Physica A 389 (2010) 1635–1642

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

Analysis of market efficiency for the Shanghai stock market over time

Yudong Wang *, Li Liu, Rongbao Gu, Jianjun Cao, Haiyan Wang

School of Finance, Nanjing University of Finance & Economics, Nanjing, 210046, PR China

ARTICLE INFO

Article history:
Received 22 June 2009
Received in revised form 26 October 2009
Available online 4 January 2010

Keywords:
Market efficiency
Scale behavior
Hurst exponents
Multifractality degrees
DME

ABSTRACT

In this paper, we analyze market efficiency for the Shanghai stock market over time using a model-free method known as multifractal detrended fluctuation analysis. Through analyzing the change of scale behavior, we find that the price-limited reform improved the efficiency in the long term, but the influence in the short term was very minor. Employing the method of moving window, using three different measures we find that the Shanghai stock market became more and more efficient after the reform. We also implement the same procedure on volatility series and find the evidence of inefficiency.

1. Introduction

The Shanghai Stock Exchange was constructed on November 26th, 1990 and was put into operation on December 19th in the same year which led to the establishment of the Chinese stock market. As an emerging market, the Chinese stock market was on the process of becoming more and more mature after it had experienced some essential reforms during its history of no more than twenty years. For listed companies and investors, one of the most important reforms was the price limit carried out on December 16th, 1996. After the reform, the range of daily price variations would be at most 10%, and some special treated stocks would be at most 5%. The Chinese stock market is a typically order-driven market. If an order price were 10% (some special treated stocks 5%) higher or lower than the closing price of a previous business day, the order would be ineffective and the transaction cannot be accomplished. This kind of artificial limit hampers the occurrence of the possible transactions to a certain extent which is intuitionally in contradiction with the free market. However, for an emerging market like the Chinese stock market, the limit is necessary and very important for controlling the speculative bubble. Before the reform, stock prices changed very fiercely with their range sometimes even reaching 100% in a day (such as 600 601, 600 653). The market could also be easily operated by some institutional investors. After the reform, the change of market index became more moderate. This reform produced essential effects on market micro-structure. It is very necessary for us to analyze the influences on market efficiency brought by the reform and the evolution of market efficiency during its history.

Many econophysicists contributed to the study of market efficiency (in Fama sense) through finding the evidence for long-range correlations. The Rescaled Range Hurst analysis (R/S) introduced by Hurst [1] in 1951 is the most popular scaling method to estimate power-law correlation exponents from random signals. However, the R/S statistic is highly influenced by outliers and presents a biased evaluation of the Hurst exponent. Peng et al. [2] proposed the detrended fluctuation analysis (DFA) when they studied the correlation of molecular chains in deoxyribonucleic acid (DNA). This method avoids the spurious detection of apparent long-range correlations that are an artifact of patchiness and has become a widely used technique for the determination of (mono-)fractal scaling properties. Using the method of DFA, Tabak and

* Corresponding author.
E-mail address: wangyudongnj@126.com (Y. Wang).

0378-4371/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.physa.2009.12.039

Cajueiro [3] also provided the evidence for the market becoming weakly efficient over time by testing for time-varying long-range correlations in prices of crude oil markets. Jose Alvarez-Ramirez et al. [4] found that crude oil markets displayed a time-varying short-term inefficient behavior that became efficient in the long term. Besides, Serletis and Rosenberg [5] considered that energy futures returns displayed long-range correlations and the particular form of which was anti-persistence employing detrended moving average analysis (DMA). Cajueiro and Tabak [6] using R/S method and AR-GARCH model analyzed emerging markets and found the evidence of becoming more and more efficient. Jose Alvarez-Ramirez [7] also found that the efficiency degrees of US stock markets were becoming higher and higher after the end of the Bretton Woods system using Time-varying Hurst exponent. Kian-Ping Lim [8] evaluated the relative efficiency of stock markets by comparing the extent of significant nonlinear serial correlations using Portmanteau bicorrelation test statistic in rolling sample framework. Cajueiro and Tabak [9] considered that financial market liberalization could increase the degree of market efficiency using time-varying Hurst exponent in the case of Athens stock exchange.

In this paper, we employ multifractal detrended fluctuation analysis (MF-DFA) to detect the evolution of efficiency degree of Shanghai stock market. We find that after an reform, Shanghai stock market became more efficient in the long term but inefficiency still existed in the short term. This reform also induced some instability to the market. To detect the local situation of market efficiency, we analyze the evolution of local Hurst exponents. We define a new measure of market efficiency degree, and find that the multifractality degree can also be used to measure the degree of market efficiency under a certain condition. Empirical results show that Shanghai stock market overall became more and more efficient after the reform. We also carry the same procedure on the volatility series. Empirical results show that volatility series of Shanghai stock market appear apparently long-range auto-correlations which indicate that the volatility series have no trend of becoming more efficient, and conventional models such as GARCH cannot be used to forecast the volatility of Shanghai stock market. Recent situation of market efficiency is also discussed.

This paper is organized as follows: Section 2 provides methodology. Data description is provided in Section 3. We show Empirical results in Section 4 and some discussions in Section 5. At last, we provide some conclusions in Section 6.

2. Methodology

The MF-DFA procedure consists of five steps as follows [10]:

Let $\{x_t, t = 1, \ldots, N\}$ be a time series, where N is the length of the series.

Step 1. Determine the "profile"

$$y_k = \sum_{t=1}^{k}(x_t - \bar{x}), \quad k = 1, 2, \ldots, N, \tag{1}$$

where $\bar{x}$ denotes the averaging over the whole time series.

Step 2. Divide the profile $\{y_k\}_{k=1,\ldots,N}$ into $N_s \equiv int(N/s)$ non-overlapping segments of equal length s. Since the length N of the series is often not a multiple of the considered time scale s, a short part at the end of the profile may remain. In order not to disregard this part of the series, the same procedure is repeated starting from the opposite end. Thereby, $2N_s$ segments are obtained altogether. Introduced by Peng et al. [2], we let $10 < s < N_s/5$.

Step 3. Calculate the local trend for each of the $2N_s$ segments by a least-square fit of the series. Then determine the variance

$$F^2(s, \lambda) \equiv \frac{1}{s}\sum_{j=1}^{s}[y_{(\lambda-1)s+j} - P_\lambda(j)]^2 \tag{2}$$

for $\lambda = 1, 2, \ldots, N_s$ and

$$F^2(s, \lambda) \equiv \frac{1}{s}\sum_{j=1}^{s}[y_{N-(\lambda-N_s)s+j} - P_\lambda(j)]^2 \tag{3}$$

for $\lambda = N_s + 1, N_s + 2, \ldots, 2N_s$. Here, $P_\lambda(j)$ is the fitting polynomial with order m in segment λ (conventionally, called mth order MF-DFA and wrote MF-DFAm).

Step 4. Average over all segments to obtain the qth order fluctuation function

$$F_q(s) = \left\{\frac{1}{2N_s}\sum_{\lambda=1}^{2N_s}[F^2(s, \lambda)]^{q/2}\right\}^{1/q} \tag{4}$$

for any real value $q \neq 0$ and

$$F_0(s) = \exp\left\{\frac{1}{4N_s}\sum_{\lambda=1}^{2N_s}\ln[F^2(s, \lambda)]\right\}. \tag{5}$$

We repeat steps 2 to 4 for several time scale s.