Solvency II Market Risk Modelling and Tool Development

Capstone project Summary

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1. Background, the purpose of the project

The main objective of this Capstone project is to develop Excel and VBA based Tools to model and verify Solvency II (SII) Market risk capital requirements. Both ad-hoc and regular quarterly calculation of the Solvency II Market risk capital requirements (SCR) is a standard task of quantitative risk managers working for insurers. The Market risk calculation is a crucial segment, which usually has a significant impact on the overall capital requirement of life and composite insurance undertakings. Due to the rapidly changing economic environment, additional analyses are often needed, which require fast and flexible methods to calculate shock scenarios. The aim of the work is to develop tools which can accurately calculate the Market risk Solvency Capital Requirement (SCR) according to the SII standard formula. The models should be designed in a user-friendly fashion which provide deep insight into the calculation steps and enable data visualization as well as easy review of the valuation results. Thus, risk management controls should be strengthened, efficiency gains and more flexibility in actuarial and risk management processes should be achieved.

Solvency II is a risk-based capital adequacy and stress testing requirement framework for insurance undertakings. The main goal of the regime is to protect insurance policyholders and beneficiaries by setting capital requirements and providing incentives for risk management. In principle it should ensure that insurers do not make promises they cannot deliver. Similar to Basel III the Solvency II framework is divided into three pillars. While the second and third Pillars focus on qualitative requirements and supervision, as well as on prudential reporting and disclosures, the first Pillar sets out quantitative requirements. This includes the rules to value assets and liabilities, to calculate capital requirements (SCR = Solvency Capital Requirement) and to identify eligible Own Funds to cover these requirements. The agreed confidence level is 99.5% value at risk (VaR). The SCR consists of different risk submodules such as Market risk, Life insurance underwriting (uw) risk, Non-Life insurance uw risk, Health insurance uw risk and Counterparty Default risk submodule. The Market risk relates to the volatility of the market values of assets and liabilities due to future changes of asset prices. The capital requirement for Market risk can be assessed by analyzing the Own Funds impact of shocks in the underlying market risk factors. The risk categories defined in Market risk are Interest rate risk, Equity risk, Property risk, Credit Spread risk, Currency risk and Concentration risk. The scope of this project covers every risk category within the Market risk submodule.

2. Market Risk Modelling and Tool development

In the project 3 models were developed in Excel and Visual Basic Application: separate tools for the Concentration risk and Interest rate risk calculation plus a Master Market Risk Model, which covers every risk category within the market risk submodule. Market risk related ad-hoc analyses with tight timeframes are often required, therefore flexibility was a key-criteria for the selection of the applied development method. The models are aimed to be used for Non-life and Traditional life insurance investments. The data handling was fully automated and the tools were designed to simulate a transparent and self-explanatory graphical user interface, which actively communicate with the user with multiple built in checks and all-around error-handling.

2.1. Concentration Risk Model

Concentration risk is a relatively small part of the Market risk valuation process, however due to it's calculation specialties, an additional model was built for this risk category. As outlined in Article 182 of the Directive 2009/138/EC of the European Parliament the capital requirement for market risk concentration shall be

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calculated on the basis of single name exposures. For this purpose exposures to undertakings which belong to the same corporate group shall be treated as a single name exposure. For the calculation of the capital requirement for market risk concentration the excess exposure thresholds and risk factors are assigned to single exposures depending on the weighted average credit quality step.
The Concentration risk model uses asset data held for the Non-life and the Traditional life business. The asset list can be imported automatically into the Concentration risk model. For checking purposes and analysis it is possible to input the asset data from the previous reporting period. The model will generate the single exposures, reconcile the counterparties and compare the market value of the two reporting periods. These single exposures will be used in the concentration risk calculation too. User defined input will be also required, which can be stored if the model is updated. Checks are implemented in the tool and results can be imported from external templates for comparison. The concentration risk can be calculated per insurance segment (Non-life, Life, Total).

