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Long memory revisit in Chinese stock markets: Based on GARCH-class models and multiscale analysis

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ABSTRACT

In the present work we propose the rescaled range analysis (R/S), modified R/S method and detrended fluctuation analysis (DFA) to investigate the long memory property of Chinese stock markets based on the conditional and actual volatility series, and show that the stock markets in China display moderate positive degree of long memory. For the robustness, we implement the multiscale analysis on dynamic changes of time-varying Hurst exponents by applying the rolling window method based on DFA. Our results reveal that APGARCH model with the superior forecasting ability captures the long memory property better than other GARCH-class models for different time scale interval. Interestingly, the time-varying Hurst exponents of the sudden "jumps" for the conditional volatility calculated by the DFA method using the APGARCH model are smaller than that of the actual volatility series, which indicates that APGARCH model may underestimate the long memory property in the Chinese stock market. Our evidences provide new perspectives for the financial market forecasting.

1. Introduction

China has experienced tremendous change in many aspects by introducing the policy of market oriented reforms, and shifted to more market oriented economy since the 90s from central planned economy; also, Chinese stock markets (Shanghai Stock Exchange and Shenzhen Stock Exchange) have experienced a tremendous growth and development since 1990; however, they are still on the early stages. Chinese stock markets have a number of unique, idiosyncratic features, such as institutional segmentation between domestic and foreign investors, different purchasing cost, high transfer rates, and high investment risk (Otorowski, 2009). Chen et al. (2007) have revealed that the share structures of Chinese stock were classified in three categories, of which one-third was publicly traded, one-third was state-owned and the last was privately owned.[1] They are common features of Chinese stock market. In order to analyze stock markets in China, we reveal some different institutional regulations between Shanghai stock market and Shenzhen stock market.[2] It is worth to analyze two Chinese stock markets (Shanghai and Shenzhen) for constructing model and econometrics analysis. However, in our paper, we focus on the long memory property in the Shanghai stock market and Shenzhen stock market, instead of the specific institutional regulations; nevertheless, those institutional regulations can also provide some implications for the empirical results as considering the long memory property.

Obviously, investigating the long memory property in stock markets has become more important in recent years. In current rapidly expanding literature, there has a large number researches of long memory property not only on the financial time series, but also on the volatility series based on the GARCH-class models (Cheung and Lai, 2001; DiSario et al., 2008; Greene and Fielitz, 1977; Kanellopoulou and Panas, 2008; Lo, 1991; Martens et al., 2009; Teverovsky et al., 1999; Willinger et al., 1999); however, there is still no consensus on what type property does the series display? Recently, based on a general framework for investigating the long memory property by R/S method or modified R/S method, Peters (1991, 1994) employed those methods to capture the structures of financial markets, and a simple volatility model that captured the property based on DFA analysis was also presented, but failed to properly provide the scaling properties at different time horizons. Indeed, scaling properties of the time series (volatility series) is an issue worthy of study.

Although volatility is now not an exactly term with widely accepted definition to capture (McAleer and Medeiros, 2008), we still introduce the daily actual volatility series (variance) calculated from the squared returns and the conditional volatility series obtained from the GARCH-class models to analyze the scaling properties. Thus, it is a good opportunity to examine the robustness of previous researches by investigating those volatility series, and also conclude which GARCH-class model can capture long memory properties accurately

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[1] More detail about Chinese stock market institutional regulations can be found in Swanson (2007). Swanson (2007) also revealed the main problems of the stock markets in China were strong policy-oriented supervision by state, and high level of separation and segregation between domestic and foreign investors.

[2] More institutional regulations can be found in Table 0, and we greatly thank anonymous reviewers for their helpful comments and suggestions on the differences between the Shanghai stock market and Shenzhen stock market.

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by comparing the conditional volatility series obtained from the GARCH-class model to those daily actual volatility series. Furthermore, our studies also have critical implications for evaluating the performance of GARCH-class models.

However, the conditional volatility series is latent, and not directly observed. Consequently, we obtain the conditional volatility series from the Generalized Autoregressive Conditional Heteroskedasticity (ARCH or GARCH), firstly proposed by Engle (1982) and Bollerslev (1986). Peters (1994) showed that financial markets displayed the stylized facts of the long memory or the long-range correlation in daily volatility series. At the same time, the R/S method has become a widely accepted method to capture the long memory properties in financial markets. Due to the development of new statistics methods (Alessio et al., 2002; Beran, 1994; Carbone et al., 2004; Cont, 2001; Elder and Serletis, 2008; Mandelbrot, 1982; Mukherjee and Sarkar, 2011; Rosenberg and Serletis, 2007), such as modified R/S method and DFA analysis, those have stimulated a large number of study in stock return from the financial markets (Assaf and Cavalcante, 2005; Barkoulas et al., 2000; Cont, 2001; Wright, 2001). By employing the GARCH-class volatility model, they showed that long memory properties widely existed in the stock market, for example, the return series in Athens Stock market (Panas, 2001), the volatility of the daily returns of Istanbul Stock market (DiSario et al., 2008; Kilic, 2004), the absolute, squared, and log squared returns in Brazilian stock market (Assaf and Cavalcante, 2005), and daily returns and daily volatility series on the financial future market (Elder and Serletis, 2008); and more literature detail could be found in Wei, Wang and Huang (2010) and Wang and Wu (2011).

