Return on Risk-Adjusted Capital under Solvency II: Implications for the Asset Management of Insurance Companies

Abstract

We derive a European life insurer's return on risk-adjusted capital (RoRAC) under the Solvency II capital requirements. To do so, we draw on historical time series data and construct a large number of asset allocations, taking into account current portfolio shares of the German life insurance industry. Then, expected profits and market risk capital charges by means of the standard formula are determined. Our results indicate that the RoRAC is mainly driven by the capital requirements, while the expected profits are almost irrelevant. Moreover, we show that less-diversified portfolios with high asset risk need to be backed by low capital buffers and thus, result in high RoRAC values. Well-diversified portfolios with balanced risk-return profiles, on the other hand, involve higher capital charges and thus achieve low RoRAC figures. Hence, under Solvency II, a RoRAC-based performance measurement may have detrimental effects for a life insurer's stakeholders.

Keywords: Asset Management, Solvency II, Performance Measurement, RoRAC
JEL classification: G11; G22; G28

1 Introduction

With the beginning of 2016, the regulatory landscape for European insurers has changed substantially. After more than a decade of development and a total of five quantitative impact studies, the European Union (EU) has started the implementation of its new risk-based capital standards Solvency II. The framework applies to all EU member states and aims at providing a comprehensive assessment of the risks associated with the insurance business. Similar to the regulatory regime of the banking sector, Basel III, Solvency II comprises three pillars (EC, 2014). While the first pillar contains quantitative requirements regarding a market consistent valuation of assets and liabilities, the second pillar focuses on qualitative aspects such as the insurer's governance and risk management system as well as the Supervisory Review Process. Finally, matters related to transparency and disclosure are covered by the third pillar.

In light of the high complexity of Solvency II, particularly smaller and medium-sized insurers face great difficulties with regard to its proper implementation. A critical aspect is the determination of the technical provisions and the Solvency Capital Requirement (SCR), which requires a certain degree of internal risk management know-how and capacity. To facilitate these calculation processes, insurers lacking an internal model can resort to the standard formula provided by the regulator. A total of six modules cover various risk categories such as market, health, life and non-life risks (EIOPA, 2014d). With a share amounting to approximately 70 percent of the overall SCR, market risk is most central for life insurers (Fitch Ratings, 2011). In contrast to internal solvency models, however, the corresponding module of the standard formula is a simple stress factor approach that demands high capital charges for volatile asset classes such as stocks and hedge funds. Moreover, these stress factors clearly superimpose the positive effect of a well-balanced asset-liability management on the SCR (Braun et al., 2017). Thus, insurers applying the Solvency II standard formula are restricted in their investment decisions (Fitch Ratings, 2011), which, in turn, is likely to result in less-diversified asset portfolios with higher levels of market risk.

Although the Solvency II standard formula has been subject to extensive discussions among academics (Linder and Ronkainen, 2004; Eling et al., 2007; Doff, 2008; Steffen, 2008) and practitioners (Fitch Ratings, 2011; Ernst & Young, 2011, 2012b,a), only few articles focus on potential asset management restrictions. Fischer and Schluetter (2015), for instance, draw on an option-pricing framework to analyze the impact of the equity risk sub-module on the investment strategy of an insurer that maximizes its shareholder value. Their results demonstrate that the standard formula exerts a strong influence on both the capital and investment strategy. Similarly, the work of Braun et al. (2017) reveals several severe shortcomings of the market risk module, which may create incentives to invest in less-diversified portfolios associated with an increased default risk. These thoughts have been extended and further developed by Braun et al. (2015), who invert a partial internal model to provide estimates for the actual ruin probabilities of the Solvency II market risk standard formula. The alarming result is that admissible portfolios may exhibit ruin probabilities that are substantially higher than the targeted level.

This paper takes a different perspective by analyzing how the Solvency II capital charges impact a life insurer's risk-adjusted performance measurement through its asset allocation. We resort to historical time series data for common asset classes and construct a large number of hypothetical portfolios. Then, the insurer's capital requirements under the market risk standard formula and the expected profit are calculated in order to determine the return on risk-adjusted capital (RoRAC). Our results indicate that well-diversified portfolios with a balanced (unbalanced) risk-return profile are associated with high (low) capital charges and thus achieve low (high) RoRAC figures. Since many insurers base their performance measurement on the RoRAC, problematic incentives can be expected to arise, which, in turn, may entail severe consequences for the insurance industry.

The rest of the paper is organized as follows. In the next section, both the Solvency II market risk standard formula, a parsimonious model for the insurer's assets and liabilities, and the definition of the

RoRAC are presented. The third section covers the data set and the portfolio construction approach, while the empirical results are discussed in the penultimate section. Finally, we summarize and conclude our findings in the last section.

