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Q1 Geography and distance effect on financial dynamics in the Chinese stock market

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HIGHLIGHTS

- Geography and distance effect is investigated for the Chinese stock market.
- Stock location has an impact on financial dynamics in most time.
- Probability of short distance is much greater than that of the long distance.
- Stock distance only affects the stock correlation of the Shanghai market.

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ABSTRACT

Geography effect is investigated for the Chinese stock market including the Shanghai and Shenzhen stock markets, based on the daily data of individual stocks. The stocks in the Shanghai city and the Guangdong province are found to greatly contribute to the Shanghai and Shenzhen markets in the geographical sector, respectively. By investigating a geographical correlation on a geographical parameter, the stock location is found to have an impact on the financial dynamics, except for the financial crisis time of the Shenzhen market. Stock distance effect is further studied, with the probability of the short distance observed to be much greater than that of the long distance. The distance is found to only affect the stock correlation of the Shanghai stock market, but has no effect on the Shenzhen stock market.

1. Introduction

Stock market has an essential function to the country economics, therefore the market evolution has attracted a great interest of scientists from different research fields, such as the economists, mathematicians, and physicists. Among them, a lot of physicists devoted to the study of financial dynamics in the past two decades [1–14], and some stylized facts have been revealed from the statistical physics perspective. Scaling behavior of the return and return interval distributions has been observed for different markets [1–4,15–18]. Volatility clustering is found to be universal for most markets [3,19]. The time correlation and time-spatial correlation is widely studied for the financial markets [20,21]. Various models have

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been proposed to understand the underlying mechanism of financial dynamics [22–25], and the economic dynamics is also investigated from the experimental perspective [26,27].

Previous studies have gained abundant characteristic of financial dynamics. However, there are few studies focusing on the geography effect on financial dynamics, by using the long-term empirical data of individual stocks. In fact, how the geography affects the finance is an important economic issue, and has received a wide discussion from the economic literature. It has ever been regarded that the rapid development of telecommunication and internet has changed the geography role in finance [28]. Economic space becomes no longer important [29–31]. However, a contrast point of view says that the spatial effect is still critical [32,33]. The geographical information has an essential influence on the pattern of cross-border equity [34]. The cultural distance is also found to contribute to the transaction cost [35]. Lucey et al. find a higher country-pair linkage for the smaller cultural distance [36]. Up to now, how geography and distance affect the financial dynamics still remains controversial.

In this article, we try to understand the geography effect on the stock market, by applying the random matrix theory, cross-correlation function, etc., based on the daily data of the individual stocks of the Chinese stock market. Our results show that the stock location still has an impact on the financial dynamics in most time. The stock distance is found to only have an impact on the Shanghai stock market, but have no influence on the Shenzhen stock market.

2. Datasets and geographical sector

The datasets are based on the daily data of the individual stocks of the Chinese stock market from the Jan. 1, 2005 to Dec. 31, 2010. Since the market experiences the financial crisis around the year 2008, the data cover three stages of the time before, in, and after the financial crisis. To ensure the stock liquidity, only the stocks whose number of trading days is no less than 150 days are selected. Finally, 778 stocks are chosen in the Shanghai stock market (SH), and 474 stocks are chosen in the Shenzhen stock market (SZ). The stock location is denoted as the headquarter location of the company, and the location of the selected stocks covers all the provinces of China.

Before investigating the geography effect on the financial dynamics, let us introduce the return and correlation definitions. For a stock i, the price return $R_i(t')$ of time t' is defined as the Logarithm return of the price $P_i(t')$ over one day,

$$R_i(t') = \ln P_i(t') - \ln P_i(t'-1). \tag{1}$$

The normalized return $r_i(t')$ of stock i is defined as,

$$r_i(t') = \frac{R_i(t') - \langle R_i(t')\rangle}{\sigma_i} \tag{2}$$

where $\sigma_i = \sqrt{\langle R_i^2\rangle - \langle R_i\rangle^2}$. The stock correlation of the price return is defined as,

$$c_{ij} = \langle r_i r_j\rangle. \tag{3}$$

In the past studies, the economic sectors have been widely investigated based on the random matrix theory [37–39]. Business sectors can be identified for most mature markets, except for the Chinese stock market. The stocks of the Chinese stock market are identified by the ST and Blue-chip sectors [38]. To understand how the geography affects the financial dynamics, here we apply the random matrix theory to revealing the geographical sector. Based on the stock correlations of the price returns in Eq. (3), the eigenvalues and eigenvectors of the correlation matrix C are analyzed. By searching for the dominant components in the eigenvectors of the first several largest eigenvalues, the geographical sectors can be identified.

As shown in Fig. 1, the absolute values $|u_i|$ of the eigenvectors are displayed for the first four largest eigenvalues of the Shanghai and Shenzhen stock markets. For both markets, a uniform distribution is observed for the eigenvectors of the largest eigenvalue λ_0. That is, similarly as the business sector [40,41], the largest eigenvalue corresponds to some "market mode" for the geographical sector. However, for the second and third largest eigenvalues, it is observed that the stocks located in the Shanghai city dominate the Shanghai stock market, and the stocks located in the Guangdong province dominate the Shenzhen stock market, respectively. For the fourth largest eigenvalue λ_3, one cannot find the significant component, i.e., no specific sector is identified. The results suggest that the stocks located in the Shanghai city and the Guangdong province play an essential role in the Shanghai and Shenzhen stock market, and the location of financial center is still crucial in financial dynamics.

3. Geographical correlation dynamics

Further, the geography effect on the stock correlation dynamics is investigated. We make a two-dimensional map for the stock location. As shown in Fig. 2, all the stocks are mapped onto an $N \times N$ lattice according to the stock location, with $N = 10\,000$. The longitude (Lon) of the stock location is mapped onto the x-axis of the lattice, and the latitude (Lat) of the stock location is mapped onto the y-axis of the lattice. The x-axis and y-axis are uniformly divided by N, with the lattice interval of the x-axis and y-axis to be $l_x = \frac{Max(Lon)-Min(Lon)}{N}$ and $l_y = \frac{Max(Lat)-Min(Lat)}{N}$, respectively. If the

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