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Comparing stochastic volatility models through Monte Carlo simulations

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Abstract

Stochastic volatility models are important tools for studying the behavior of many financial markets. For this reason a number of versions have been introduced and studied in the recent literature. The goal is to review and compare some of these alternatives by using Bayesian procedures. The quantity used to assess the goodness-of-fit is the Bayes factor, whereas the ability to forecast the volatility has been tested through the computation of the one-step-ahead value-at-risk (VaR). Model estimation has been carried out through adaptive Markov chain Monte Carlo (MCMC) procedures. The marginal likelihood, necessary to compute the Bayes factor, has been computed through reduced runs of the same MCMC algorithm and through an auxiliary particle filter. The empirical analysis is based on the study of three international financial indexes.

Keywords: Jump diffusion; Stochastic volatility; MCMC; Particle filters; Bayes factor; VaR

1. Introduction

Stochastic variance models are an important tool to describe financial time series due to their flexibility in modeling time-varying volatilities, which is a typical pattern in financial applications. In general such models are specified in continuous time and are

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used to price financial derivatives. In this paper we study some different non-nested parameterizations of stochastic volatility models recently proposed. More precisely, we consider models with and without jumps and with different specification on the volatility equations. Following Chernov et al. (2003) we distinguish between logarithmic and affine models. Furthermore, the introduction of jumps in modeling financial returns seems appropriate in order to describe rare events like crashes in the market. On the other hand, it is not intuitive to understand whether the volatility process jumps or not. Sometimes there is evidence that the volatility dynamics hardly follow a diffusive behavior and tend to sharply increase when a jump is observed in the return series. Some empirical evidence shows that taking into account jumps, together with stochastic volatility, leads to an improved fit of the data on derivatives (see Bakshi et al., 1997). In any case, it is not clear whether the introduction of a jump component improves the description of the underlying financial returns.

Comparing stochastic volatility models is not an easy task, due to the presence of one or more latent factors in their specification. In the recent literature, Chernov et al. (2003) compare non-nested parameterizations using the efficient method of moments (EMM). In their analysis, models with and without jumps based on affine and logarithmic dynamics have been included. From a different point of view, simulation techniques appear to be a viable and simpler solution to rank alternative specifications. More precisely, sequential procedures and Markov chain Monte Carlo (MCMC) algorithms are useful to compute, respectively, the likelihood function and the posterior distributions. These Monte Carlo strategies naturally lead to the use of Bayesian tools for the analysis. For example, Bayes factors have been used in Chib et al. (2002) and in Eraker et al. (2003) to compare, respectively, logarithmic and affine models. A different approach based on the deviance information criterion (DIC) has been recently introduced in Berg et al. (2004) and has been applied to logarithmic parameterizations. Their analysis does not include affine models. All of these papers analyze the models just according to their ability to fit the data. Form a completely different point of view Eberlein et al. (2003) analyze some models, not necessarily based on stochastic variances, according to their forecasting performance. This seems a reasonable approach if we would like to focus on risk management applications.

We face the problem of the comparison taking into account both goodness-of-fit statistics and forecasting performance. The first criterion we use is based on the Bayes factor, which seems a natural choice from a Bayesian point of view. The second criterion relies on the ability to forecast conditional variances. We test the forecasting performance studying the value-at-risk (VaR) statistics. Our evaluation has been carried out through MCMC and particle filtering procedures. In order to make inference we adopt an efficient MCMC strategy. The inferential procedure is based on the delayed rejection (DR) algorithm proposed in Tierney and Mira (1999) in a medical context and originally applied to affine models with jumps in Raggi (2004). To compute the likelihood function and the one-day-ahead forecasts we adopt a version of the auxiliary particle filter (Pitt and Shephard, 1999). The use of particle filters for stochastic volatility models with jumps has been introduced in Chib et al. (2002) and in Johannes et al. (2003). In those works volatilities and returns are uncorrelated. We adopt a particle filter that take into account the feedback effect induced by the correlations between processes.