XVA Analysis and Techniques `IT Quant' in Python and Cuda GPU (51h)

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The 2007-08 subprime and credit crisis and the 2011 European sovereign debt crisis have highlighted counterparty risk. This is the risk of non-payment of promised cash-flows due to the default of a party in an OTC derivatives transaction, priced as the so-called credit valuation adjustment (**CVA**). A key related issue is the so-called wrong-way risk, i.e. the risk of positive dependence between the counterparty risk exposure and the default risk of the counterparty. As banks themselves have become risky, counterparty risk must be considered in a bilateral perspective (CVA and debt valuation adjustment **DVA**), where the counterparty risk of the bank itself is part of the modeling. In this context, the classical assumption of a risk-free asset which is used for financing purposes (lending or borrowing as needed) is not sustainable anymore, which raises the companion issue of a proper accounting of the funding costs of a position (funding valuation adjustment **FVA**). Since August 2007 one also saw the emergence of a systemic counterparty risk, in the form of various significant spreads between quantities that were very similar before, notably between **OIS** swap rates and **LIBOR** swap rates of different tenors. Through its relation with the concept of discounting, this systemic component of counterparty risk has impacted on all derivatives markets. Last but not least, since counterparty risk is hardly hedgeable in practice, capital at risk is required from banks by regulators in order to absorb exceptional losses beyond the expected levels reserved as CVA and FVA. This gives rise to the **KVA**, which is the cost for the bank of remunerating shareholder capital at risk at some hurdle rate throughout the life of the portfolio (moreover, capital can be used for funding purposes, so that the FVA and KVA metrics are intertwined). The recent trend of the regulation is to push participants to negotiate centrally (as opposed to bilaterally above) via clearing houses (or central counterparties, **CCP**s) and to guarantee their failure through initial margining (an additional layer of collateral that comes on top of the variation margin which is priced by the FVA), but this prompts even more funding requirements and a related **MVA** (margin valuation adjustment). It also triggers a shift from counterparty risk to systemic and liquidity risks.

The aim of the course is to study these topical and controversial issues: CVA, DVA, FVA, multiple curves, KVA, CCPs and collateral, from the following angles:

- ***Economical:*** XVA analysis from the balance sheet, double counting issues, shareholder vs. bank as a whole perspectives (connection with the Modigliani and Miller theory), CVA+FVA+MVA+KVA entry price vs. (CVA-DVA) exit price decompositions;
- ***Mathematical:*** Enlargement of filtration, models of random times, default intensity modeling, XVA nonlinearities and backward SDEs;
- ***Financial modeling:*** Multiple curves, wrong way and gap risks modeling, XVA analysis for bilateral vs. centrally cleared transactions;

- ***Algorithmic/computational:*** Exposure-based vs. nested Monte Carlo approaches, high-dimensional regression techniques, risk measures computations, quasi-regression techniques and second generation XVA metrics computation, machine learning techniques for XVA computations (stochastic gradient descents, XVA compression through genetic optimization algorithms), GPU acceleration techniques;
- ***IT:*** Python and Cuda GPU programming. Initiation to the python Quantlib and machine learning pytorch and tensorflow libraries. The course will be accompanied and illustrated by means of Python jupyter notebooks and Cuda NVIDIA programming sessions.

References: Related material on ***https://math.maths.univ-evry.fr/crepey/***

Prior knowledge: Stochastic analysis, mathematical finance, and numerical finance at MSc level. Some knowledge of corporate finance is also useful but will be recalled during the course.

Assessment: Written examination and/or projects.