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Empirical study of recent Chinese stock market

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ABSTRACT

We investigate the statistical properties of the empirical data taken from the Chinese stock market during the time period from January, 2006 to July, 2007. By using the methods of detrended fluctuation analysis (DFA) and calculating correlation coefficients, we acquire the evidence of strong correlations among different stock types, stock index, stock volume turnover, A share (B share) seat number, and GDP per capita. In addition, we study the behavior of "volatility", which is now defined as the difference between the new account numbers for two consecutive days. It is shown that the empirical power-law of the number of aftershock events exceeding the selected threshold is analogous to the Omori law originally observed in geophysics. Furthermore, we find that the cumulative distributions of stock return, trade volume and trade number are all exponential-like, which does not belong to the universality class of such distributions found by Xavier Gabaix et al. [Xavier Gabaix, Parameswaran Gopikrishnan, Vasiliki Plerou, H. Eugene Stanley, Nature, 423 (2003)] for major western markets. Through the comparison, we draw a conclusion that regardless of developed stock markets or emerging ones, "cubic law of returns" is valid only in the long-term absolute return, and in the short-term one, the distributions are exponential-like. Specifically, the distributions of both trade volume and trade number display distinct decaying behaviors in two separate regimes. Lastly, the scaling behavior of the relation is analyzed between dispersion and the mean monthly trade value for each administrative area in China.

1. Introduction

Understanding economic phenomena in terms of ideas and tools from statistical physics has been very attractive to physicists [1–3]. In particular, empirical evidence of scaling and long-range correlations in financial time series is of great interest because of its analogy to collective phenomena in complex physical systems. Meanwhile, volatility of financial time series is a key variable in analyzing and modelling financial markets. It concerns the risk measures associated with the dynamics of price of a financial asset. The absolute value of the return, which is a traditional measure for volatility, usually has a memory and hence a return is more likely to be followed by a return with close (absolute) value, which leads to periods of large volatility and other periods of small volatility (called volatility clustering) [4–7]. However, in this paper, we change the definition of volatility to be the absolute value of the difference between the daily new account numbers for two consecutive days. Based on such a definition the volatility clustering has also been observed.

Recent studies [8–11] reveal more information about the temporal structure of the volatility time series by analyzing volatility return intervals, the time between two consecutive events with volatilities greater than a given threshold. The

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regularity discovered is analogous to a statistical law discovered in geophysics more than a century ago and known today as the Omori law [12] describing the aftershock following a large earthquake. Here, we show the relaxation dynamics of the new volatility characterized by the Omori law, which holds not only after significant volatilities, but also after "intermediate-shocks".

The statistical properties of financial time series exhibit several universalities verified by many diverse financial markets, which are called stylized facts [13–15]. Here, we particularly pay attention to the following ones. For example, the power-law distribution of stock return and the number of trade, with exponent $\zeta_r = \zeta_N \simeq 3$; the power-law distribution of trading volume, with exponent $\zeta_q \simeq 1.5$. All previous studies [16–19] were based on the financial data from mature financial markets in developed countries. Here, in this paper, on the base of empirical analysis and theoretical reasoning, we present dramatically different results by checking the data generated by the recent Chinese stock market. It is found that the robustness of the "cubic law of returns" and "half-cubic law of trading volume" has been broken. We draw a more specific and accurate conclusion.

In addition, we perform the scaling analysis of the fluctuations of trade activities that are occurred in the recent Chinese stock market through the method of mean-variance analysis introduced by Menezes and Barabasi [20–22]. Furthermore, we explore the correlations among several fundamentally quantities such as different stock types, stock index, volume turnover, A share (B share) seat number, and GDP per capita with the tools of detrended fluctuation analysis (DFA) [23–26] and correlation coefficient, which is helpful for understanding the fluctuation behavior in Chinese stock market.

This paper is organized as follows. Section 2 presents information about the data set. In Section 3, we present the correlations between those quantities mentioned in the paragraph right above and show the evidence of abnormality of Chinese stock market in the period considered. In Section 4, we study the relaxation dynamics of aftershocks after large volatility. In Section 5, we check the statistical behavior of stock return, trade volume and the number of trade and propose a theoretical proof, based on a plausible assumption, which provides an explanation for some empirical findings. Besides, we analyze the scaling behavior of the fluctuations of trade activities. Section 6 presents a brief discussion and the main conclusion.

2. The data sets

In order to capture various characteristics of Chinese stock market, we analyze three different data sets.

(1) We study the Shanghai Stock Market Monthly Statistics [27] from January, 2006 to July, 2007. We analyze the time series of several quantities, such as 380 daily P/E ratio $r(t)$ for seven different stock types, the number of new holders' accounts for each month, monthly close price of SSE Composite Index, and regional distribution of listed companies classified by stock type and sectors, of member firms by turnover ranking, and of A share holders' accounts, traded value and trade number of A share in thirty-one administrative areas (provinces, autonomous regions and municipalities) in China.

(2) The second data set is composed of population size and GDP per capita of each administrative area in 2005 and 2006 which are provided by National Bureau of Statistics of China [28].

(3) In order to compare the difference from western markets, we get 395 daily trade data of SP500 Index (New York), CAC40 Index (Paris), and FTSE 100 Index (London) in the time period from 4 April, 2006 to 31 July, 2007 in the third data set from Yahoo Finance [29].

3. Correlation behavior

The correlations of stock returns are important for risk estimation, and can be utilized for forecasting financial time series [30–34]. To quantify the long-term memory property in financial time series, we use the detrended fluctuation analysis (DFA). This method, proposed by Peng et al. [23], is based on random walk theory. Its advantage over many other methods, for instance autocorrelation and Hurst Index, is that it allows for the detection of long-range correlations embedded in seemingly non-stationary time series and also avoids the spurious detection of apparent long-range correlations caused by artifacts of non-stationarity.

Let us suppose that x_i $(i = 1, \ldots N)$ is a time series of length N. The first thing to be done in DFA is to integrate the time series

$$y(j) = \sum_{i=1}^{j} \left[x_i - \langle x \rangle\right], \tag{1}$$

where

$$\langle x \rangle = \frac{1}{N} \sum_{i=1}^{N} x_i \tag{2}$$

is the global mean value of the time series x_i. Then the second step in DFA is to divide the integrated time series into n_s non-overlapping boxes of equal length s. Due to the fact that some of the data points may be left out, the procedure is repeated