2 Model Framework

Solvency II Standard Formula for Market Risk

The standard formula has been calibrated using historical financial market data and relies on the value at risk (VaR) with a confidence level of 99.5 percent and a one-year time horizon (EIOPA, 2014a). The capital charges for specific market risk categories are derived from scenarios within sub-modules. More specifically, each scenario represents the effects of exogenous capital market shocks on the insurer's basic own funds (BOF). The most capital-consuming sub-modules cover interest rate risk, equity risk, spread risk, and property risk (Fitch Ratings, 2011). The interest rate risk sub-module comprises two scenarios to capture both upward and downward changes in the value of interest-sensitive assets and liabilities. Investments affected by stock market fluctuations, on the other hand, are covered by the equity sub-module, which further distinguishes between equities from the European Economic Area/Organization for Economic Cooperation and Development (Type 1) and other equities such as those from emerging markets (Type 2). Moreover, all assets and liabilities subject to changes in real estate prices are contained in the property risk sub-module. Finally, changes in the BOF resulting from widened credit spreads are captured by the spread risk sub-module. The overall market risk capital requirement ($\mathrm{SCR}_{\mathrm{Mkt}}$) is then derived by aggregating the individual capital charges according to a correlation matrix as given by the regulator (EIOPA, 2014a).[1]

We draw on the most recent technical specifications by EIOPA (EIOPA, 2014a; EIOPA, 2014b; EIOPA, 2014c) to determine the individual stress factors (see Table 1). Regarding the interest rate risk sub-module, we assume that the term structure is flat and that the insurer invests in EUR-denominated assets only. The risk-free rate equals 0.35 percent and is proxied by the mean of the AAA-rated Eurozone zero bond spot yield curve for maturities ranging from 1 to 30 years at the end of December 2015. After averaging the stress factors for all maturities, we obtain an upward shock of +43 percent and a downward shock of −37 percent.[2] For Type 1 equities, the stress has been set to 39 percent, while a common shock amounting to 49 percent applies to Type 2 equities.[3] Furthermore, we resort to the Barclays U.S. Corporate Bond Index as proxy for the insurer's corporate bond portfolio. Given its modified duration of 7.02 at the end of December 2015 and the average spread shock across all investment-grade rating classes (AAA to BBB), we compute a single spread risk stress factor of 9.04 percent. Finally, a uniform stress factor of 25 percent is prescribed for all property categories.

[1]For a detailed presentation of the market risk standard formula refer to Braun et al. (2015, 2017).
[2]Since the regulator requires an absolute increase in the upward scenario of at least one percentage point (EIOPA, 2014a), the shock needs to be manually adjusted for risk-free interest rates that are too low.
[3]Please note that these figures equal the base equity stresses without taking into account the so-called symmetric adjustment mechanism (for further information refer to EIOPA, 2014a).

Sub-module	Shock (in percent)
Interest Rate Risk	–37.00/+43.00
Type 1 Equities	–39.00
Property Risk	–25.00
Spread Risk	–9.04

Table 1: Stress Factors – Solvency II Market Risk Standard Formula

Stylized Insurance Company

We model the insurer's assets and liabilities by means of a parsimonious discrete-time model with a one-period evaluation horizon.[4] More specifically, by assuming that all cash flows are exchanged at $t = 0$, the deterministic assets at the beginning of the period (A_0) divide into the available equity (EC_0) and the premium payments (Π_0) of the policyholders. We treat the life insurance portfolio as fixed in the short term and let the stochastic assets at $t = 1$ depend exclusively on the asset portfolio return ($\tilde{r}_A$):

$$\tilde{A}_1 = A_0 \cdot (1 + \tilde{r}_A). \tag{1}$$

The aggregated portfolio return $\tilde{r}_A$, in turn, is obtained from the portfolio weights w_i and normally distributed, discrete returns r_i for each asset class i ($i = 1, ..., n$) as follows:

$$\tilde{r}_A = \begin{pmatrix} w_1, & w_2, & \cdots & w_n \end{pmatrix} \begin{pmatrix} \tilde{r}_1 \\ \tilde{r}_2 \\ \vdots, \\ \tilde{r}_n \end{pmatrix} = \mathbf{w}'\mathbf{R}, \tag{2}$$

with $\mathbf{w}$ being the portfolio weights vector and $\mathbf{R}$ the random vector of asset class returns. Under the assumption of normality, the first two central moments entirely describe the asset return distribution at time $t = 1$. Hence, we have:

$$\mu_A = E[\tilde{r}_A] = E\left[\sum_{i=1}^{n} w_i \tilde{r}_i\right] = \sum_{i=1}^{n} w_i \mu_i = \mathbf{w}'\mathbf{M}, \tag{3}$$

and

$$\sigma_A^2 = \mathrm{Var}\left[\tilde{r}_A\right] = \mathrm{Var}\left[\sum_{i=1}^{n} w_i \tilde{r}_i\right] = \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \rho_{i,j} \sigma_i \sigma_j = \mathbf{w}'\Sigma\mathbf{w}, \tag{4}$$

[4] A similar model has first been presented by Kahane and Nye (1975) who simultaneously optimize the investment and insurance portfolios of the property-liability insurance sector. Additionally, Braun et al. (2015, 2017) draw on such an asset-liability framework.

with the vector of mean returns $\mathbf{M}$, the correlation coefficient $\rho_{i,j}$ between the returns of asset classes i and j, as well as the variance-covariance matrix of asset returns Σ.