In our paper, we investigate the long memory property based on the daily actual volatility and the conditional volatility series from the high-frequency data obtained from Shenzhen and Shanghai stock markets. The contributions of our article can be summarized below.

Firstly, we employ the daily actual volatility (variance) calculated from the squared returns and the conditional volatility series obtained from the GARCH-class models (GARCH, APGARCH, EGARCH and GJR) to investigate the long memory property, which renders a good opportunity to examine the robustness of previous researches by the GARCH-class model using the volatility series.

Secondly, we initially applied R/S and modified R/S method to investigate the long memory property, and then use DFA method. Due to the significant advantage of concentrating the fluctuations around trend rather than a range of the time series data, DFA analysis can capture the non-stationary time series better than the R/S method. Therefore, we obtain the results to conclude which GARCH-class model can capture long memory property accurately by comparing the conditional volatility series obtained from the GARCH-class model to those daily actual volatility series. It is critically important to evaluate the performance of GARCH-class models.

Our results show that the Hurst exponents by DFA method are almost around 0.63 indicating the existence of moderate degree of long memory in Chinese stock markets. Moreover the Hurst exponents are obviously larger than those obtained from R/S method, smaller than those obtained from modified R/S method. Interestingly, we also reveal that the long memory property may be overestimated by the volatility series obtained from the GARCH and GJR models, and underestimated by the volatility series obtained from the APGARCH and EGARCH models, in comparison with the actual volatility series.

Thirdly, we introduce the forecasting accuracy to evaluate GARCH-class model. By considering the 1-, 5-, and 21-day out-of-sample forecasting accuracy of GARCH-class model (GARCH, APGARCH, EGARCH and GJR) based on the six loss functions, which apply bootstrap procedures of superior predictive ability (SPA) test, we reveal that APGARCH model under the MSE and QLIKE loss function captures the best volatility dynamics in those volatility series.

Fourthly, applying the DFA analysis based on the best forecasting accuracy model (APGARCH model), we reveal multiscale results that those volatility series of the Chinese stock markets display the positive long memory property for different time scale interval, and also obtain the same results from the actual volatility series. Interestingly, the Hurst exponents of the sudden "jumps" for the volatility series obtained from the APGARCH model calculated by the DFA method, such as unpredictable events, are smaller than that of the actual volatility series indicating that some non-parameter GARCH-class model, such as APGARCH model, may underestimate the long memory property in the Chinese stock market. Our evidences provide new perspectives for the financial market forecasting.

Our paper is organized below. In Section 2, we present the volatility model frameworks, and provide the data and preliminary analysis in Section 3, and obtain the empirical results and forecasting performance in Sections 4 and 5. Some conclusions can be found in Section 6.

The difference between the Shanghai stock market and Shenzhen stock market.

Institutional regulations		Shanghai stock market	Shenzhen stock market
Common features		• Guarantee safe operation and enhance management level • Focus on development of trading funds for stable development • Formulate business rules and arranges for listings • Perform supervision and regulations • Apply the principle of price and time precedence	
Different feature	Established time	November 1990	December 1990
	System design	• Two different type shares: A-shares are priced and traded in RMB, which are available to domestic investors only; and B shares are prices in US dollar, which are available not only to domestic investors, but also to foreigner. • Dynamics changes of stock price in daily transaction are limited to 10% (more detail can be found in Chen et al. (2007)). •Treasure bonds, corporate bonds, convertible corporate bonds can be allowed to trade.	• The initial public offering has been suspended since 2002. • ChiNext board has opened since October 2009.
	Market capitalization	US$2.3 trillion (Dec 2011)	US$ 1 trillion (Dec 2011)
	Indices	• The SSE Composite Index are all listed stocks (A shares and B shares) at the Shanghai Stock Exchange.	

Note: more institutional detail can be found in http://www.sse.com.cn/sseportal/en/home/home.shtml and http://www.szse.cn/main/en/.

In order to capture the volatility series more accurately, Bollerslev (1986) extended the work of autoregressive conditional heteroskedasticity (ARCH) proposed by Engle (1982). Empirical findings showed that GARCH model could perform much better in financial markets and resource markets (Bollerslev et al., 1994; Koopman et al., 2005; Sadorsky, 2006; Wang and Wu, 2011; Wei, Wang and Huang (2010)). The sample GARCH (1, 1) model can be shown as follows;

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2. \tag{1}$$

Due to volatility clustering, asymmetric leverage effects, and long memory, Cont (2001) suggested that some GRACH-class models could characterize those stylized facts accurately. Firstly, EGARCH is a useful tool for investigating volatility; the good feature of EGARCH model proposed by Nelson (1991) is that it can capture the property