GC Briefing
An update from the Financial Integration Team

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MetaRisk® and QIS 4 Draft: Calculating Market Risk

Solvency II will allow insurers to use approved internal models instead of the standard formula to evaluate market risk and determine solvency capital requirements. With an approach that includes the use of dividends and coupons, MetaRisk® offers a more realistic assessment than the standard formula, enabling more effective decision-making.

Standard Formula vs. Internal Model: Selecting the Tools of the Trade

With Solvency II, the European Union intends to protect policyholders and the stability of the European (and by extension global) insurance system. At the heart of this proposed regulation is the solvency capital requirement (SCR), which requires that risk-bearers have a 99,5 percent probability of remaining solvent for the coming 12 months in the face of the many risks that threaten solvency.

In preparing for Solvency II, insurers have a choice. They can use the standard formula, currently defined in QIS 4 Technical Specifications, Draft, December 2007 (QIS 4 Draft). The goal is for the standard formula to be universally applicable, which does not necessarily mean that it will be universally advantageous. Alternatively, carriers can implement internal models that have been approved by the appropriate supervisory authorities.

Though the standard model final requirements are still being defined, Guy Carpenter's MetaRisk simulation platform is on track to constitute a viable alternative to the standard formula. Specifically, MetaRisk addresses:

- Underwriting risk
- Market risk
- Credit risk
- Operational risk

As a result, the platform includes all the dimensions likely to be necessary for building a Solvency II-compliant internal model.

Economic Balance Sheet Approach in Solvency II

The SCR is used to determine whether an insurance company's net asset value (NAV) is sufficient to withstand adverse developments. Ultimately, NAV should be sufficient to withstand risks related to underwriting, the market, credit and operations for the coming 12 months at a probability of 99,5 percent. By stressing the balance sheet, the SCR assesses an insurer's solvency. The first step in the evaluation is to determine the carrier's NAV on an economic basis, a process that is performed every year at 1 January.

NAV is determined by subtracting the market value of all liabilities (MVL) from the market value of all assets (MVA). MVL is calculated by evaluating all future cash flows on a discounted basis and incorporating risk margins. After calculating NAV, a distribution of profits and losses for all significant risk categories must be determined to derive the capital needed to satisfy the 99,5 percent probability requirement. The role of the distribution is to ascertain the adverse net economic result for the 200-year return period. Individual risk categories and their interdependencies are parameterized, after which a Monte Carlo simulation is used to derive the distribution of net economic results.

Market Risk According to QIS 4 Draft

The market risk capital charge in Solvency II, as proposed in QIS 4 Draft,[1] consists of a set of stress tests for adverse developments in the financial markets. The purpose of these tests is to ascertain immediately the implications of a variety of financial market scenarios on an insurer's NAV – and ultimately on its solvency in the wake of adverse financial market conditions.[2]

According to the SCR, sub-risk stress tests should have an instantaneous effect on NAV as the result of:

- An upward and downward shock to the risk-free term structure (Mkt_{int})
- A downward shock to equity (Mkt_{eq})
- A downward shock to property (Mkt_{prop})
- A shock to currency exchange rates (Mkt_{fx})
- An increased credit spread over the risk-free interest rate term structure (Mk_{tsp})
- An excessive concentration of equity and (non-governmental) fixed income instruments with the same counterparty (Mkt_{conc})

In the standard formula, every stress test is defined in a way that ensures that the capital charge for each sub-risk is nonnegative. Since stress tests for the sub-risks are assessed independently, total market risk SCR_{mkt} is achieved via aggregation using a prescribed correlation matrix, such as:

$$SCR_{mkt} = \sqrt{\sum_{rxc} CorrMkt_{r,c} \cdot Mkt_r \cdot Mkt_c}$$

SCR_{mkt}: solvency capital requirement for market risk

CorrMkt: correlation between sub-risk $_r$ and sub-risk $_c$

Mkt_r and Mkt_c: solvency capital requirement calculated for sub-risk r or c, where r and c are each one of interest (int), equity (eq), property (prop), foreign exchange (fx), spread (sp) or concentration (conc).

The sum is taken across all combinations of r and c.

[1] *QIS 4 Technical Specifications, Draft, December 2007.*

[2] *Market risk is also decreased by the risk-mitigating effect of future profit sharing for equity risk, property risk, interest rate risk and spread risk. This offset mostly has an impact for life insurance.*

The standard approach to assessing market risk is quite conservative[3] because the scenarios evaluated using the SCR are considered to occur simultaneously at the beginning of the year – directly following the initial available capital assessment. Further, the standard formula ignores coupons, interest and dividends, which could be used in practice to offset a loss of value.