The insurer's liabilities at $t = 0$ equal the present value of the expected future payments to its policyholders. Hence, $\tilde{L}_1$ can be determined as:

$$\tilde{L}_1 = L_0 \cdot (1 + \tilde{r}_L), \tag{5}$$

where $\tilde{r}_L$ denotes the stochastic growth rate of the liabilities and is also assumed to be normally distributed, i.e. $\tilde{r}_L \sim N(\mu_L, \sigma_L)$. The stochastic equity at $t = 1$ is then given as:

$$\tilde{E}_1 = \tilde{A}_1 - \tilde{L}_1. \tag{6}$$

In the next step, we define the expected profit as change in the equity, i.e. $\Delta\tilde{E} = \tilde{E}_1 - E_0$ with mean:

$$\begin{aligned} \mu_{\Delta\tilde{E}} &= E\left[\tilde{E}_1 - E_0\right] \\ &= E\left[\tilde{A}_0(1+\tilde{r}_A)\right] - E\left[\tilde{L}_0(1+\tilde{r}_L)\right] - (A_0 - L_0) \\ &= A_0\mu_A - L_0\mu_L, \end{aligned} \tag{7}$$

and variance:

$$\begin{aligned} \sigma^2_{\tilde{A}} &= \mathrm{Var}[\tilde{E}_1 - E_0] \\ &= \mathrm{Var}[A_0(1+\tilde{r}_A)] + \mathrm{Var}[L_0(1+\tilde{r}_L)] - 2\mathrm{cov}[A_0(1+\tilde{r}_A), L_0(1+\tilde{r}_L)] \\ &= A_0^2\sigma_A^2 + L_0^2\sigma_L^2 - 2A_0L_0\rho_{A,L}\sigma_A\sigma_L. \end{aligned} \tag{8}$$

In Equation (8), $\rho_{A,L}$ represents the asset-liability correlation, which is exclusively driven by the common variation of assets and liabilities to changes in interest rates. The remaining equity, property, and spread risks on the insurer's asset side, on the other hand, are considered to be stochastically independent from its liabilities (Braun et al., 2017). Therefore, it can be approximated by the following relationship:

$$\rho_{A,L} \approx D_A/D_L \quad \text{for} \quad D_A \leq D_L. \tag{9}$$

Equation (9) indicates that a smaller duration gap results in higher $\rho_{A,L}$ values.[5] For determining the Solvency II capital charges and the expected profit, a few more assumptions are needed. First, we fix the balance sheet sum at EUR 10 bn, 12 percent of which are assumed to be equity (Braun et al., 2015, 2017). Second, the duration of the insurance liabilities equals 10 (Steinmann, 2006), while the mean of the liability growth rate is set to 1.25 percent.[6]

[5]Its maximum value in our analysis is restricted by the modified duration figures of government bonds and corporate bonds investments (see next Section for further details).

[6]This figure corresponds to the 2016 technical interest rate in Germany (BaFin, 2015b). With the beginning of 2017, it has been reduced to 0.9 percent.

Additionally, in order to assess the level of concentration within the asset portfolios, we derive the so-called diversification index (Woerheide and Persson, 1993). It is defined as:

$$\begin{aligned} DI_i &= 1 - \sum_{j=1}^{n} w_{ij}^2 \\ &= 1 - HHI_i \end{aligned} \tag{10}$$

with w_{ij} being the weight of asset class j in portfolio i, and $\mathrm{HHI_i}$ the Herfindahl index.[7]

Risk-Adjusted Performance Measurement

By providing important insights on a firm's financial success and stability, an accurate performance measurement is crucial for all stakeholders. In case of life insurance companies, it allows both equity holders, policyholders, and potential investors to make well-informed investment and product purchase decisions. Generally, most performance statistics relate an income figure to a capital base. However, many well-known metrics such as the Return on Equity (ROE) (Modigliani and Miller, 1958) or the Return on Investment (ROI) (Phillips and Phillips, 2009) are associated with several disadvantages (ECB, 2010). First, the risk taken by the firm regarding leverage, funding and liquidity profile is completely ignored, which also holds true for other risk elements such as the firm's solvency situation or quality of its assets. Second, the ROE is short-term oriented and does not take into account effects from long-term strategies. For example, costs incurred from measures aiming to improve a firm's overall situation in the long run have a negative effect on the current ROE. This, in turn, makes it difficult to assess whether a fluctuating ROE results from long-term restructuring plans or negative operating results today. Third, instead of considering market values of equity, the ROE is based on the corresponding book values. Hence, the ROE can be easily manipulated through accounting maneuvers.

