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Heat Kernel Framework for Asset Pricing in Finite Time

We propose a heat kernel approach for the development of a flexible and mathematically tractable asset pricing framework in finite time. The pricing kernel, giving rise to the price system in an incomplete market, is modelled by weighted heat kernels that are driven by multivariate Markov processes and that provide enough degrees of freedom in order to calibrate to relevant data, e.g. to the term structure of bond prices. It is shown how, for a class of models, the prices of bonds, caplets, and swaptions can be computed in closed form. The dynamical equations for the price processes are derived, and explicit formulae are obtained for the short rate of interest, the risk premium, and for the stochastic volatility of prices. Several of the closed-form asset price models presented in this paper are driven by combinations of Markovian jump processes with different probability laws. Such models provide a rich basis for consistent applications in several sectors of a financial market including equity, fixed-income, commodities, and insurance. The flexible, multidimensional and multivariate structure, on which the asset price models are constructed, lends itself well to the transparent modelling of dependence across asset classes. As an illustration, the impact on prices by spiralling debt, a typical feature of a financial crisis, is modelled explicitly, and contagion effects are readily observed in the dynamics of asset returns.