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Which stocks are profitable? A network method to investigate the effects of network structure on stock returns

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HIGHLIGHTS

- A network method is developed to investigate the structural evolvement of Chinese stock market.
- A modularity method is proposed to detect the inter-effect and intra-effect of industries.
- Regression models are developed to determine the effect of network metrics and stock returns.

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ABSTRACT

According to asset pricing theory, a stock's expected returns are determined by its exposure to systematic risk. In this paper, we propose a new method for analyzing the interaction effects among industries and stocks on stock returns. We construct a complex network based on correlations of abnormal stock returns and use centrality and modularity, two popular measures in social science, to determine the effect of interconnections on industry and stock returns. Supported by previous studies, our findings indicate that a relationship exists between inter-industry closeness and industry returns and between stock centrality and stock returns. The theoretical and practical contributions of these findings are discussed.

1. Introduction

According to asset pricing theory (APT), a stock's expected returns are determined by its exposure to environmental and systematic risk [1–4]. However, traditional pricing models are mostly defined based on the features of individual stocks, such as firm size, book-to-market equity ratio, and price-to-cash flow ratio. Thus, the inter-stock and inter-industry effects on stock returns remain unknown.

Recent financial research has used network models to represent the underlying relations between industries. Most of these networks are quite simple, with industries as nodes and business trades between industries as edges. Systematic risks contained in the industry network are then investigated to explain industry returns. For example, Acemoglu et al. [5] argue that sectoral risks can be transmitted to other sectors through a network of input and output linkages in a system [5]. Starting from the idea of network structure, Aobdia et al. [6] construct an industry network based on trade flows across different industries and find that firms in central industries are more exposed to systemic risks than other firms [6]. Ahern and Jarrad (2014) further shows that systematic risks constitute the aggregation of idiosyncratic shocks and that sectors that are more central in a network of intersectoral trade usually have higher returns because they experience greater exposure to systematic risk [7].

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Complex networks based on individual stock indicators, such as price, volume, and volatility, have also attracted attention from researchers in physics and statistics. In such a network, individual stocks are nodes, and the correlations between stock returns are usually used as edges. Such studies focus on the features and structures of the complex network itself, and few financial problems are discussed. In our study, we apply the network construction method to a complex network in order to investigate the effects of network structure on stock returns. Specifically, we investigate the following two detailed research questions:

(1) Do industry relations in a network affect industry returns?
(2) Do stock relations in a network affect stock returns?

Regarding the first question, previous studies [5–7] have shown that risk can be transmitted between industries, leading to a return framework based on industry relations. Asness, Porter, and Stevens [8] include both within-industry and across-industry variables to model stock returns [8]. We similarly construct two industry-related components based on the network structure of the stock market, namely, intra-industry closeness and inter-industry closeness, to explain returns.

Regarding the second question, few studies have examined the relationship between individual stock returns and stock relations. However, Ahern and Jarrad (2014) has shown that industries in more central network positions tend to have higher returns [7]. To determine whether this finding also applies to individual stocks, we measure stocks' network centrality in this study.

The rest of the paper is organized as follows: Section 2 reviews relevant prior work on complex networks. Section 3 describes the analytical method. Detailed results are then presented in Section 4. Finally, we discuss the findings and conclude the paper in Section 5.

2. Complex networks

2.1. Complex network theory and its application

Complex network theory originates from discrete mathematics and graph theory, and it has developed over many decades as a theoretical framework for understanding the structural characteristics of networks [9]. Two well-known classes of complex networks are scale-free networks [10] and small-world networks [11,12]. Both of these types of networks are characterized by specific structural features—power-law degree distributions for the former and short path lengths and high clustering for the latter. As the study of complex networks has continued to increase in importance and popularity, many other aspects of network structure have attracted research attention, and research on complex networks has been used in fields such as computer science, biology, communications and engineering, and the social sciences [13].

2.2. Complex network analysis on stock markets

The dynamic nature of a financial market can be mapped as a complex network. For a stock market, networks are constructed based on the correlations of stock price returns. Previous research has examined the common topological and statistical features of such networks (Table 1). For example, Lee et al. [14] show that a network based on the Korean stock exchange is a scale-free network [14]. Boginski et al. [15] and Huang et al. [16] further show that stock networks follow a power-law model [15,16]. Given these findings, cliques and independent sets in stock networks have been identified [15], providing a technical method for determining stock clustering. In addition to these studies, much recent work uses network structure to elucidate the underlying properties of stock markets. For example, Tabak et al. [17] find that the relative importance of different industries within a stock network varies [17]. Tse et al. [18] study different stock network structures by using different construction methods, ultimately developing an index method [18]. Lee et al. [19] use the minimum spanning tree method on Korean stock market data and find that higher market volatility is associated with a denser minimum spanning tree of stocks [19]. Peron et al. [20] view stock markets as evolving systems [20]. They propose an entropy-related measure to analyze the topological and dynamic evolution of financial networks and to identify shared behaviors between stocks during financial crises.

In addition to price return networks, networks based on relations between investors and transactions in a stock market are also constructed. For example, Li and Wang [21] use networks to represent various patterns of HSI fluctuation, and based on important topological nodes, they extract hidden patterns of such fluctuation [21]. Moreover, Bakker et al. [22] consider the psychological factors that affect market valuation to construct "investor trust networks" [22]. Their simulation results show that real-life trust networks can significantly delay the stabilization of a market. Jiang et al. [23] construct a trading network between investors of a highly liquid stock and find that the trading network has a power-law degree distribution and disassortative architectures [23]. Furthermore, they extend their work on trading networks to investigate financial research problems. One representative work is to identify the abnormal trading motifs and stock manipulations based on the network topology [24]. It contributes to the field of market surveillance. Another work is to study the correlations between market indicators and network topological metrics to unveil how the trading behaviors affect the market performance [25]. It contributes to the behavioral finance research.