Generally, the various business lines of an insurance company are associated with different levels of risks. Thus, risk-adjusted measures are more appropriate to assess their performance. In contrast to figures based on plain returns, they answer the question whether higher risks have been sufficiently rewarded by higher returns (ECB, 2010). One prominent measure among insurers and reinsurers is the Return on Risk-Adjusted Capital (RoRAC) (Fitch Ratings, 2016). This ratio relates a non-adjusted return to a risk-adjusted capital base (Matten, 1996). Since we are interested in how Solvency II impacts the RoRAC of a life insurance company, we take the capital requirements of the market risk standard formula as capital base, while the expected change in equity serves as the income figure. Therefore, it is given as:

$$\mathrm{RoRAC} = \frac{\mathrm{E}[\Delta \tilde{E}(\mathrm{w})]}{\mathrm{SCR}_0(\mathrm{w})}. \tag{11}$$

[7]The Herfindahl index has been developed as a statistical concentration measure for several contexts such as a country's trade outcome or industrial market concentration (Hirschman, 1964).

From Equation (11) it is apparent that both the numerator and denominator depend on the investment class weights w of the insurer's asset portfolio. The latter are determined by the asset management, which needs to find the optimal portfolio structure such that the RoRAC is maximized.

3 Data and Asset Portfolios

3.1 Historical Time Series Data

We draw on five common investment classes that are characteristic for a European life insurer's asset allocation, i.e. stocks, government bonds, real estate, corporate bonds, and money market instruments. Each of them is proxied by a benchmark index, for which we analyzed historical time series data from January 2000 to December 2015. More specifically, the stock sub-portfolio is represented by the S&P 500 Index, which comprises the 500 largest U.S. stock companies. The Barclays U.S. Treasury Index measures the returns of debt securities issued by the U.S. treasury and hence, serves to reflect the insurer's investments in government bonds. For corporate bonds, we resort to the Barclays U.S. Corporate Index that covers investment-grade securities from U.S. and non-U.S. industrial, utility, and financial companies. Real estate investments are proxied by the S&P Case-Shiller U.S. National Home Price Index, which measures single-family home price indices for all nine U.S. census divisions. Finally, regarding money market instruments, we draw on the 3-month U.S. Treasury Bill rate.[8]

Scenario A – 4 Asset Classes: 01/2000 – 12/2015				
No.	Asset class	μ_i	σ_i	w_i
1	Stocks	5.45%	16.66%	6.0%
2	Government bonds	5.54%	4.89%	78.0%
3	Corporate bonds	6.55%	5.94%	6.0%
4	Real estate	3.56%	2.94%	10.0%
–	–	–	–	–

Scenario B – 5 Asset Classes: 01/2011 – 12/2015					
No.	Asset class	μ_i	σ_i	w_i	D_i
1	Stocks	12.62%	13.87%	6.0%	–
2	Government bonds	3.12%	3.80%	66.0%	5.82
3	Corporate bonds	4.77%	4.68%	6.0%	7.02
4	Real estate	4.70%	2.83%	10.0%	–
5	Money market	0.06%	0.01%	12.0%	–

Table 2: Asset Classes – Descriptive Statistics

In order to allow for different interest environments, business cycles, and other macroeconomic effects, two calibration periods are considered. Scenario A covers the period from 2000 until 2015 and assumes that the insurer invests in stocks, corporate bonds, real estate, and government bonds only. The after-crisis scenario B, on the other hand, is restricted to 2011 to 2015 and further includes the possibility to invest in money market instruments.[9] Table 2 gives an overview of the corresponding mean returns, standard deviations, and average portfolio weights (refer to Section 3.2) within the two setups. Additionally, the right part shows the modified durations of our government and corporate bond indices at the end of December 2015. In scenario A, both fixed-income instruments exhibit attractive risk-return profiles that

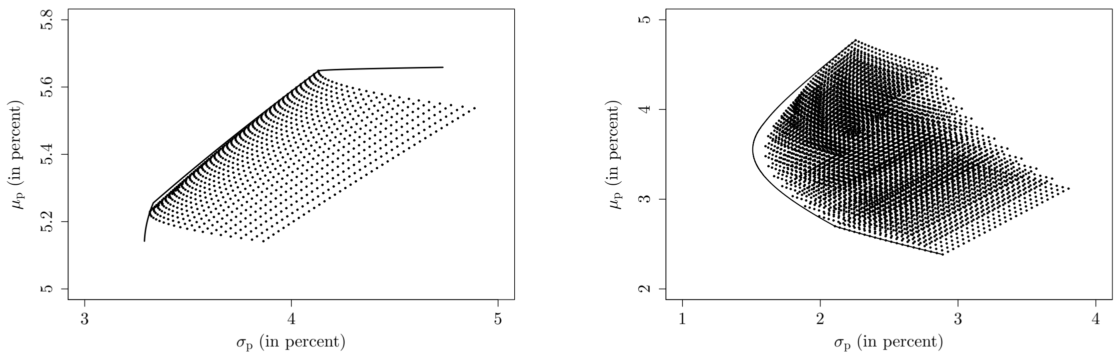
[8] All data have been obtained from Bloomberg and Datastream.

