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Statistical properties of daily ensemble variables in the Chinese stock markets

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Abstract

We study dynamical behavior of the Chinese stock markets by investigating the statistical properties of daily ensemble return and variety defined, respectively, as the mean and the standard deviation of the ensemble daily price return of a portfolio of stocks traded in China's stock markets on a given day. The distribution of the daily ensemble return has an exponential form in the center and power-law tails, while the variety distribution is lognormal in the bulk followed by a power-law tail for large variety. Based on detrended fluctuation analysis, R/S analysis and modified R/S analysis, we find evidence of long memory in the ensemble return and strong evidence of long memory in the evolution of variety.

Keywords: Econophysics; Ensemble return; Variety; Probability distribution; Long memory; Statistical test

1. Introduction

Financial markets are complex systems, in which participants interact with each other and react to external news attempting to gain extra earnings by beating the markets. In the last decade, econophysics has begun to flourish since the pioneering work of Mantegna and Stanley in 1995 [1]. Econophysics is an emerging interdisciplinary field, where theories, concepts, and tools borrowed from statistical mechanics, nonlinear sciences, mathematics, and complexity sciences are applied to understand the self-organized complex behaviors of financial markets [2–4]. Econophysicists have discovered or rediscovered numerous stylized facts of financial markets [2,5], such as fat tails of return distributions [1,6–13], absence of autocorrelations of returns [2], long memory in volatility [14–16], intermittency and multifractality [7,17–19], and leverage effect [20,21], to list a few.

Recently, Lillo and Mantegna have introduced the conception of ensemble variable treating a portfolio of stocks as a whole [22–25]. They have defined two quantities, the ensemble return and variety. The ensemble return μ is the mean of the returns of the portfolio at time t, which is a measure of the market direction, while the variety σ is the standard deviation of all the returns at time t, which characterizes how different the

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behavior of stocks is. In the time periods when the markets are very volatile, the ensemble return has larger fluctuations and the variety is larger as well. It is very interesting to note that there are sharp peaks in the variety time series when the market crashes [24,25], which is reminiscent of the behavior of volatility. In addition, the daily ensemble return of stocks in the New York Stock Exchange (NYSE) is found to be uncorrelated, while the daily variety has long memory [23]. Despite of such remarkable similarities shared by the ensemble return and the return and by the variety and the volatility, there is significant difference between these "competing" quantities, especially the shapes of the corresponding distributions.

There are a huge number of studies in the literature showing that emerging stock markets behave differently other than the developed markets in many aspects. In most developed markets, the daily return has well established fat tails, while the distributions of daily returns are exponential in several emerging markets, e.g., in China [26], Brazil [27], and India [28]. It is very interesting to investigate the statistical properties of the ensemble variables extracted in emerging stock markets, which is the main motivation of the current work. We shall focus on the Chinese stock markets in this paper.

The paper is organized as follows. In Section 2, we explain the data set analyzed and define explicitly the ensemble return and variety. Section 3 presents analysis on the probability distributions of the daily ensemble return and variety. We discuss in Section 4 the temporal correlations of the two quantities, where we adopt R/S analysis and detrended fluctuation analysis (DFA) to estimate the Hurst index and perform statistical tests using Lo's modified R/S statistic. The last section concludes.

2. China's stock markets

Before the foundation of People's Republic of China in 1949, the Shanghai Stock Exchange (SHSE) was the third largest worldwide, after the NYSE and the London Stock Exchange and its evolution over the period from 1919 to 1949 had enormous influence on other world-class financial markets [29]. After 1949, China implemented policies of a socialist planned economy and the government controlled entirely all investment channels. This proved to be efficient in the early stage of the economy reconstruction, especially for the heavy industry. However, planned economic policies have unavoidably led to inefficient allocation of resources. In 1981, the central government began to issue treasury bonds to raise capital to cover its financial deficit, which reopened the China's securities markets. After that, local governments and enterprises were permitted to issue bonds. In 1984, 11 state-owned enterprises became share-holding corporations and started to provide public offering of stocks. The establishment of secondary markets for securities occurred in 1986 when over-the-counter markets were set up to trade corporation bonds and shares. The first market for government-approved securities was founded in Shanghai on November 26, 1990 and started operating on December 19 of the same year under the name of the SHSE. Shortly after, the Shenzhen Stock Exchange (SZSE) was established on December 1, 1990, and started its operations on July 3, 1991. The historical high happened in 2000 when the total market capitalization reached 4968 billion yuan (55.5% of GDP) with 1535.4 billion yuan of float market capitalization (17.2% of GDP). The size of the Chinese stock market has increased remarkably.

The data set we used in this paper contains daily records of $n = 500$ stocks traded the SHSE and SZSE in the period from February 1994 to September 2004. The total number of data points exceeds one million. For each stock price time series, we calculate the daily log-return as follows:

$$r_i(t) = \ln[P_i(t)/P_i(t-1)], \tag{1}$$

where $P_i(t)$ is the close price of stock i on day t. The ensemble return $\mu(t)$ is then defined by

$$\mu(t) = \frac{1}{n}\sum_{i=1}^{n} r_i(t), \tag{2}$$

while the variety $\sigma(t)$ is defined according to

$$\sigma^2(t) = \frac{1}{n}\sum_{i=1}^{n}[r_i(t) - \mu(t)]^2. \tag{3}$$