State Price Densities implied from weather derivatives

Wolfgang Karl Härdle[1], Brenda López Cabrera[1]
and Huei-Wen Teng[2]* (鄧惠文)
[1]CASE - Center for Applied Statistics and Economics, Humboldt-Universität zu Berlin
[2]Graduate Institute of Statistics, National Central University

Astract

A State Price Density (SPD) is the density function of a risk neutral equivalent martingale measure for option pricing, and is indispensible for exotic option pricing and portfolio risk management. Many approaches have been proposed in the last two decades to calibrate a SPD using financial options from the bond and equity markets. Among these, non and semi parametric methods were preferred because they can avoid model mis-specification of the underlying and thus give insight into complex portfolio propelling. However, these methods usually require a large data set to achieve desired convergence properties. Despite recent innovations in financial and insurance markets, many markets remain incomplete and there exists an illiquidity issue. One faces the problem in estimation by e.g. kernel techniques that there are not enough observations locally available. For this situation, we employ a Bayesian quadrature method because it allows us to incorporate prior assumptions on the model parameters and hence avoids problems with data sparsity. It is able to compute the SPD of both call and put options simultaneously, and is particularly robust when the market faces the illiquidity issue. By comparing our approach with other approaches, we show that the traditional way of estimating the SPD by differentiating an interpolation of option prices does not hold in practice. As illustration, we calibrate the SPD for weather derivatives, a classical example of incomplete markets with financial contracts payoffs linked to non-tradable assets, namely, weather indices. Finally, we study the dynamics of the SPD weather type.

Keywords: weather derivatives, temperature derivatives, HDD, CDD, SPD, mixture, quadrature, Bayesian, option trading strategies