[9] The results of scenario A remain unchanged if the asset class money market instruments is added as well. However, by analyzing a different number of investment opportunities, scenario B serves as sensitivity analysis with respect to the time horizon, the total number of portfolios, and the overall portfolio compositions.

even outperform stock investments, while the opposite holds true for scenario B. Furthermore, money market holdings are almost risk-free (0.01 percent), but exhibit an expected return almost equal to zero (0.06 percent).

3.2 Asset Portfolios

We draw on a systematic approach and assess all feasible asset compositions in order to construct realistic portfolio structures. Short sales are excluded and each asset class is restricted by an upper bound.[10] The latter are defined as double of the respective industry averages of the asset compositions of 85 German life insurers at the end of the third quarter 2015 (BaFin, 2015a). Consequently, both stocks and corporate bonds are restricted to a maximum of 12 percent. With an average of approximately 9.3 percent, the upper limit of real estate is set to 20 percent. Money market instruments, on the other hand, exhibit an upper bound of 24 percent. Finally, government bonds amount to at least 56 percent in each portfolio in scenario A and to 32 percent in scenario B.[11]



(a) Scenario A (b) Scenario B

Figure 1: Risk-Return Profiles of the Insurer's Stylized Asset Portfolios

In scenario A, we apply discrete steps for each portfolio weight of 0.5 percent. Due to limited computing capacity, the introduction of money market instruments in scenario B requires a minimum of 1 percent steps. In this setup, a total of 1,025 (A) and 6,825 (B) unique portfolio combinations are obtained. Figure 1 shows their risk-return profiles and the corresponding efficient frontiers in the mean-variance space.[12]

It is evident that the inefficient areas are well covered by our constructed asset portfolios. Furthermore, even without running optimization procedures, some of them are located on the efficient frontiers. Due to the additional asset category, Figure 1b is more densely populated than Figure 1a. The shorter-term risk-return profiles result in a broad range of the expected returns from approximately 2.3 to 4.8 percent.

[10]Investment restrictions imposed by member states have been eliminated with the introduction of Solvency II (EC, 2009; EC, 2015). Therefore, distinguishing between insurers' so-called free and restricted assets is no longer necessary.
[11]These shares are derived from the budget constraint, which requires all portfolio weights to sum up to unity.
[12]The efficient frontiers have been derived from mean-variance optimizations and serve for illustration purposes only.

In scenario A, on the other hand, the latter lie between 5 and 5.8 percent, while the standard deviations are overlapping to a certain extent. As indicated by Table 2, the average portfolio in scenario A comprises 6 percent stocks, 78 percent government bonds, 6 percent corporate bonds, and 10 percent real estate investments. Its mean return equals 5.39 percent with an average standard deviation of 3.92 percent. In scenario B, stocks and corporate bonds account for 6 percent, real estate for 10 percent, money market instruments for 12 percent, and government bond holdings for 66 percent on average.[13]

4 Empirical Results

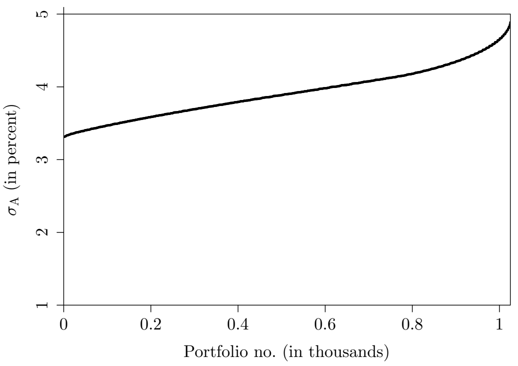
The standard deviations and diversification index (DI) values for each asset allocation are shown in Figure 2. In Figures 2(a) and 2(b), the portfolios have been ordered according to their level of market risk. The standard deviation varies between 3.3 and 4.8 percent in scenario A (Figure 2a) and between 1.6 and 3.8 percent in scenario B (Figure 2b). As can be seen from Equation (10), the DI is defined between zero and unity. Well-diversified portfolios exhibit higher index values, while the opposite holds true for less-diversified asset allocations. The lower bound of zero is obtained with a one-asset portfolio. Our results for both scenarios demonstrate that the DI value is negatively related to asset risk. In other words, less risky asset compositions are typically more diversified. Furthermore, the DI values in scenario A are more dispersed than those in scenario B.

Figure 3 shows the insurer's expected profits, Solvency II capital requirements, and RoRAC values for each portfolio. At first glance, it can be seen that scenario B exhibits a pattern with higher variation regarding all three dimensions. While the expected profits for scenario A are less dispersed and lie between EUR 400 to EUR 460 mn with an average of EUR 429 mn (Figure 3a), the minimum (maximum) expected profit in scenario B amounts to EUR 128 mn (EUR 368 mn) with an average of EUR 247 mn (Figure 3b).[14] Although the portfolios in scenario B exhibit a significantly lower asset risk compared to those from scenario A (Figure 2a), their Solvency II capital charges are, on average, on a higher level (Figure 3d). That is, the minimum (maximum) capital requirement equals approximately EUR 298 mn (EUR 1.15 bn) with the average charge amounting to EUR 686 mn. For scenario A (Figure 3c), on the other hand, the corresponding figures are EUR 290 mn (minimum), EUR 1.09 bn (maximum), and EUR 638 bn (average).

