The Particle Method for Smile Calibration

Julien Guyon [1]

[1] Bloomberg, NY

The calibration of models to market smiles is a crucial issue for risk management in finance. This used to be done by running time-consuming optimization routines. In this short course we will show how particle methods very efficiently solve a wide variety of smile calibration problems, without resorting to any optimization:
– Calibration of the local volatility model with stochastic interest rates
– Calibration of stochastic local volatility models, possibly with stochastic interest rates and stochastic dividend yield
– Calibration to the smile of a basket of multi-asset local volatility-local correlation models, possibly with stochastic volatility, stochastic interest rates, and stochastic dividend yields
– Calibration of path-dependent volatility models and path-dependent correlation models
– Calibration of cross-dependent volatility models
The particle method is a Monte Carlo method where the simulated asset paths interact with each other so as to ensure that a given market smile (or several of them) is fitted. PDE methods typically do not work for these high-dimensional models. The particle method is not only the first available exact simulation-based method for smile calibration. It is also robust, easy to implement, and fast (as fast as a standard Monte Carlo algorithm), as many numerical examples will show. As of today, it is the most powerful tool for solving smile calibration problems. Icing on the cake: there are nice mathematics behind the scenes, namely the theory of McKean stochastic differential equations, propagation of chaos, and a new Malliavin disintegration by parts formula. Some crucial mathematical questions, such as the existence and uniqueness of the McKean SDEs that arise in these smile calibration problems, are still open problems.

Short Bio

Julien Guyon is a senior quantitative analyst in the Quantitative Research group at Bloomberg L.P., New York. He is also an adjunct professor in the Department of Mathematics at Columbia University and at the Courant Institute of Mathematical Sciences, NYU. Before joining Bloomberg, Julien worked in the Global Markets Quantitative Research team at Societe Generale in Paris for six years (2006-2012), and was an adjunct professor at Universite Paris 7 and Ecole des ponts. He co-authored the book Nonlinear Option Pricing (Chapman & Hall, CRC Financial Mathematics Series, 2014) with Pierre Henry-Labordere. His main research interests include nonlinear option pricing, volatility and correlation modeling, and numerical probabilistic methods. Julien holds a Ph.D. in Probability Theory and Statistics from Ecole des ponts. He graduated from Ecole Polytechnique (Paris), Universite Paris 6, and Ecole des ponts. A big soccer fan, Julien has also developed a strong interest in sports analytics, and has published several articles on the FIFA World Cup, the UEFA Champions League, and the UEFA Euro in top-tier newspapers such as The New York Times, Le Monde, and El Pais, including a new, fairer draw method for the FIFA World Cup.