

## Market Solvency Capital Requirement Minimization: How Non-linear Solvers Provide Portfolios Complying with Solvency II Regulation

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**Abstract :** In this article, a portfolio optimization problem is performed in a Solvency II context: it illustrates how advanced optimization techniques can help to tackle complex operational pain points around the monitoring, control, and stability of Solvency Capital Requirement (SCR). The market SCR of a portfolio is calculated as a combination of SCR sub-modules. These sub-modules are the results of stress-tests on interest rate, equity, property, credit and FX factors, as well as concentration on counter-parties. The market SCR is non convex and non differentiable, which does not make it a natural optimization criteria candidate. In the SCR formulation, correlations between sub-modules are fixed, whereas risk-driven portfolio allocation is usually driven by the dynamics of the actual correlations. Implementing a portfolio construction approach that is efficient on both a regulatory and economic standpoint is not straightforward. Moreover, the challenge for insurance portfolio managers is not only to achieve a minimal SCR to reduce non-invested capital but also to ensure stability of the SCR. Some optimizations have already been performed in the literature, simplifying the standard formula into a quadratic function. But to our knowledge, it is the first time that the standard formula of the market SCR is used in an optimization problem. Two solvers are combined: a bundle algorithm for convex non- differentiable problems, and a BFGS (Broyden-Fletcher-Goldfarb- Shanno)-SQP (Sequential Quadratic Programming) algorithm, to cope with non-convex cases. A market SCR minimization is then performed with historical data. This approach results in significant reduction of the capital requirement, compared to a classical Markowitz approach based on the historical volatility. A comparative analysis of different optimization models (equi-risk-contribution portfolio, minimizing volatility portfolio and minimizing value-at-risk portfolio) is performed and the impact of these strategies on risk measures including market SCR and its sub-modules is evaluated. A lack of diversification of market SCR is observed, specially for equities. This was expected since the market SCR strongly penalizes this type of financial instrument. It was shown that this direct effect of the regulation can be attenuated by implementing constraints in the optimization process or minimizing the market SCR together with the historical volatility, proving the interest of having a portfolio construction approach that can incorporate such features. The present results are further explained by the Market SCR modelling.

**Keywords :** financial risk, numerical optimization, portfolio management, solvency capital requirement

**Conference Title :** ICFMRPM 2020 : International Conference on Financial Mathematics, Risk and Portfolio Management

**Conference Location :** Paris, France

**Conference Dates :** June 25-26, 2020