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Spatial and temporal structures of four financial markets in Greater China

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HIGHLIGHTS

- Sector and subsector structures for different stock markets.
- The leverage effect in Taiwan and Hong Kong stock markets.
- The anti-leverage and leverage effects in mainland China in two different periods.
- The power-law behavior in recurrence interval distributions.

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ABSTRACT

We investigate the spatial and temporal structures of four financial markets in Greater China. In particular, we uncover different characteristics of the four markets by analyzing the sector and subsector structures which are detected through the random matrix theory. Meanwhile, we observe that the Taiwan and Hong Kong stock markets show a negative return-volatility correlation, i.e., the so-called leverage effect. The Shanghai and Shenzhen stock markets are more complicated. Before the year 2000, the two markets exhibited a strong positive return-volatility correlation, which is called the anti-leverage effect. After 2000, however, it gradually changed to the leverage effect. We also find that the recurrence interval distributions of both the trading volume volatilities and price volatilities follow a power law behavior, while the exponents vary among different markets.

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1. Introduction

Financial markets are complex systems with many-body interactions. In recent years, much attention of physicists has been paid to the financial dynamics, and physical concepts and methods are applied to analyze the dynamic behavior. As large amounts of financial data are available now, it allows to explore the fine structure of the financial dynamics and achieve various empirical results [1–8]. With rapid development of the economy, the financial markets in Greater China attract more attention from the world. Let us now focus on four stock markets, i.e., the Shanghai stock market, Shenzhen stock market, Taiwan stock market and Hong Kong stock market. Due to different political and economic systems, the dynamic behavior varies much among the four markets. The economy style of Taiwan is a typical export-oriented one. The stock market developed much through several important economic policies, such as import substitution, export expansion and structural adjustment. Hong Kong is a financial center in Asia, and the economy is prosperous. The Shanghai and Shenzhen stock markets are both in mainland China, and undergoing rapid development in recent years. To the best of our knowledge, there have not been literatures focusing on the comparative study of the spatial and temporal structures of the four stock

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Table 1
The second column shows the time periods of 259 stocks for the Shanghai (SH), Shenzhen (SZ), Taiwan (TW) and Hong Kong (HK) stock markets. T is the total number of the daily data. $\lambda^{ran}_{\min(\max)}$ represents the low (up) bound of the eigenvalues of the Wishart matrix, while $\lambda^{real}_{\min(\max)}$ is that of the real cross-correlation matrix. γ_p is the power law exponent for the price volatility, and γ_v is the one for the volume volatility.

	Time period	T	$\lambda^{ran}_{\min}$	$\lambda^{ran}_{\max}$	$\lambda^{real}_{\min}$	$\lambda^{real}_{\max}$	γ_p	γ_v
SH	2003.1–2011.7	2067	0.42	1.83	0.02	98.0	3.0	4.2
SZ	2003.1–2011.4	2000	0.41	1.85	0.12	98.0	3.1	4.3
TW	2003.1–2011.11	2206	0.43	1.80	0.14	72.3	3.2	4.7
HK	2003.1–2011.9	2146	0.43	1.82	0.12	35.5	3.2	3.7

markets, although some relevant works could be found such as the comparison between the response dynamics in transition economies and developed countries [9]. In this paper, we intend to provide a comparative study about the four stock markets, and understand how political and economic environments may influence the financial dynamics.

In the past years the properties of the cross-correlation matrix of individual stock prices have been analyzed, e.g., with the random matrix theory (RMT), and much effort has been made to identify the business sectors by the components in the eigenvectors of the cross-correlation matrix [10–17]. In this paper, the analysis of the so-called spatial structure is just an analysis about the cross-correlations between individual stocks based on the RMT theory. After taking into account the signs of the components in an eigenvector, a sector may be further separated into two subsectors, i.e., the positive and negative subsectors [18]. The purpose of this paper is to investigate the spatial structures of the four stock markets in Greater China, and uncover characteristics of the sector and subsector structures for each market.

The dynamic behavior of the stock prices has been studied for years, and various results have been obtained. For example, the probability distribution of the price return usually exhibits a power-law tail, the price volatility is long-range correlated in time, while the price return itself is short-range correlated [2,19–21]. To better understand the dynamic behavior of the stock prices, one may consider a higher-order time correlation, i.e., the return-volatility correlation [5,6,14,22]. A negative return-volatility correlation, which is called the leverage effect, was first discovered by Black in 1976 [23,24]. The leverage effect is observed in most of the stock markets in the world, while a positive return-volatility correlation, which is called the anti-leverage effect, was detected in the stock markets of mainland China [1,4,6]. The leverage and anti-leverage effects are crucial for the understanding of the price dynamics [5,6,22]. In this study, we analyze the return-volatility correlation function of the four corresponding stock-market indices, i.e., the Shanghai Composite Index, Shenzhen Composite Index, Taiwan Weighted Index and Hang Seng Index.

The analysis of the recurrence interval may deepen the understanding of the dynamic behavior in financial markets [21,25]. Recently, statistical properties of the recurrence intervals of volume volatilities and price volatilities have been studied [26–29]. We present a comparative study on the recurrence interval distributions of the four stock markets. For each market, we analyze the recurrence interval distributions for both the trading volume volatilities and the price volatilities.

The paper is organized as follows. In Section 2, we investigate the sector and subsector structures. In Section 3, we analyze the return-volatility correlation function and the distributions of the recurrence intervals for both volume volatilities and price volatilities. In Section 4, we present the conclusion.

2. Sector and subsector structures

We define the logarithmic price return of the ith stock over a time interval Δt as

$$R_i(t', \triangle t) \equiv \ln P_i(t' + \triangle t) - \ln P_i(t'), \tag{1}$$

where $P_i(t')$ represents the close price at time t', and we set Δt to be one day. To ensure that the results are independent of the fluctuation scales of the stock prices, we introduce the normalized return of the ith stock

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

where $\langle \cdots \rangle$ represents the time average over time t' and the standard deviation of R_i is denoted by $\sigma_i = \sqrt{\langle R_i^2 \rangle - \langle R_i \rangle^2}$ [30]. Then, the elements of the equal-time cross-correlation matrix C are defined by

$$C_{ij} \equiv \langle r_i(t') r_j(t') \rangle, \tag{3}$$

which measure the correlations between the returns of individual stocks. According to the definition, C is a real symmetric matrix with $C_{ii} = 1$. The value of C_{ij} ranges from -1 to 1.

In this paper, we compute the cross-correlation matrix C with the daily stock prices of the four stock markets in Greater China. The time periods of 259 stocks for each stock market are shown in the first column of Table 1. Why do we choose 259 stocks for each stock market? On the one hand, we should use as many stocks as we can. On the other hand, the available data of the stocks should be as long as possible. Under these conditions we obtain 259 stocks for the Shanghai stock market.

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