2.2. Interest Rate Risk Model

Interest rate risk calculation was modelled both as a separate tool and as part of the Master Market Risk Model. According to Article 182 of Solvency II (Directive 2009/138/EC) the capital requirement for the risk in the term structure of interest rates for a given currency shall be equal to the loss in the basic own funds resulting from an immediate increase or decrease of the risk-free term structure. The increase or decrease of the interest rates at any maturity shall be at least one percentage point.
The developed models can calculate Interest rate risk by modified duration and linear approximation or by the more accurate cashflow based method. Input files are asset list and the EIOPA terms structures. The import of both input data is automatic and no data manipulation is required by the user. In case of the individual Interest rate risk Model, the list of bonds – subject to the valuation – can be inputted either manually or it can be automatically extracted from the total asset list. Checks are implemented at this stage to ensure correct data processing. The calculation takes place on a separate tab. It is possible to perform individual bond valuations, where the entire cashflow vector is generated. Besides the Interest rate risk, Dirty value plus bond duration is recalculated. Comparisons are also implemented in case results would be available from external sources. The tools can also automatically process the valuation for all the fixed-income securities at once. Individual comparisons are built-in for the result data too.

2.3. Master Market Risk Model

Besides Concentration risk and Interest rate risk, the Master Market Risk Model comprises the other four components of the Market risk submodule. In the following paragraph I give a brief explanation about the main idea of each of the implemented risk categories.
The equity risk module (*Article 168)* includes a risk sub-module for type 1 equities (decrease of 39% or 22% for investments in related undertakings is assumed) and a risk sub-module for type 2 equities (decrease of 49% is assumed). The capital requirement for spread risk (*Article 176)* on bonds and loans shall be equal to the loss in the basic own funds that would result from an instantaneous relative decrease of stress in the value of each bond or loan other than mortgage loans. The risk factor shall depend on the modified duration of the bond or loan. According to *Article 188* the capital requirement for the risk of an increase or decrease in value of a foreign currency against the local currency shall be equal to the loss in the basic own funds that would result from an instantaneous increase or decrease of 25% in the value of the foreign currency against the local currency. The calculation of the capital requirement for property risk is very simple. It is equal to the loss in

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the basic own funds that would result from an instantaneous decrease of 25% in the value of property (*Article 174 of Solvency II)*.

Similar to the Concentration risk and Interest rate risk tools data can be automatically or manually pulled into the Master Market Risk Model. The valuation can be run for each asset and every risk type at once. Calculation methods of exceptional cases are also handled. The results are summarized in a report format including the sub-results as well. Individual result comparison is available with external market risk figures. There are multiple built in features which help the navigation within the model and several settings are available to display the optimal amount of data. A comprehensive scrutiny sheet was added as well, which includes a checklist (with both automatic and user defined checks) and multiple result summaries as well as comparisons (results are cross-checked between the Economic Balance Sheet, the asset list and the model).

3. Project assessment, key outcomes and benefits

Working on this task was a challenging but rewarding and very interesting at the same time. It helped me to gain better understanding of the Solvency II risk management framework. I could already put the models to work and they performed well on real work. It was a lot faster to perform the calculations and saved a lot of time which I could spend on reviewing the results or on other tasks. Adding more advanced calculation methods (e.g. CF based Interest rate risk calculation) proved to be very helpful in some of the recently performed nonstandard assessments. Despite the positive first experience, further testing should be done and there are many long-term enhancement opportunities. On top of verifying market risk results, with some extensions, the developed tools can be used efficiently to support the regulatory reporting process. Solvency and Financial Condition Report (SCFR), Regular Supervisory Report (RSR) Own Risk and Solvency Assessment (ORSA) all require detailed information and summaries about the Market risk and assets allocated for individual insurance segments. Furthermore, it was possible to make good use of the tools especially in recent times, when several forecasts and shock scenario analysis were carried out, in the wake of the pandemic situation.

4. Potential future developments

Since in the project a lot of work was done on automatization of data processing and SCR calculation in an easily auditable and intuitive manner, further improvements can be made on alternative scenario generation. The calculation potential of the models should be extended to Unit-Linked asset portfolios with Big data characteristics.

- **Sensitivity result calculation feature:** stress testing and scenario-analysis is a standard part of regulatory reports such as ORSA and SFCR. Furthermore, with the help of flexible scenario generation and allowance for alternative term structures ad-hoc analysis can be easily performed to calculate Market risk and assess shock impact on the Economic Balance Sheet.
- **Market Risk Calculation Tool development for Unit-Linked Asset portfolio**: in Unit-Linked (UL) businesses asset allocation is driven by policyholders, therefore greater diversification and investments in collective investment undertakings is common. Decomposed asset data subject to analysis can often hold Big Data characteristics. Application the tools for UL datasets would require optimization of calculation power, or the usage of Python might worth considering.
- **Implementation of Concentration risk and cashflow based Interest rate risk calculation in the Master Market Risk Tool:** Incorporating these functionalities in the Master tool can further simplify and speed up the calculation process.

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