Market Risk Assessment According to MetaRisk

MetaRisk takes a more integrated approach to stressing the balance sheet and assessing solvency. Unlike the standard formula, MetaRisk specifically addresses both asset risks and asset returns as they influence solvency.

Economic Scenario Generator

An economic scenario generator (ESG) is central to the MetaRisk approach to calculating market risk. The ESG provides a large set of scenarios for the evolution of risk-free yield curves, appreciation and dividends for equities and for the appreciation of property. Currently the evolution of eight risk-free yield curves (varying by country), five equity indices and one global property index are modeled.

The economic scenarios constitute the foundation for assessing market risk in MetaRisk. Since each economic scenario contains coherent scenarios for the modeled financial entities, dependencies among appreciation, dividend and yield curve evolutions are explicitly modeled. Because MetaRisk uses the yield curve both to discount technical provisions and to evaluate the market value of fixed income instruments, the interest rate interdependence between assets and liabilities is captured.

Calculating Market Risk

Market risk is derived from one-year changes in the insurer's NAV related to investments and changes in interest rates. MetaRisk measures these changes in each iteration of the model. For a single iteration, the market risk component (before any reallocation to the underwriting result) is calculated as the negative of the after-tax[4] sum of:

- Appreciation and coupons on bonds
- Appreciation and dividends on equities
- Appreciation on property
- Interest on cash
- Interest on other invested assets
- The positive or negative impact on the balance sheet resulting from changes during the year in the yield curve used to evaluate incoming reserves[5]

The positive or negative impact from changes in interest rates on incoming loss and loss adjustment expense reserves is the difference in the market values (best estimate plus market value margin) of cash flows remaining until run-off at the end of the solvency assessment year, as calculated using the beginning- and the end-of-year yield curves.

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[3] *In the standard model, a situation in which there was no change to the interest rate term-structure would result in zero market interest rate capital charge.*

[4] *In determining the impact of taxes, we assume that the tax rate applies if the change in capital is positive and that there are no taxes if the change in capital is negative. This approximation likely understates the tax benefit when the change in capital is a small negative value, as the company can likely increase its deferred tax asset in those situations. Because we are focusing primarily on the 200-year return period for this analysis, we assume that losses are so great that the company will not be allowed to increase its deferred tax asset and the effective tax rate is 0 percent.*

[5] *Adverse development for discounted incurred loss, being defined as [Outgoing Reserve -(Incoming Reserve + Paid during the year)], could be the result of both an adverse development in nominal loss and a decrease of the yield curve increasing the value of discounted reserves. In the Solvency II framework these effects are isolated, with the first effect being categorized as underwriting risk and the second as market risk.*

MetaRisk assumes that the interest rate in effect at the beginning of the year is earned during the year. Consequently, there is no interest rate risk impact on loss payments during the first year, and cash flows during the first year are evaluated using the beginning yield curve. If the market value of net reserves from the end of the year until run-off is higher with the end-of-year yield curve compared to the beginning-of-year curve, the difference represents an increase in market risk.

Unlike the standard formula, MetaRisk addresses the effects of coupons, interest and dividends, which can offset a loss of value. The result is a more realistic expression of a company's true market risk. While this consideration is an improvement over the standard formula, there are some factors not currently modeled in MetaRisk, including spread risk, currency risk and concentration risk.

Reallocating Investment Income from Market Risk to Underwriting Risk

Policy pricing reflects, as appropriate, the future investment income likely to be generated by policy cash flows. Premiums are paid up front and losses are paid afterwards. For long-tail businesses, a considerable amount of investment income is generated. A portion of the investment income can be transferred to the underwriting result in order to facilitate the measurement and comparison of profitability among product lines. The income allocated should correspond to the risk-free return achievable on reserves and premium payments. This approach is reasonable when using an economic capital model for managing and improving business operations.

The current release of MetaRisk transfers the risk-free portion of the investment income to underwriting risk. The result is an increase in market risk and a decrease in underwriting risk. Guy Carpenter continues to follow Solvency II calibration requirements to ensure that MetaRisk will remain compliant with the evolving proposed regulations and stay appropriate for strategic business management.[6]

Case Study Assumptions

This example evaluates market risk for a company in run-off[7] as of 1 January 2008 using both the QIS 4 Draft standard model stress tests and MetaRisk.

