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Market-consistent actuarial valuations with application to EIOPA Risk-Margin and time-consistent pricing

Ahmad Salahnejhad Ghalehjooghi (NN)

To obtain a market-consistent price, we combine hedgeable financial risk with an (partially) unhedgeable actuarial risks in a hybrid payoff by the “two-step valuation” which is built based on the conditional valuation operators. In a general setting, the valuation process comprises the no-arbitrage price of the pure financial risk, the value of partially hedged actuarial risk attributable to its correlation with financial risk (if available), and finally the value of pure actuarial risk through well-known actuarial premium principles. We implement the two-step valuation in the multi-period setting by using a backward iteration method and obtain a time-consistent market-consistent (TCMC) price over the whole valuation period. We also provide a market-consistent version of the alternative pricing methods: the Best-Estimate pricing method typically used for pension liabilities and the EIOPA Risk-Margin method used under Solvency II to value life insurance liabilities. By comparing these prices with the TCMC price for a unit-linked contract, we show that the EIOPA Risk-Margin method acts in the correct direction to reflect part of the uncertainty attributable to the future dynamics of non-hedgeable risks, whereas Best-Estimate pricing completely ignores that uncertainty. Because the Risk-Margin method still ignores the second order uncertainty (also called Uncertainty on Uncertainty), it is not fully time-consistent and its gap with TCMC should not be ignored for long-dated contracts.

The multi-period conditional operators in the two-step valuations imposes a considerably high volume of calculations. In this talk, we also introduce some techniques to implement the numerical calculations of the EIOPA Risk-Margin and time-consistent actuarial pricing in an efficient way. We (numerically) show that the two-step actuarial valuation is capable to captures the partial (or perfect) hedge because all three prices converge to one adjusted Best-Estimate price when the correlation between financial and actuarial risks increases.

Algorithms in FRTB

Harish Kumar (EY) and Niels van der Kleij (EY)

Adoption of the Fundamental Review of the Trading Book (FRTB) requires the implementation of a number of computationally expensive methods. We consider three methods and present an efficient algorithm for each:

• Proxy selection using t-Distributed Stochastic Neighbor Embedding (t-SNE);

• P&L vector generation using Adjoint Algorithmic Differentiation (AAD) computed sensitives instead of full revaluation;

• Continuity assessment for NMRF using modellability clustering.

A new pricing model for cash-settled swaptions

Raoul Pietersz (ABN AMRO)

The market for cash-settled swaptions has changed its quotation conventions. Cash-settled zero-wide collars struck at the swap-settled forward have started trading at non-zero prices. Apart from full-fledged term-structure models, a simple arbitrage-free model to consistently value both cash-settled and swap-settled swaptions has been lacking so far. We propose a straightforward arbitrage-free model that consistently values cash-settled and swap-settled swaptions, and that also allows to match the newly published zero-wide collar premiums. The defining characteristic of the model is to explicitly specify the swap-settled annuity as a function of a discount swap rate under the swap-settled annuity measure. The new methodology has many desirable features, and a numerical example illustrates how the model performs in realistic market scenarios.

Adjoint algorithmic differentiation in practice

Liviu Sandu

The goal of the presentation is to show what is to be done when a project including Adjoint Algorithmic Differentiation (AAD) computation is required to be built from scratch. It, practically, explains some of the theory included in the books *Evaluating Derivatives: Principles and Techniques of Algorithmic Differentiation* by Andreas Griewank and *The Art of Differentiating Computer Programs* by Uwe Neumann and different reference articles on the theme - that can be found on the Internet - about concrete applications of AAD.

The target is quant developers, but analysts can also find something useful in the presentation, as it explains how the formulae are deduced and how to help when existing code has to be adapted to AAD.

Presentation paragraphs:

• From formulae to algorithms:

- Answered questions: “Why are those odd formulae like that?” “What is their meaning?”;

• Implementation flavours (first derivative):

- Answered questions: “What is the difference between them?”, “Why and when should I use one or another?”, “Given an algorithm, how am I going to design the tangent and, mainly, the adjoint model of it?", "Where are the pitfalls?", and "How does operator overload model actually works?";

• Implementation issues:

- Answered questions: "How do I start to design?", "What is the meaning of the coding rules described in the books?", "Some examples?", and "How am I going to implement an "if" statement in AAD?"