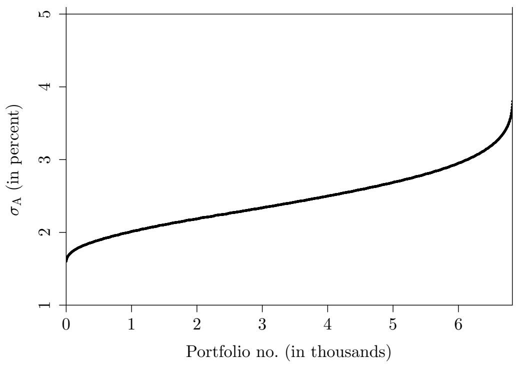
Figures 3(a)–(d) further reveal at least two general and important insights. First, as has been expected, scenario A provides evidence for an an increasing relationship between the level of risk and the expected change in the insurer's equity (cf. Figure 2a and Figure 3a). In other words, portfolios with a higher market risk are typically associated with a higher expected profit, although a significant variation is observed. For example, the most (least) risky portfolio does not offer the maximum (minimum) expected profit. In scenario B, on the other hand, a negative relationship seems to prevail (Figure 3b).

[13] These portfolio shares are almost identical to the average asset portfolio of all German life insurance companies at the end of the third quarter of 2015 (BaFin, 2015a).

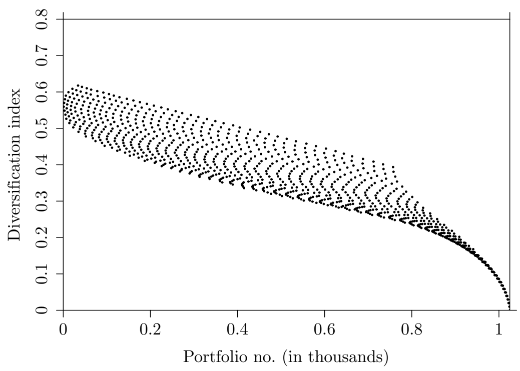
[14] Please note that the expected profit is non-negative for all portfolios since we exclusively consider the insurer's asset management result.



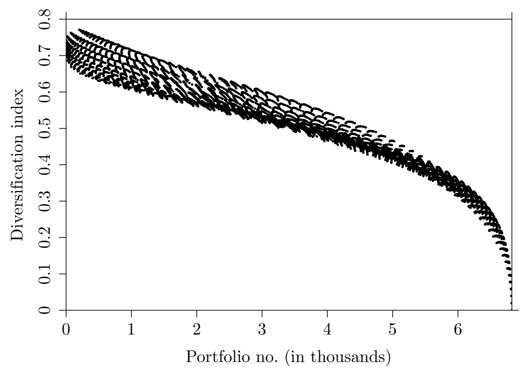
(a) Scenario A – σ_A per portfolio



(b) Scenario B – σ_A per portfolio



(c) Scenario A – Diversification index per portfolio



(d) Scenario B – Diversification index per portfolio

Figure 2: Standard Deviation and Diversification Index per Portfolio

Similarly to the first setup, the asset composition associated with the highest (lowest) asset risk does not result in the maximum (minimum) profit. Second, Figures 3(c) and 3(d) indicate a negative trend of the Solvency II capital charges that are almost in line with the shapes of the DI index values (cf. Figure 2c and Figure 2d). More specifically, well-diversified portfolios exhibiting relatively low asset risk require higher capital levels than less-diversified portfolios. This counterintuitive and surprising observation can be explained by the design of the market risk standard formula (EIOPA, 2014a). That is, the well-diversified compositions comprise investments in stocks, corporate bonds, and real estate, which are all subject to sub-modules with high stress factors. The more the share of government bonds in the portfolios increase, the lower the levels of diversification become. As a consequence, asset risk increases (cf. Figure 2a and Figure 2b). However, since government bond investments require no equity buffers under the standard formula, the capital charges start to decrease.