	Yield Curve
T=	Y_0 =
1	3,44%
2	5,11%
3	5,50%
4	5,63%
5	5,76%
6	5,77%

[6] *If all cause-effect relationships (correlations) that exist between different risk categories were explicitly modeled, it would not make any difference for the total SCR requirement if the risk was classified on a lower level as market risk or underwriting risk.*

[7] *A company in run-off is chosen for simplification to avoid assessing interest rate risk for premium provisions.*

Liabilities

Technical provisions have the expected pay-out pattern on 1 July during the coming four years shown in the table below. The Market Value Margin is assumed to be zero to simplify the example.

	2008	2009	2010	2011
Pay-out	500	400	300	200

The "MVL" is the present value of these payments using the yield curve above. As such, MVL = 1290[8]

Assets

Bonds

	Bond 1	Bond 2	Bond 3	Bond 4
Par	400	200	150	350
Coupon	5,11%	5,50%	5,63%	5,76%
Maturity	1,5	2,5	3,5	4,5
Market Value	410,2	205,6	154,3	360,5
Rating	govmt	govmt	govmt	govmt

Cash, Equity and Property

		Swedish	Japanese	Swedish
Asset class	Cash	Equity	Equity	Property
Market Value	100	150	150	250
Rating		A	BBB	

The "MVA" is the sum of the market values shown in the tables above. As such, MVA = 1781.

Net Asset Value

NVA = MVA – MVL = 1781 – 1290 = 491

[8] *For detailed calculations and the formula used, please see Appendix A.*

Case Study Results

Using the above assumptions, we can compare the market risk capital requirement generated by MetaRisk with that calculated using the standard formula. MetaRisk was used to determine market risk both with and without reallocation to underwriting risk. Market risk as determined by QIS 4 Draft is substantially different from the MetaRisk results, as shown in the table below.

- Market risk QIS 4 Draft = 146
- Market risk MetaRisk® (without reallocation to underwriting risk) = 20
- Market risk MetaRisk® (with reallocation to underwriting risk) = 55

The differences in results are attributable to the following differences in assumptions:

1. The standard formula does not take coupons, dividends and interest on cash into account. There are on average 62 in coupons, dividends and interest on cash during the year.

2. The standard model includes spread risk, concentration risk and currency risk. MetaRisk does not take these risk categories into account. The lack of these sub-risks has minor impact since all bonds are assumed to be government bonds and there is no foreign exposure. If these risks are excluded from the standard formula in our example, the total market risk charge would be reduced by 1 to 145. Concentration risk has a minimal effect on the total market risk capital requirement because it is completely uncorrelated with the other risks in the standard formula and is small relative to the total in this case study.

3. The standard formula assumes everything happens on 1 January (conservative). MetaRisk assumes interest rates are fixed during the first year (simplification) and then change.

4. The standard model's stress test levels for equity, property and interest rates are not exactly the same as the outcomes from the ESG, and they reflect different implicit correlations than the standard formula. The difference in the equity risk capital requirement is 6; the difference in the property capital requirement is 5.

The difference in market risk between MetaRisk and the standard model is 91 (146 – 55). Of this difference, the cash investment return treatment in MetaRisk explains 62 and the differences in the stress tests for equity and property explain 11. A portion of the unexplained risk emanates from differences in yield curves and implicit correlations which are more difficult to quantify. Nonetheless, it is clear that the differences in evaluation dates (on 1 January as compared to throughout the year) and the exclusion of concentration risk are relatively small.

Analysis Using the QIS 4 Draft Approach

As indicated above, the SCR for market risk derived using the QIS 4 Draft approach (SCR_{mkt}) is 146.[9]

[9] *This case assumes government bonds only, with no foreign exchange exposure.*

The components of market risk according to the standard formula are shown in the table below. The impact of the correlations is to reduce total market risk by 45 from the amount that would be derived if it were assumed that all risks occurred concurrently (191).

Risk category	MKT_{int}	MKT_{eq}	MKT_{prop}	MKT_{sp}	MKT_{conc}	MKT_{fx}	**SCR_{mkt}**
Capital charge	26	96	50	0	19	0	**146**

Mkt_{int} = 26 (result of the up-stress)

- Mkt_int^{up}: Increase of yield curve by QIS 4 Draft prescribed stress. The Net Present Value (NPV) of Assets and Liabilities are recalculated using the new yield curve. The MVL decreases to 1223 and the MVA decreases to 1687. △NAV = -27 as Asset Class (AC) goes from 491 to 464.
- Mkt_int^{down}: Decrease of the yield curve by QIS 4 Draft prescribed stress. MVL goes to 1337; MVA goes to 1851 and △NAV=+23

Mkt_{eq} = 96
Fall of "Global" equity by 32 percent. MVA decreases by 96.

Mkt_{prop} = 50
Fall of global property by 20 percent. MVA decreases by 50.

