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Efficient PDE Based Numerical Estimation of Credit and Liquidity Risk Measures for Realistic Derivative Portfolios

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Summary

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In the Basel III accords in 2013, it was stated that financial institutions should charge Credit Value Adjustment (CVA) to their counterparties for (previously under-regulated) Over-The-Counter (OTC) trades. This CVA can be used to hedge a possible default of the counterparty. One important ingredient of CVA is the calculation of the future exposure of the portfolio on which CVA has been charged. This future exposure is also used to determine more recent value adjustments like Debt Value Adjustment (DVA) and Capital Value Adjustments (KVA), and can be calculated from a future distribution of the portfolio value. This distribution can also be used to compute quantiles which are so-called 'worst case' scenarios, and are therefore relevant for risk management. Computing the distribution of future portfolio values requires simulating the future states of the risk factors, and then evaluating the portfolio in all these future states. As the number of risk drivers in a typically traded portfolio is high, computing exposure for portfolios is a numerical challenge. One of the key contributions of this thesis is the Finite Difference Monte Carlo (FDMC) method for an efficient computation of future exposure.

The method is validated by comparing it with two other computational techniques, namely a semi-analytic method and the regression based, Stochastic Grid Bundling (SGBM) method. The comparison is made by considering exposures, quantiles and sensitivities of exposures of exotic options driven by one, two or three risk factors.

For portfolios driven by more than four risk factors, the exposure can be approximated by using a dimension reduction technique. We show that by decomposing the problem, exposure profiles for portfolios consisting of multiple derivatives driven by even 7 different risk factors can be computed by solving only one, two and three-dimensional PDEs.

By using the FDMC method, it is possible to incorporate stochastic volatility

and stochastic interest rate in exposure calculations of Foreign Exchange derivatives. For two real market scenarios, we have shown that these factors have to be taken into account, and an industry standard piecewise constant volatility model is not sufficient whenever considering expected or worst case scenario outcomes in Counterparty Credit Risk (CCR).