Physica A 389 (2010) 1425–1433

Contents lists available at ScienceDirect

Physica A

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

Long memory volatility in Chinese stock markets

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ARTICLE INFO

Article history:
Received 22 February 2009
Received in revised form 3 October 2009
Available online 21 December 2009

Keywords:
Volatility persistence
Semi-parametric test
Efficient market hypothesis

ABSTRACT

In this study, the long memory property in the volatility of Chinese stock markets is examined. For this purpose, we applied two semi-parametric tests (GPH and LW) and the FIGARCH model, to four Chinese market indices: Shanghai A, Shanghai B, Shenzhen A and Shenzhen B. From the results of our analysis, we can conclude that the volatility of Chinese stock markets exhibits long memory features, and that the assumption of non-normality provides better specifications regarding long memory volatility processes.

1. Introduction

It is well known that the volatility of financial asset returns often exhibits a long memory property where the autocorrelations of the absolute and squared returns of time series are characterized by a very slow decay [1]. Such a feature is a crucial component of asset risk management, investment portfolios, and the pricing of derivative securities, as its presence is closely connected to the predictability of volatility [2].

Although those working in econometrics became aware of volatility persistence in financial data at the beginning of the 1980s, a parsimonious tool able to analyze the long memory property in the volatility of financial time series has remained out of reach for researchers [3]. One linear measure of the long memory in volatility can be found in the fact that different return transformations, such as absolute returns, or squared returns, display a long memory property [4–20].

Interestingly, this evidence is not consistent with either the generalized ARCH (GARCH) model of Bollerslev [21] or the integrated GARCH (IGARCH) model of Engle and Bollerslev [22]. To overcome this problem, Baillie et al. [23] extended the standard GARCH model with a fractionally integrated process. This approach — the so-called fractionally integrated GARCH (FIGARCH) model — allows fractional orders $I(d)$ of integration between zero and one, and estimates an intermediate process between GARCH and IGARCH [24–28].

The primary aim of this study is to examine the long memory property in the volatility of four Chinese market shares (Shanghai A, Shanghai B, Shenzhen A and Shenzhen B) using three long memory techniques (the GPH test, the local Whittle estimator and FIGARCH model). The Chinese stock market possesses characteristics of a transition economic system and the trading of its shares are recently open to international investors. Due to difference of socialist and capitalist economic systems, the dynamics of the Chinese stock market may exhibit some unique characteristics compared to other mature stock markets. Recently, the Chinese stock market has received great attention from the econophysics community as a new source of empirical studies. For example, the scaling behavior and long range correlations are statistically discovered in stock returns, intertrade durations and the trading volume in the Chinese stock market [29–33].

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0378-4371/$ – see front matter
doi:10.1016/j.physa.2009.12.004

The contribution of this study is three fold. First, some studies have mainly focused on the long memory property in the return series of Chinese market indices [11,34,35]. However, there is (to our best knowledge) still a lack in the research that has examined the long memory property in the volatility of the Chinese stock market. Therefore, our study is an initial attempt to contribute in this neglected research area.

Second, using the three different techniques, our study improves the robustness of statistical results for long memory against short memory in volatility. In particular, we found that the FIGARCH model of Baillie et al. [23] is a useful approach which can capture the long memory property in the volatility of the Chinese stock market.

Third, the non-normal distribution of a financial time series is an important component for enhancing the measurement accuracy of value-at-risk (VaR) in risk and portfolio management [36,37]. We found that the FIGARCH model with a Student-t distribution is suitable to take into account long memory volatility processes and heavy-tailed properties for the Chinese stock market.

The rest of this paper is organized as follows. Section 2 presents the methodology for semi-parametric tests and the FIGARCH model. Section 3 describes the characteristics of the sample data. Section 4 provides the estimation results of semi-parametric tests and the FIGARCH model. The final section summarizes the most relevant conclusions.

2. Model framework

2.1. Semi-parametric long memory tests

As defined by Beran [38], a stationary long memory process can be characterized by the hyperbolic decay of its autocorrelation function, $\rho(k) \sim ck^{2d-1}$, by the behavior of the spectral density $f(\lambda)$ of the process which takes the form:

$$f(\lambda) \sim c\left|1 - e^{-i\lambda}\right|^{-2d}, \quad \text{as } \lambda \to 0 \text{ with } d \neq 0, \tag{1}$$

where, $c \neq 0$, d is the long memory parameter (or fractional differencing parameter) and $0 < |d| < 0.5$.

In order to estimate the parameter of d, Geweke and Porter-Hudak (GPH henceforth) [39] proposed a semi-parametric method of the long memory parameter d which can capture the slope of the sample spectral density through a simple OLS regression based on the periodogram, as follows:

$$\log I(\lambda_j) = \beta_0 - d \log\{4\sin^2(\lambda_j/2)\} + \eta_j, \quad j = 1, \ldots, M \tag{2}$$

where $I(\lambda_j)$ is the jth periodogram point; $\lambda_j = 2\pi j/T$; T is the number of observations; β_0 is a constant; and η_j is an error term. As argued by GPH [39], the inclusion of improper periodogram ordinates M, causes bias in the regression which result in an imprecise value of d. To achieve the optimal choice of T, several choices can be established in terms of the bandwidth parameter $M = T^{0.5}, T^{0.6}, T^{0.7}, T^{0.8}$.

Another semi-parametric test is the Local Whittle (LW) estimator of Robinson [40] based on the Gaussian maximum likelihood function (L_T), as follows:

$$L_T(d) = 2d\frac{1}{m}\sum_{j=1}^{M}\log\lambda_j - \log\left(\frac{1}{m}\sum_{j=1}^{M}\lambda_j^{2d} I(\lambda_j)\right), \tag{3}$$

where $\lambda_j = 2\pi j/T$ as before. Eq. (3) can be concentrated by the form of the Whittle log-likelihood function:

$$L_T(G, d) = -\frac{1}{M}\sum_{j=1}^{M}\left(\log G\lambda_j^{-2d} + \frac{I(\lambda_j)}{G\lambda_j^{-2d}}\right), \tag{4}$$

where G is a constant. Like the GPH test, the optimal choice of M corresponds to the bandwidth parameter $M = T^{0.5}, T^{0.6}, T^{0.7}, T^{0.8}$.[1]

2.2. FIGARCH model

Following Engle [42], the time series y_t and the associated prediction error $\varepsilon_t = y_t - E_{t-1}[y_t]$ are considered, where $E_{t-1}[\cdot]$ is the expectation of the conditional mean on the information set at time $t-1$. The standard GARCH model of Bollerslev [21] is as follows:

$$\varepsilon_t = z_t\sigma_t, \quad z_t \sim N(0, 1), \tag{5}$$

$$\sigma_t^2 = \omega + \alpha(L)\varepsilon_t^2 + \beta(L)\sigma_t^2, \tag{6}$$

[1] Phillips and Shimotsu [41] simulated the optimal value of M, corresponding to sample sizes of 1000, 500, and 200. For the robustness of our method, we tried various values of M in this study.