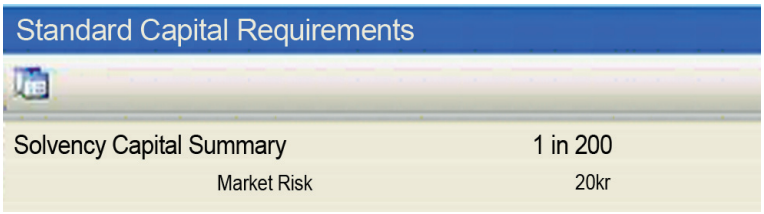
Mkt_{conc} = 19
Following a rather involved formula.

Mkt_{spread} = 0
Government bonds are excluded from Spread Risk.

Mktfx = 0
We assume there is no foreign currency exposure.

Analysis Using MetaRisk

The SCR for market risk derived using MetaRisk before reallocating the risk-free rate to underwriting is 20.



The SCR for market risk derived using MetaRisk after reallocating the risk-free rate to underwriting, is 55.

Market risk has increased by 35, which has been used to lower underwriting risk due to the reallocation of investment income at the risk-free rate.

Calibration of 1-in-200 Year Stress Levels

Part of the difference in capital requirements emanates from differences in the amount of loss at the 1/200 year level. The 1/200 year returns for equity and property in MetaRisk's ESG differ from the QIS 4 Draft standard tests.

	QIS 4 Draft	ESG
Equity Shock	-32 percent	-24 percent* to -38 percent**
Property Shock	-20 percent	-18 percent

**United States*
***Japan*

The returns shown in the table above represent the 1/200 values for each region's appreciation. MetaRisk also considers dividends and implicit correlations for returns across regions. In this example, the 1/200 total return for an equity portfolio that is 50 percent in European equities and 50 percent in Japanese equities is -28 percent or 4 percentage points lower than the standard formula. With 300 in equities on the opening balance sheet, the equity capital requirement is 12 = (0.04 x 300) less using MetaRisk and the standard formula.

The table below compares the one-year changes in the yield curve at the 0,5 and 99,5 percentiles from MetaRisk for Swedish bonds.

	Yield Curve Changes during the year							
Duration	0.25	1	2	3	5	10	20	30
Mean	7%	16%	-13%	-17%	-18%	-20%	-20%	-20%
0,5% percentile [D]	-38%	-34%	-51%	-54%	-53%	-51%	-52%	-52%
99,5% percentile [U]	72%	96%	51%	45%	37%	25%	29%	28%

The corresponding interest rate shocks are higher in the standard model for durations shorter than 10 years, and lower in the standard model for durations longer than 10 years.

Appendix A: MVL and MVA Formulas

MVL =

$$\frac{500}{(1+0{,}0344)^{0{,}5}}+\frac{400}{(1+0{,}0511)^{1{,}5}}+\frac{300}{(1+0{,}0550)^{2{,}5}}+\frac{200}{(1+0{,}0563)^{3{,}5}}=1290$$

MVA =

$$\left(\frac{0{,}0511\cdot 400}{(1+0{,}0344)^{1/2}}+\frac{0{,}0511\cdot 400}{(1+0{,}0511)^{3/2}}+\frac{400}{(1+0{,}0550)^{3/2}}\right)+$$
$$+\left(\frac{0{,}0550\cdot 200}{(1+0{,}0344)^{1/2}}+\frac{0{,}0550\cdot 200}{(1+0{,}0511)^{3/2}}+\frac{0{,}0550\cdot 200}{(1+0{,}0550)^{5/2}}+\frac{200}{(1+0{,}0563)^{5/2}}\right)+$$
$$+\left(\frac{0{,}0563\cdot 150}{(1+0{,}0344)^{1/2}}+\frac{0{,}0563\cdot 150}{(1+0{,}0511)^{3/2}}+\frac{0{,}0563\cdot 150}{(1+0{,}0550)^{5/2}}+\frac{0{,}0563\cdot 150}{(1+0{,}0563)^{7/2}}+\frac{150}{(1+0{,}0576)^{7/2}}\right)+$$
$$+\left(\frac{0{,}0576\cdot 350}{(1+0{,}0344)^{1/2}}+\frac{0{,}0576\cdot 350}{(1+0{,}0511)^{3/2}}+\frac{0{,}0576\cdot 350}{(1+0{,}0550)^{5/2}}+\frac{0{,}0576\cdot 350}{(1+0{,}0563)^{7/2}}+\frac{0{,}0576\cdot 350}{(1+0{,}0576)^{9/2}}+\frac{350}{(1+0{,}0577)^{9/2}}\right)+$$
$$+100+150+150+250=1781$$

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