculation and simulation. It has strong memory ability, non-linear mapping ability and strong self-learning ability. Based on the influence of external changes on the accuracy of time series model, neural network model can be introduced to solve the nonlinear relationship between complex financial time series data, so as to achieve high prediction accuracy.

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