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Variance-Gamma and Normal-Inverse Gaussian models: Goodness-of-fit to Chinese high-frequency index returns

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ABSTRACT

In this study Variance-Gamma (VG) and Normal-Inverse Gaussian (NIG) distributions are compared with the benchmark of generalized hyperbolic distribution in terms of their fit to the empirical distribution of high-frequency stock market index returns in China. First, we estimate the considered models in a Markov regime switching framework for the identification of different volatility regimes. Second, the goodness-of-fit results are compared at different time scales of log-returns. Third, the goodness-of-fit results are validated through bootstrapping experiments. Our results show that as the time scale of log-returns decrease NIG model outperforms the VG model consistently and the difference between the goodness-of-fit statistics increase. For high-frequency Chinese index returns, NIG model is more robust and provides a better fit to the empirical distributions of returns at different time scales.

1. Introduction

Chinese economy is becoming more integrated into the global financial system as a result of the ongoing financial liberalization and reforms. In line with this trend, in 2014 Chinese Central Bank

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widened the exchange rate bands to 2% around the benchmark rates. Due to the strict exchange rate and capital account control mechanism in China, shares that are traded by domestic investors are not open for foreign investment, except the limited investment opportunity through the qualified foreign institutional investor programme. In this fragmented market A-shares are traded by domestic investors, whereas B-shares are quoted in US dollars and can be traded by both domestic and foreign investors. However, the number of listed companies and market capitalization of the B-share market is very small compared to the A-shares market for domestic investors.

Chinese stock market has some interesting and peculiar features that offers a unique case for empirical studies. First, Chinese stock market that consists of Shanghai and Shenzhen stock exchanges, is one of the largest stock markets in the world in terms of total market capitalization. Second, controversial to its development in terms of size, the share of institutional investors is about 20% of the total market value.

The retail character of the Chinese stock market can be explained by: (i) the seclusion from foreign investment; (ii) availability of limited financial instruments for investment; and (iii) the low interest rate policy of the government for many years to stimulate investment-led growth. Therefore, Chinese non-institutional investors, who have no access to foreign capital markets and financial products in a continuously low interest rate economy, have few alternatives for investment except the real estate and stock markets. Therefore, Chinese stock market is a special example of a large sized retail investors' market, which is mostly secluded from foreign investment.

Chinese stock market is highly dependent on the fiscal and monetary policies of the central government. Lack of financial instruments for hedging and investment diversification creates high volatility and bubble-burst cycles in the market. Therefore, financial derivatives are introduced recently in China, such as the exchange traded fund (ETF 50) options. Existing index futures and ETF 50 options are the only financial derivatives traded in the mainland markets. Stock index futures for the Shanghai and Shenzhen stock markets are introduced by the China Financial Futures Exchange in 2010. In line with the financial liberalization of the Chinese financial markets ETF 50 options are launched in February 2015.

Until recently a financial derivatives market was not existent in China and the goodness-of-fit of different distributions used in Lévy processes that extend the Black–Scholes model has not been studied. The classical Black–Scholes model gave the practitioners in the financial industry a prescription for pricing and hedging financial derivatives. However, in time, it became increasingly evident that the assumptions of the Black–Scholes model fail to capture the underlying dynamics of asset prices properly. Deviations of actual returns from the Black–Scholes assumption of normality has been well documented (e.g. Fama, 1965; Mandelbrot, 1963; Cont, 2001). Black–Scholes assumption of normality has been relaxed in various option pricing models that are widely used in pricing financial derivatives. In Praetz (1972) an inverse gamma distribution is first utilized to identify the behavior of stock returns, which is considered as a basis for all future stochastic variance models including the Variance Gamma (VG) (Madan & Seneta, 1990) and Normal-Inverse Gaussian (NIG) (Barndorff-Nielsen, 1998) models.

VG and NIG models, which are widely used in pricing financial derivatives, have been investigated in various studies in terms of their fit to empirical stock returns. NIG model is first introduced in Barndorff-Nielsen (1998) and compared with the hyperbolic distributions using data from Danish stock market. Madan and Seneta (1987) compares the VG model with normal, stable and the Press compound events model using the Chi-square goodness-of-fit statistics for the Sydney Stock Exchange. They show that VG model improves upon the fit of Press, normal and stable processes, whereas Madan, Carr, and Chang (1998) conclude that the VG option pricing model reduces the pricing bias that exists in the Black–Scholes model. An empirical examination of the VG option pricing model for foreign currency options in comparison with Black and Scholes (1973) and Merton (1976) jump-diffusion models is given in Daal and Madan (2005). They document that the VG model performs better than other models considered. An investigation of the performance of the NIG and VG models is provided in Figueroa-Lopez, Lancette, Lee, and Mi (2012) for the high-frequency stock returns in the US, however, no goodness-of-fit comparison is given. An empirical analysis of goodness-of-fit of the VG model for the daily US stock returns is given in Rathgeber, Stadler, and Stöckl (2013), which utilizes a Markov regime switching model for the identification of high and low volatility periods.