• Memory issues:

- Answered questions: "Should I worry about memory consumption?" If yes, what should I do?";

• More concrete examples:

- Answered questions: "In case of sensitivities for CVA how will AAD code be included?", "Do I have to transform ALL library code?", "In case of Monte Carlo pricing what are some of the problems?", and "What am I going to do about sensitivity to correlation coefficients?".

Robotics as an enabler for risk management

<u>Roald Waaijer (Deloitte) and Martijn Westra (Deloitte)</u>

Digitization of white collar jobs via robotic and cognitive automation and advances in data science have sparked this new revolution. Insight driven organizations (IDOs) embed analysis, data and reasoning into decision making processes using analytics to tackle their most complex business challenges. Deloitte envisions potential in the application towards risk and financial reporting processes within financial institutions. With important benefits: (1) potential increase in operational efficiency of the reporting cycle up to 90% and (2) the ability to move towards a more continuous risk monitoring framework. In our presentation we will talk about and demonstrate the potential of Robotic Process Automation (RPA) for the Risk function of a financial institution.

The developments of Monte Carlo models for counterparty exposure risk management

<u>Peter den Iseger (ABN AMRO)</u>

During the last two years ABN AMRO had developed new Monte Carlo models for counterparty exposure risk management. This is challenging as measuring counterparty risk brings many model component together, including modelling for future paths for risk factors, being able to price quickly and efficiently different trading products and modelling collateral and netting agreements. Besides this there are challenges in aligning the models with the available market data, portfolio snapshots and the calculations systems. During this presentation I will give you a flavour of what such a project entails, what the challenges are, the underlying models we use and the practical implementation and use of these models.

The collocating local volatility framework - A fresh look at efficient pricing with smile

<u>Lech Grzelak (Rabobank)</u>

It is a market practice to price exotic derivatives, like callable basket options, with the local volatility model (B. Dupire, 1994, E. Derman & I. Kani, 1994) which can, contrary to stochastic volatility frameworks, handle multi-dimensionality easily. On the other hand a well-known limitation of the nonparametric local volatility model is the necessity of a short-stepping simulation, which, in high dimensions, is computationally expensive. In this article we propose a new local volatility framework called the Collocating Local Volatility (CLV) model which allows for large Monte Carlo steps and therefore it is computationally efficient. The CLV model is by its construction guaranteed to be almost perfectly calibrated to implied volatility smiles/skews at a given set of expiries. Additionally, the framework allows to control forward volatilities without affecting the fit to plain vanillas. The model requires only a fraction of a second for complete calibration to simple vanilla products and, finally, it allows for calculation of the Greeks without re-simulating of the Monte Carlo paths. We will apply the CLV model for pricing FX barrier options and also show that under this new framework we can easily price Bermudan options on 100-dimensional baskets of correlated underlyings within just a few seconds. Illustrative examples will be also presented.

Market data used in real-life

<u>Vivike Lapoutre (Optiver)</u>

At Optiver, we make markets on derivatives at exchanges across the world. This provides us with a myriad of market data on the products we trade, as well as on our own orders and parameters.

In this talk I will address three different applications of market data: quantitative trading, historical analysis, and investigation of the relationship between products. Together with these applications I will also touch upon the challenges involved.

Applied Conic Finance

<u>Wim Schoutens (KU Leuven)</u>

We give an introduction to Conic Finance. Conic Finance is a new quantitative finance theory incorporating in a fundamental way bid and ask pricing. We provide the basics and its connection with the concept of acceptability and coherent risk measures. Distorted expectations are employed to actually calculate bid and ask prices. We elaborate on various applications of the theory.

Towards a futureproof anti money laundering framework

Pieter-Jan van Kessel (PWC) and Casper Ruizebdaal (PWC)

The majority of banks is using static, rule based presumptions on customer behaviour as a basis for detecting suspicious transactions and reporting these to the Financial Intelligence Authorities (FIU). As a consequence, a high number of false alerts are generated and there is a large risk of missing suspicious transactions due to 'blindness' of current detection systems. Machine learning techniques can improve both the efficiency and effectiveness of the Anti Money Laundering (AML) framework by gaining a more sophisticated understanding of customer behaviour. In this session we first describe the current AML framework. Subsequently, we indicate at which stages of the AML framework supervised and/ or unsupervised machine learning algorithms could be applied and provide you with an explanation of these algorithms, their properties and how to apply these.