

Research on Investor Sentiment from the Perspective of a Complex Network

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Abstract: Considering the financial market as a complex network system, we can look at its complexity from multiple aspects. The stock market is not only a key part of the financial market, but also one of the remarkable characteristics is that the investor sentiment in China's stock market is more volatile, and the impact of this fluctuation on the stock price is also more significant. This paper takes CSI 300 as the research object, selects five indicators of price-earnings ratio, turnover rate, stock price amplitude, stock price fluctuation and liquidity, and uses the principal component analysis method to construct the investor sentiment index and prove its rationality. At the same time, based on Pearson's correlation coefficient, the stock price fluctuation network and investor sentiment network are constructed, so as to better understand the relationship between investor sentiment and stock price fluctuation, and understand investor sentiment from multiple dimensions. The empirical analysis shows the following conclusions: there is a strong correlation between investor sentiment and stock price; investor sentiment shows high consistency in the same industry; and the investor sentiment network meets the characteristics of small world network in complex network.

Keywords: Investor Sentiment; Complex Network; Principal Component Analysis; Stock Price Volatility; Pearson Correlation Coefficient.

1. Introduction

China's stock market has many unique characteristics, which have an important impact on investor sentiment and market behavior, and bring challenges to the traditional investment strategies. [1]The stock market is a complex system. In this system, the investor sentiment of individual stocks affects each other, and changes the trading behavior of investors, prompting the stock price changes.[2]The linkage characteristics of the stock price make these influences constantly spread and spread to the whole stock market. The study of complex networks provides us with a brand-new perspective that helps us to better understand and deal with various complex problems.[3]

2. Investor Sentiment Research

2.1. Investor Sentiment Indicator Analysis

Through the extensive review and in-depth research of the existing literature, a series of indicators that may reflect the investor sentiment of individual stocks were selected. These indicators include: stock price amplitude, stock price volatility, liquidity, turnover rate and price ratio.

$$AM_{it} = \frac{|H_{it} - L_{it}|}{C_{it-1}} \quad (1)$$

Amplitude (AMit) is expressed as the ratio of the absolute difference between the highest price H_t and the lowest L_t on the opening of the stock on day t and the C_{t-1} of the closing price of the previous day. The traditional volatility model is also the most widely used fluctuation model. CLA model is widely used, and the volatility model of high land price PKM does not comprehensively consider the fluctuation relationship between high and low price and closing price. Zhang Xiaoyan and zhong-hua shen (2011) pointed out that on the relative efficiency than only considering the closing price of traditional method increased 7.4 times, using this method to measure the stock index futures GK volatility.[4]So

this paper use this method to calculate stocks GK volatility, opening price (O_t), closing price (C_t), the highest (H_t), the lowest price (L_t) specific formula is as follows:

$$\begin{aligned} \sigma_{GK}^2 &= 0.511(u - d)^2 - 0.019[c(u + d) - 2ud] - 0.383c^2 \quad (2) \\ u &= H_t - O_t \\ d &= L_t - O_t \\ c &= C_t - O_t \end{aligned}$$

Liquidity (FL) refers to the ability of banks to withdraw cash or pay due for loans. Baker and stien (2004) point out that the liquidity of the stock market can reflect the degree of investors' participation in stocks, which is mainly reflected through trading volume indicators.

$$FL = \frac{AS_{it}}{FMC_{it}} \quad (3)$$

Among them: AS_{it} is the daily turnover of the stock, and FMC_{it} is the free-circulation market value. Turnover rate (TR) refers to the frequency with which stocks are traded in the market over a specific period of time, which is widely used in the field of stock market sentiment research. Price / earnings ratio (PE), fully known as the ratio of stock price to earnings per share, is an important financial indicator to measure whether the stock price is reasonable.

2.2. Principal Component Analysis

The core composition of emotion was refined through the principal component analysis and the sentiment index was calculated accordingly. [5]In this study selected the data of 20 trading days of CSI 300 component stocks in May 2024 as the basic template for calculation, and collected a total of 6000 sets of data. In the data processing phase, the KMO (Kaiser-Meyer-Olkin) tests and Bartlett spherical tests (Bartlett's Sphericity Test) were first performed on five representative indicators of emotion. Analysis of the selected sample data revealed a KMO value of 0.621 and a p-value of less than 0.05, indicating that it is suitable for principal component analysis.

