Network of listed companies based on common shareholders and the prediction of market volatility

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HIGHLIGHTS

- Build a one-dimensional network based on common shareholders in China stock market.
- The degree of common shareholder' network follows Weibull distribution.
- Provide economic mechanism of why network structure affects the stock market.
- Diameter has the strongest ability to predict market volatility and improve R^2.

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ABSTRACT

In this paper, we build a network of listed companies in the Chinese stock market based on common shareholding data from 2003 to 2013. We analyze the evolution of topological characteristics of the network (e.g., average degree, diameter, average path length and clustering coefficient) with respect to the time sequence. Additionally, we consider the economic implications of topological characteristic changes on market volatility and use them to make future predictions. Our study finds that the network diameter significantly predicts volatility. After adding control variables used in traditional financial studies (volume, turnover and previous volatility), network topology still significantly influences volatility and improves the predictive ability of the model.

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1. Introduction

The network of listed companies and shareholders has been widely studied. Many papers on this topic have focused on methods to generate networks and statistics of topological characteristics. One example includes building a bipartite network to describe the shareholding relationship between shareholders and companies [1,2]. Another study built a one-dimensional network to consider the cross-shareholding relationship among listing companies [3–6]. Most of these studies have focused on statistical topological characteristics such as degree, average path length, betweenness and clustering coefficient. The results have reflected the small-world characteristics and scale-free property of the companies' network [7–10].

Although these studies have improved our understanding of the interactive relationship between companies and shareholders, it is still not clear how these networks affect the stock market. In this paper, we focus on the relationship between shareholders' network and the volatility of stock market. Ref. [11] found a strong relationship between trading

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Table 1
Data for shareholders' change: Q_1 is Quarterly change number, Y_1 is yearly changes number, Q_2 is Quarterly Overlap Ratio, Y_2 is Yearly Overlap Ratio.

Year	Q_1	Y_1	Q_2	Y_2
2004	3.35	7.12	66.51%	28.80%
2005	3.88	6.97	61.17%	30.34%
2006	5.72	8.11	42.81%	18.95%
2007	5.73	8.96	42.67%	10.37%
2008	3.54	7.24	64.63%	27.65%
2009	4.60	6.71	53.95%	32.89%
2010	3.99	6.70	60.14%	32.96%
2011	3.37	6.44	66.30%	35.63%
2012	2.79	5.38	72.09%	46.22%
2013	3.50	5.55	64.95%	44.54%

network topological variables and stock volatility, but did not pay attention to the economic implication of the network. Two main differences distinguish our study from those above:

Firstly, our study transformed the bipartite network used in previous studies into a one-dimensional version. In our paper, the network nodes represent the listed companies. A company was connected with another if it had an identical shareholder. From economic perspective, the edges of the one-dimensional network represent covariance between listed companies caused by the trading behavior of the common shareholders. A typical example is described in Ref. [12] that the two stocks held by same mutual funds may have significantly positive correlation on their returns. The one-dimensional network allows us to catch the similar economic mechanism as in Ref. [12]. We assume companies B and C have independent fundamentals. However, because fund A may simultaneously buy and sell the share of B and C, the stock prices of two companies may fluctuate simultaneously. If more shares of B and C are held by investment fund A, greater correlation of volatility exists between the two companies. In our network, fund A is the common shareholder. Companies B and C are connected because they have the same shareholder. Moreover, we consider two types of networks: unweighted and weighted. The weight is based on how many common shareholders exist.

Secondly, our study emphasizes the economic interpretation of network topological characteristics and the mechanism that how changes of network affect the market volatility. In our common shareholding-based network, topological characteristics reflect investment diversification of shareholders (especially those who own the majority of market wealth) [13]. For example, when the investment is more decentralized, investors hold more stocks but less shares of each. Therefore, more common shareholders exist in the stock market, and companies correlate with each other more strongly. Because of the lower shareholding weight, the reduction of shareholders has a limited impact on the stock market. Conversely, if the network appears loosely structured, there are less common shareholders and more concentrated investments. Investors probably allocate most of their wealth to a limited number of stocks. Because of heavy weights on shares, the reduction of the holdings of common shareholders leads to herding behaviors, information cascade and large stock volatility [14,15].

Our network modeling method is more meaningful in the Chinese stock market because of the frequent trading of large shareholders. In the Chinese stock market, investment institutions and large individual shareholders prefer trading rather than holding stocks and sharing profits with the company (statistics shown in Table 1). Studies [16,17] showed that large shareholders in Chinese stock market present heavily herding behavior, especially in bulling and falling period [18]. Our statistics also showed that large shareholders tend to buy and sell stocks simultaneously when they are affected by market sentiment. The frequent trading of large shareholders induced price fluctuation, as well as the change of common shareholders of stocks, which caused the correlation between shareholders' network and market volatility.

For the topological characteristics, we select four indicators to measure change in network structure: average degree, clustering coefficient, average path length and diameter. When investment diversification in the market is high, the network average degree and clustering coefficient are higher because there are more common shareholders. Companies in the network have more neighbors or have formed more communities. The average path length and diameter are lower because more neighbors decrease the distance between two companies in the network, as well as the maximum distance between two companies. Conversely, when investment diversification is low, the opposite occurs. We use the network structure to predict market volatility. Our null hypothesis is as follows: a listed company's network can predict future market volatility. If the current network structure is tight (having a higher degree, or shorter diameter), trading behavior of large shareholders has less impact on market volatility, and vice versa.

Based on the above, we linked topological characteristics to the stock market volatility. Our results showed that changes in diameter, average path and clustering coefficient can significantly predict market volatility in the next period. Moreover, we add in control variables that are widely believed to have a relationship with market volatility in traditional financial studies, including the following: trading volume [19–21], turnover [22–24], and volatility in the previous period [25,26]. After taking control variables into account, the prediction of diameter on the market volatility is still significant. To improve the r-square, a comparison is made with the model having only control variables. The results of this comparison imply that overall investment diversification has the potential to influence future market volatility. Our result is consistent with the economic theory of institutions' trading behavior [27] and the shareholders' impact on co-movement of stocks' volatility [12,28]. Our study also shows that the network based on common shareholders reflects information regarding the