Bayesian option pricing framework with stochastic volatility

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Abstract

The application of stochastic volatility (SV) models in the option pricing literature usually assumes that the market has sufficient option data to calibrate the risk-neutral parameters of the model. When option data are not available, market practitioners have to estimate the model from the historical returns of the underlying asset and then transform the resulting model to its risk-neutral equivalent. However, the likelihood function of an SV model can only be expressed in a high dimensional integration, making the estimation a highly challenging task. Bayesian approach has been the classical way to estimate SV models under the data-generating (physical) probability measure but it is still unclear about the transformation from the estimated physical dynamic to its risk-neutral counterpart. Inspired by the Duan (1995) GARCH option pricing approach, we propose an SV model that enables us to perform Bayesian inference and transformation to risk-neutral dynamic simultaneously and conveniently. Our model relaxes the normality assumption on innovations of both return and volatility processes. Our empirical study shows that the estimated option prices generate a realistic implied volatility smile shapes. In addition, the volatility premium is almost flat across strike prices so that adding a few option data to the historical time series of the underlying asset can greatly improve the estimation of option prices.