The final emotions are expressed as follows:

$$S = 0.0696PE + 0.221FL + 0.2092TR + 0.24AM + 0.2599GK \quad (4)$$

2.3. The Rationality Analysis of the Emotional Index

Baker and Wurgler (2007) proposed the idea that the sentiment index can be considered effective when there is some synergistic change between the sentiment index and the market activity.[6]To test this view, two stocks were randomly selected for in-depth analysis. The change trend of 000001.SZ and 600085.SH closing price and the change of investor sentiment index were randomly selected for observation. It can be observed that the 000001.SZ sentiment index showed a significant upward trend on certain key trading days during the period from June 1,2022 to June 1,2024. Specifically, around the 10th, 100th, 117th and 424th trading days, the sentiment index showed a significant peak, and at the same time, the stock price also showed a corresponding upward trend at these key nodes, indicating a close positive correlation between the stock price and the sentiment index. During the period of 145 to 415 trading days, the sentiment index of 000001.SZ showed a trend of fluctuating decline, which was also reflected in the stock price, that is, the stock price also showed a trend of fluctuating decline.600085.SH There is a high degree of consistency in stock price and mood fluctuations.

3. Establishment and Analysis of Investor Sentiment Network

3.1. The Establishment of the Investor Sentiment Network and the Stock Price Volatility Network

He Hongzeng (2023) constructed the stock market price network through in-depth study of the price fluctuations of the stock market. [7] He uses Pearson's correlation coefficient to measure the linear degree of correlation between two variables, thus revealing the internal connection between stock price movements, providing us with a new perspective on the dynamics of the market. This paper draws on He Hongzeng's method, and on this basis, using the investor sentiment index formula constructed in the previous section to make a detailed calculation and analysis of the investor sentiment index of 486 trading days of CSI 300 component stocks from June 1,2022 to June 1,2024. For those observations that did not reach the statistically defined high correlation (absolute correlation less than 0.8 and p-value greater than 0.05), we recorded them as 0 to show that they were not significantly correlated in the set of variables studied. At the same time, the same analysis of the stock price to build a stock price fluctuation network and investor sentiment network.

3.2. Analysis of Mesocentrality

If a node is located on multiple shortest paths, then the node may play a key role in information transfer, resource allocation, and so on. Therefore, mesonumber centrality is often used to identify key nodes in the network and has important implications for understanding the structure and function of the network. Specifically, the number of node i is defined as:

$$BC_i = \sum_{s \neq i \neq t} \frac{n_{st}^i}{g_{st}} \quad (5)$$

Where g_{st} is the number of shortest paths from node s to node t , and n_{st}^i is the number of shortest paths through node i in the shortest path of g_{st} from node s to node t . By comparing the stock price fluctuation network with the investor sentiment network, there are 9 stocks in the top 10% of the number of mediation. Except 300015.SZ, the other nodes with high correlation are all belong to the photovoltaic equipment and battery industry. This phenomenon shows that over the past two years, the investor sentiment change in photovoltaic equipment and batteries has remained highly consistent with the sentiment trends in most stocks in the market. In the correlation network, this state appears in a higher centrality. This also reflects a higher correlation between investor sentiment in the photovoltaic equipment and battery industry and sentiment in the overall stock market.

Through in-depth observation of the change trend of the CSI 300 index, photovoltaic industry index and power equipment new energy index, we can clearly find that the stock price fluctuations of the photovoltaic industry and power industry are highly consistent with the changing trend of the whole CSI 300 index. This phenomenon not only reveals the close connection between the photovoltaic industry and the power industry in the current market environment, but also confirms from the side the internal correlation between the market sentiment and the stock price changes reflected by the sentiment index.

3.3. Modularity Analysis of Social Networks

Social network modularity is a method of classifying individuals or collectives in social networks according to specific attributes, interests or social relationships, which has a profound significance in the field of sociology. Through the iterative optimization of Louvain algorithm[8],the number of stocks in the four modules exceeds 5%, and the stocks in these four modules either belong to similar industries or the stock price fluctuations show similar characteristics.

3.4. Network Degree Analysis

In the complex network structure of investor sentiment shows a few stocks exceed 10% of the number of nodes. Specifically, there are only six such stocks, which are respectively 002074.SZ, 300450.SZ, 688223.SH, 601877.SH, 600958.SH, 002311.SZ. These stocks have a significant position and influence in the investor sentiment network, and their stock price volatility may have a chain effect on the market as a whole. At the same time, notice a more common phenomenon: there are a large number of stock nodes with degrees less than 1%. Specifically, the number of such stocks is 175. These stocks have a relatively low position in investor sentiment networks, and their share price volatility have limited overall impact on the market. This phenomenon reveals that the constructed investor sentiment network has the characteristics of scale-free network, that is, the degree distribution of nodes in the network shows a long tail distribution, and a few nodes have higher degrees, while most nodes have lower degrees. Therefore, it can be proved that the investor sentiment network conforms to the characteristics of the scale-free network.

4. Conclusion

The constructed investor sentiment index can reflect investor sentiment to a large extent, and provide new ideas for

stock market investor sentiment research from the perspective of complex network. Through empirical analysis, it is found that the constructed investor sentiment index can reflect investor sentiment and prove that there is a strong correlation between investor sentiment and stock price. Through the constructed investor sentiment network, it is found that the investor sentiment shows a high degree of consistency in the same industry, and it also proves that the investor sentiment network conforms to the characteristics of the small world network in the complex network.

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