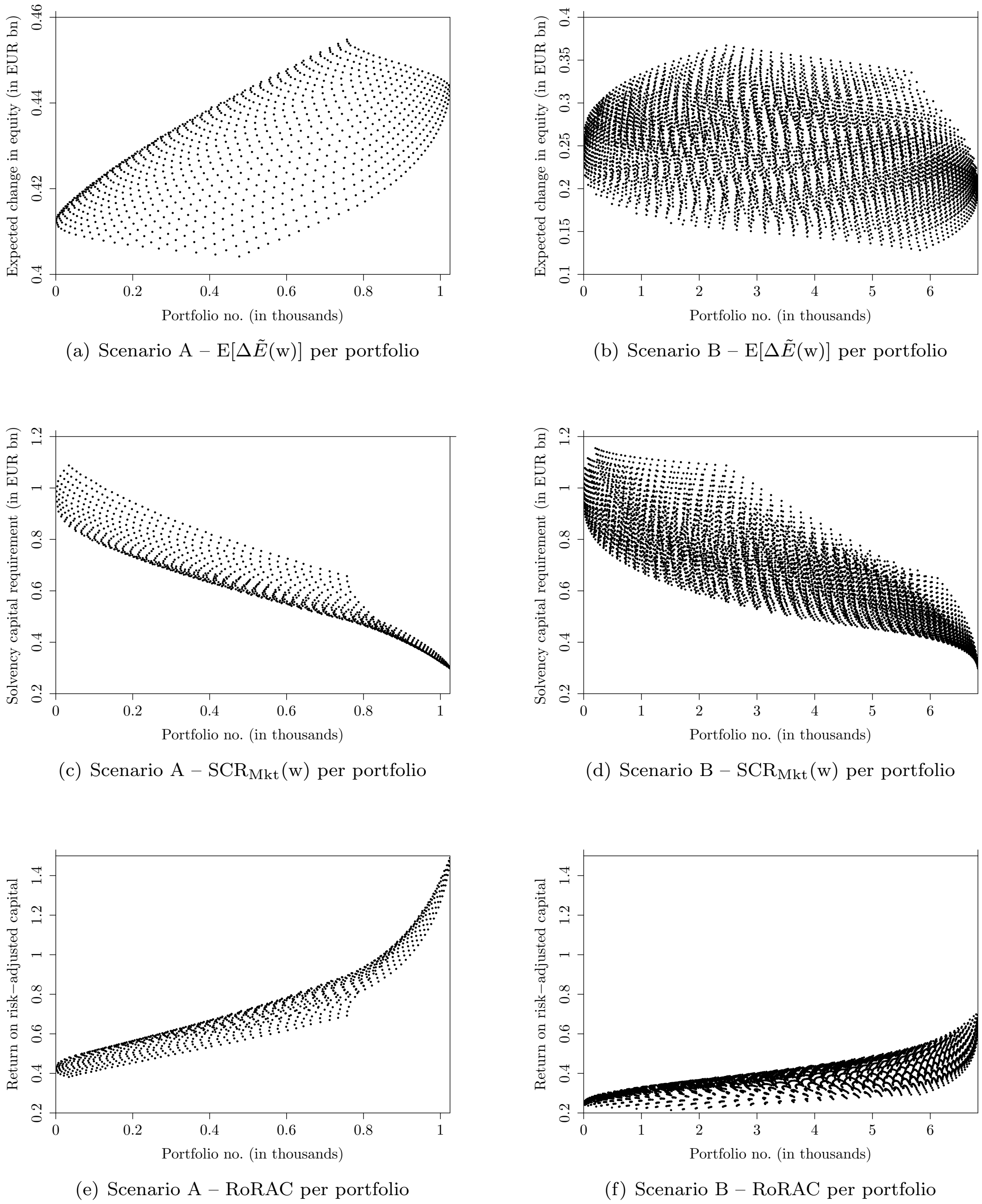
Figures 3(e) and Figures 3(f) show the corresponding RoRAC figures for each asset portfolio. In scenario A, the maximum (minimum) RoRAC amounts to 148.9 percent (38.2 percent), whereas it equals

69.9 percent (21.4 percent) in scenario B. The corresponding averages are given by 73.6 percent and 37.4 percent, respectively. Generally, it becomes evident that the shapes are almost inverse to those of the Solvency II capital charges (cf. Figures 3c and 3d), while the patterns observed for the expected changes in the insurer's profits do not shine through. To be more specific, well-diversified portfolios are associated with low RoRAC figures and less-diversified asset compositions with high RoRAC figures. Therefore, it can be concluded that the Solvency II capital requirements exert a stronger influence on the RoRAC than the expected economic profits. This, in turn, implies that insurers, which base their performance measurement on the RoRAC, are incentivized to decrease their capital charges instead of maximizing their expected economic profits.

The seemingly very high RoRAC figures can be explained by several simplified assumptions of our analysis. First, in contrast to the asset side, the firm's liability structure is static and grows by 1.25 percent independent of the portfolio under consideration. For higher growth rates, the insurer's expected profits might be lower in practice. Second, in particular in scenario A, all asset classes exhibit attractive risk-return profiles that are not necessarily appropriate indicators of future returns. As has been demonstrated by scenario B, the volatilities are almost unchanged, but the expected returns are considerably lower (except from investments in real estate). Third, we focus on the financial result only, while all operational costs and the insurer's underwriting results have been excluded from the analysis. Fourth, we determine the RoRAC based on the conservative assumption that the insurer holds exactly 100 percent of the SCR, which represents a lower bound as well. The reinsurance company Munich Re, for instance, has a target Solvency II ratio amounting to 175 percent (Munich Re, 2015a). Moreover, in the past two years, this threshold has been clearly exceeded with 277 percent in 2014 and 302 percent in 2015 (Munich Re, 2015b).[15]

