



Analysis of network clustering behavior of the Chinese stock market



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HIGHLIGHTS

- We show that there exist prominent sector structures.
- Furthermore, the Real Estate (RE) and Commercial Banks (CB) subsectors are mostly anti-correlated.
- We find that while the sector structures are relatively stable from 2007 through 2013.
- We show that this anti-correlation behavior is closely related to the monetary and austerity policies of the Chinese government.

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ABSTRACT

Random Matrix Theory (RMT) and the decomposition of correlation matrix method are employed to analyze spatial structure of stocks interactions and collective behavior in the Shanghai and Shenzhen stock markets in China. The result shows that there exists prominent sector structures, with subsectors including the Real Estate (RE), Commercial Banks (CB), Pharmaceuticals (PH), Distillers&Vintners (DV) and Steel (ST) industries. Furthermore, the RE and CB subsectors are mostly anti-correlated. We further study the temporal behavior of the dataset and find that while the sector structures are relatively stable from 2007 through 2013, the correlation between the real estate and commercial bank stocks shows large variations. By employing the ensemble empirical mode decomposition (EEMD) method, we show that this anti-correlation behavior is closely related to the monetary and austerity policies of the Chinese government during the period of study.

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1. Introduction

In recent years, the dynamics of financial markets have attracted much attention. Indeed, a financial market can be viewed as a complex system that consists of many individuals interacting (nonlinearly) with each other. In such a system, quantities such as the stock prices can be observed which show frequent large fluctuations and clustering behaviors that have been well documented [1,2] that are commonly known as the stylized facts of financial markets. These stylized facts are both affected by the internal interactions among the individual elements and also the external information on the market. Researchers have studied the statistical properties of stock price fluctuations and also the correlations among different individual stocks [3–9]. They have discovered that whether they are mature markets in the US and Europe, or emerging

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Table 1
CICS 1st level of CSI300.

Industry	Code	Number of stocks	Closing price average	Closing price SD
<i>Industrials</i>	<i>IN</i>	64	14.19	29.90
<i>Financials</i>	<i>FI</i>	52	13.08	15.15
<i>Materials</i>	<i>MA</i>	51	16.52	36.60
<i>Materials</i>	<i>MA</i>	51	16.52	36.60
<i>Consumer discretionary</i>	<i>CD</i>	27	15.67	22.19
<i>Energy</i>	<i>EN</i>	23	20.13	32.50
<i>Health care</i>	<i>HC</i>	16	26.70	44.93
<i>Consumer staples</i>	<i>CS</i>	14	33.25	81.87
<i>Utilities</i>	<i>UT</i>	13	8.49	7.36
<i>Information technology</i>	<i>IT</i>	8	14.28	16.48
<i>Telecommunication services</i>	<i>TS</i>	3	14.28	29.44

markets such as those in China and India, there are universal behaviors on the distributions of stock price fluctuation—the inverse cubic law [3–6]. On the other hand, the statistical properties of the correlation among stocks of a market display both similarities and differences in different markets [10–12].

In order to explain the structure of the interactions between individual elements in a financial market, researchers have also analyzed the characteristics of the spectrum of correlation matrix of the stock price fluctuations. In a physical system, the interactions among individual units induce collective behavior and thus show correlations among the units. However, the interactions among individuals in a financial market are yet unknown to us. One of the methods to study the interactions among different stocks is the Random Matrix Theory [13,4,14,15]. Mathematically, the Random Matrix Theory is equivalent to Principal Component Analysis with a noise cut-off based on the Marchenko–Pastur distribution. We therefore adopt this method in the analysis of our dataset from the Chinese stock markets. More specifically, we study the market data from the China Securities Index 300 (CSI300).

2. Sample dataset

The China Securities Index 300 is normally rebalanced every six months except for temporary adjustments. In order to obtain a reasonably long sampling period, we collect the daily data of CSI300 index constituent stocks adjusted in June 2010 from 9 October 2007 to 29 March 2013 (excluding weekends and market closed dates). The dataset is filtered according to the following principles (the data obtained from Rasset Database): (1) Delete the stocks which have more than 50 missing trading days; (2) An individual stock is deleted from the dataset when it has missing prices for more than 25 continuous trading days; (3) For an individual stock when a trading day is missing, the closing price of the previous trading day is used. In accordance with the criteria above, 214 stocks remain in the sample dataset and each stock has 1334 observations.

According to the China Securities Index Co. Ltd, these stocks are classified into 10 industries by the China Industry Classification Standard (CICS), and are listed in Table 1. The listed companies are divided into 10 CICS First Level Industry (CICS1), 25 CICS Second Level Industry (CICS2), 67 CICS third Level Industry (CICS3), and 38 CICS fourth Level Industry (CICS4). In Table 1, the closing price average is the average of all the daily closing price average over the whole trading period of the stocks within that industry. Similarly, the closing price standard deviation (SD) is the average of all the closing price standard deviation of the stocks over the whole trading period within the same industry.

3. Analysis of structure of the CSI300 sectors

We here define the logarithmic price return $R_i(t)$ of stock i on trading day t as:

$$R_i(t) = \ln p_i(t) - \ln p_i(t - 1), \tag{1}$$

where $p_t(t)$ is the closing price of the i th stock on trading day t . In order to compare the results of different datasets, we further normalize the logarithmic price return as follows:

$$r_i(t) = \frac{R_i(t) - \langle R_i(t) \rangle}{\sqrt{\langle R_i(t)^2 \rangle - \langle R_i(t) \rangle^2}}, \tag{2}$$

where $\langle X \rangle$ stands for the average of X during the trading period. From Eq. (2), we can then obtain the cross-correlation matrix C . Its elements C_{ij} are defined as:

$$C_{ij} = \langle r_i(t)r_j(t) \rangle. \tag{3}$$

It is clear that the correlation matrix C is a symmetric matrix with $C_{ii} = 1$, and $-1 \leq C_{ij} \leq 1$. If the N time series with length T are all uncorrelated, the resulting correlation matrix becomes the well-known Wishart Matrix [16,17]. In the limit

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