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Realized volatility in the futures markets

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Abstract

Using intraday returns on four futures contracts over a 5-year period, we calculate and analyze model-free measures of futures return volatility. We focus on the temporal characteristics and distributional properties of daily returns, return volatilities, (log of) standard deviations, standardized returns and pairwise correlations. The behavior of a number of tests for Gaussianity under long memory is explored via a simulation study. The simulation results indicate that tests of the "goodness-of-fit" variety are appropriate to use while the commonly employed Jarque–Bera test is severely oversized and its use is not recommended. We find that the standard deviations and the pairwise correlations exhibit long memory while the standardized returns are serially uncorrelated. We also find that the (unconditional) distributions of daily returns' volatility are leptokurtic and highly skewed to the right while the distributions of the standardized returns, the standard deviations and the pairwise correlations are statistically indistinguishable from the Gaussian distribution. Our results are consistent with that of Andersen et al. [Journal of the American Statistical Association 96 (2001a) 42; Journal of Financial Economics 61 (2001c) 43] on the time-series properties of realized volatility. The dynamic characteristics of the volatility series are modelled using fractionally integrated ARMA models.

JEL classification: C32; G1
Keywords: Realized volatility; High-frequency data; Long memory; Tests for normality; ARFIMA

1. Introduction

Accurate measures and good forecasts of asset return volatility are critical for the implementation and evaluation of asset pricing theories, portfolio choice and risk management. Asset return volatility can not be directly observed and is time-varying. As a result,

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economists have built increasingly sophisticated statistical models to capture the characteristics of financial markets' volatility. Previous studies focus on parametric ARCH and GARCH models, stochastic volatility models, implied volatility from certain option pricing models or direct indicators of volatility such as ex post squared or absolute returns. Partial surveys of the voluminous literature on these models are given by Bollerslev et al. (1994), Ghysels et al. (1996) and Campbell et al. (1997).

Recently, there has been renewed interest in obtaining improved daily volatility estimates by using high-frequency, intraday returns to construct daily "realized" or "integrated" volatility. Daily realized volatility is obtained as the sum of intraday squared returns. Using the theory of quadratic variation, Andersen and Bollerslev (1998) and Barndorff-Nielsen and Shephard (2001a) show that the realized volatility estimator, say v_t^2, is a consistent estimator of the actual volatility in the sense that $v_t^2 \rightarrow \sigma_t^2$, where σ_t^2 is the actual (but unobservable) volatility.[2] This is an interesting result for it is model-free and does not depend upon any particular form of σ_t^2.

In this paper, we construct and examine the distributional properties of daily futures realized volatility using high-frequency, intraday futures returns. We consider four of the most heavily traded futures contracts worldwide: the Deutsche Mark, the S&P500 index, US Bonds and the Eurodollar.[3]

We find that the logarithmic realized standard deviations exhibit long memory and approximate Gaussianity, while the standardized returns also exhibit approximate Gaussianity but are serially uncorrelated. Our analysis confirms previous work by Andersen et al. (2001a) (henceforth ABDL) and by Andersen et al. (2001c) (henceforth ABDE), who found similar results for daily foreign exchange return volatilities and daily stock return volatilities, respectively. Our approach differs, however, with the existing literature in several respects. First, rather than relying on descriptive statistics and graphs in investigating the distributional properties of the time series studied, as in ABDL (2001a) and ABDE (2001c), we perform a variety of formal statistical tests designed to capture the distributional properties of the volatility and return series. Second, we conduct a simulation study to examine the properties of these tests in the presence of long memory. Third, we model the realized volatility and logarithmic standard deviations using ARFIMA models and investigate the time-series properties of the series once long memory is removed.[4] Finally, we apply the methodology of realized volatility in the futures markets using a new dataset.

[2] Barndorff-Nielsen and Shephard (2001b) examined the finite-sample properties of the realized volatility estimator in a simulation study. Their experiments suggest that the realized volatility error can be substantial but the theoretical results are reliable for the realized logarithmic standard deviation.

[3] The concept of realized volatility has been used in financial economics for a number of years, but has been applied mainly to data with lower than intraday frequency. Hsieh (1991) uses 15-min equity returns to construct daily standard deviations. Campbell et al. (2001), Merton (1980), Poterba and Summers (1986), Schwert (1990) and French et al. (1987) used daily returns in constructing monthly stock return volatilities. However, little was known about the properties of the realized volatility estimator v_t^2 until recently.

[4] Our modeling of realized volatility can be viewed as a univariate complement to the work of Andersen et al. (2001b), who use a fractional vector autoregressive model (FVAR) to examine the joint behavior of three realized volatility series.