Msc thesis proposal:

Efficient Calculation Methods for Counterparty Credit Risk

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The thesis research is dedicated to improving the efficiency of the existing computational methods for the counterparty credit risk (CCR). Particularly,

* we shall consider speeding up the standard Monte Carlo simulation method by means of importance sampling,
* as well as the improved version of the Fourier method (the COS method) by relaxing the curve of dimension.

**Background**

CCR is the risk that a bank suffers from economic losses in the OTC (Over-the-Counter) derivatives and Repos due to the default of the counterparty of those trading positions.

A common measure for the quantification of the CCR is the so-called Potential Future Exposure (PFE), which is defined as the 97.5% quantile of the future exposure distribution of a netting set or of a higher-level portfolio at a future time point, as illustrated by Figure 1.

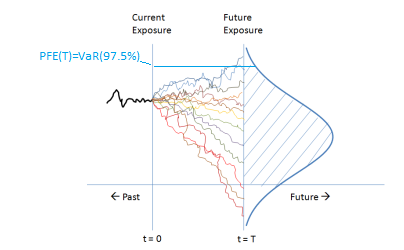


Figure 1 Illustration of the future exposure distribution

The netting set is a portfolio of trades, whereby the MtM prices of the trades are allowed to be netted based on a bilateral netting agreement between the bank and its counterparty.

The future exposure, i.e. the total positive MtM price, of a netting set is a random variable, since the driving risk factors of the trades (such as interest rates, FX rates, credit spreads, etc) at a future time point are not yet known today.

PFE is usually adopted by banks to define the trading limit to control CCR. The standard numerical method, if not the only method, in industry for PFE calculations is the Monte Carlo simulation. In this MC framework, the risk factors are first simulated according to pre-selected stochastic models, then the simulated scenarios are fed to the pricing functions of the trades to yield their MtM prices at a future time point, and at last we aggregate them up to yield the future exposure distribution of the whole portfolio and return the 97.5%-th quantile as the PFE value.

Since Feb. 2022, FF Quant has been researching on the application of the COS method to replace the Monte Carlo simulation in this context. It belongs to the family of Fourier methods and solves the distribution of future exposure via inverting the characteristics function, which we calculate via numerical integration. The COS method was first introduced in 2008, initially for the purpose of option pricing. However, the essence of the method is to recover the unknown density function from its Fourier-cosine series expansion, with the key insight that the series coefficients are almost readily available from the characteristic function which is very often easier to derive than the density function itself.

**Challenge**

The challenge in the standard Monte Carlo simulation method is the slow convergence rate. A large number of simulation is required to obtain an accurate estimate of the 97.5% quantile.

Initial results of the COS-PFE method being developed at FF Quant are very promising for small netting sets which have up to 3 dimensions, while the “curse of dimension” remains as the bottleneck for higher dimensions, which is an intrinsic problem of multi-dimensional numerical integration.

**The goal and content of this thesis**

The goal of this thesis project is to improve the performance of current numerical methods in two ways:

* Replace the standard Monte Carlo simulation method by Monte Carlo simulation with importance sampling. Here the key insight is that the change of measure can be done efficiently with the help of the COS method.
* Push up the limit of the direct application of the COS method by mean of including dimension-reduction techiques which are currently being developed by another Msc thesis project at FF Quant.

The thesis project will begin with a literature study on PFE and CCR in general.

As the 2nd step, the student will study the methodologies of PFE-COS method and dimension-reduction techniques being developed at FF Quant.

As the 3rd step, the student will apply the dimension-reduction techniques on the existing PFE-COS method to push up the calculation limit and test on large netting sets, e.g. with up to 6 dimensions or more. The performance needs to be compared to standard MC method.

In the 4th step, the student will conduct a literature review on importance sampling methods in general and then develop an efficient algorithm using the COS method to find the auxiliary distribution needed for importance sampling.

At last, the student compares the performance of the two enhanced methods, and conclude on future research works.

**Contact**

If you are interested to enter the field of quantitative risk analysis, this is a very good starting point. Please feel free to contact me directly if this topic is of your interest, or if you would like to learn more details: [fang.fang@ffquant.nl](mailto:fang.fang@ffquant.nl) or [f.fang@tudelft.nl](mailto:f.fang@tudelft.nl)

**About FF Quant Advisory B.V.**

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<http://fsquaredquant.nl/>

We provide quantitative consulting services to banks, insurance companies and other financial institutions. Our expertise include the development, validation and audit of regulatory and non-regulatory risk models and of pricing models for financial instruments.

We are also specialized in researching, developing and testing quantitative toolkits. Other services include, but are not limited to, backtesting of trading strategies, applying machine learning techniques to replace traditional quantitative models, etc.

1. Part-time Assistant professor at the Applied Mathematics Department of TU Delft; Director of FF Quant Advisory B.V. https://fsquaredquant.nl/ [↑](#footnote-ref-2)