A more detailed overview of selected portfolios is given in Table 3. We show the asset allocations with the minimum and maximum expected asset return (economic profit), standard deviation, Solvency II capital charge, RoRAC, and diversification index value. The table contains the portfolio weights and durations. Scenario A is shown in the upper part, while the figures of scenario B are included in the lower part. As has been observed from Figure 3(e), the maximum RoRAC (148.9 percent) is obtained by portfolio (d). The latter is completely undiversified (DI: 0) and consists of government bonds only. Although it is therefore associated with the highest level of asset risk (4.89 percent) in our analysis, it requires the lowest Solvency II capital charges (EUR 298 mn). Portfolio (e), on the other hand, generates the minimum RoRAC amounting to 42.7 percent. Both the portfolio weights and the DI index value of 0.618 indicate a well-balanced diversification, which, however, is not rewarded with adequate capital requirements. On the contrary, the insurance company needs equity buffers of approximately EUR 1.09 bn to hold this asset allocation.

[15] According to BaFin (2016), the average solvency ratio of German life insurers in January 2016 amounts to 283 percent.



(a) Scenario A – $\mathrm{E}[\Delta\tilde{E}(\mathrm{w})]$ per portfolio

(b) Scenario B – $\mathrm{E}[\Delta\tilde{E}(\mathrm{w})]$ per portfolio

(c) Scenario A – $\mathrm{SCR}_{\mathrm{Mkt}}(\mathrm{w})$ per portfolio

(d) Scenario B – $\mathrm{SCR}_{\mathrm{Mkt}}(\mathrm{w})$ per portfolio

(e) Scenario A – RoRAC per portfolio

(f) Scenario B – RoRAC per portfolio

Figure 3: Expected Profits, Solvency Capital Requirements, and RoRAC per Portfolio

Scenario A – 4 Asset Classes: 01/2000 – 12/2015														
No.	min.	max.	w_{ST}	w_{GB}	w_{CB}	w_{RE}	w_{MM}	μ_p	σ_p	D	$\Delta\tilde{E}$	SCR	RoRAC	DI
(a)	μ_p, ($\Delta\tilde{E}$)	–	0%	80.0%	0%	20.0%	–	5.14%	3.86%	4.66	404.18	649.41	62.2%	0.320
(b)	–	μ_p, ($\Delta\tilde{E}$)	12.0%	76.0%	12.0%	0%	–	5.65%	4.13%	5.27	454.81	657.18	69.2%	0.394
(c)	σ_p	–	9.0%	62.0%	9.0%	20.0%	–	5.23%	3.31%	4.24	412.51	966.71	42.7%	0.559
(d)	SCR (DI)	σ_p, (RoRAC)	0%	100.0%	0%	0%	–	5.54%	4.89%	5.82	443.70	298.00	148.9%	0
(e)	RoRAC	SCR (DI)	12.0%	56.0%	12.0%	20.0%	–	5.25%	3.38%	4.10	415.29	1,087.64	38.2%	0.618

Scenario B – 5 Asset Classes: 01/2011 – 12/2015														
No.	min.	max.	w_{ST}	w_{GB}	w_{CB}	w_{RE}	w_{MM}	μ_p	σ_p	D	$\Delta\tilde{E}$	SCR	RoRAC	DI
(f)	μ_p ($\Delta\tilde{E}$)	–	0%	76.0%	0%	0%	24.0%	2.38%	2.89%	4.42	128.36	437.68	29.3%	0.365
(g)	–	μ_p ($\Delta\tilde{E}$)	12.0%	56.0%	12.0%	20.0%	0%	4.77%	2.26%	4.10	367.12	1,087.64	33.8%	0.618
(h)	σ_p	–	8.0%	40.0%	8.0%	20.0%	24.0%	3.59%	1.60%	2.89	249.08	1,002.96	24.8%	0.730
(i)	SCR (DI)	σ_p	0%	100.0%	0%	0%	0%	3.12%	3.80%	5.82	201.80	298.00	67.7%	0
(j)	–	SCR (DI)	12.0%	32.0%	12.0%	20.0%	24.0%	4.04%	1.80%	2.70	293.68	1,154.87	25.4%	0.771
(k)	RoRAC	–	0%	56.0%	0%	20.0%	24.0%	2.70%	2.11%	3.26	159.90	746.33	21.4%	0.589
(l)	–	RoRAC	2.0%	96.0%	2.0%	0%	0%	3.34%	3.57%	5.73	224.10	320.82	69.9%	0.077

Table 3: Characteristics of Selected Asset Portfolios – 01/2000 – 12/2015

This table shows the portfolio weights of the five asset classes ($w_{ST}, ..., w_{MM}$), the expected return (μ_p), the standard deviation (σ_p), the asset duration (D), the expected change in the insurer's equity ($\Delta\tilde{E}$), the Solvency II market risk capital requirement (SCR), the return on risk-adjusted capital (RoRAC), as well as the diversification index value (DI) for several asset portfolios that have been selected according to the criteria in columns two and three. The upper part contains scenario A with four asset classes from 01/2000 – 12/2015, whereas the lower part shows scenario B with five asset classes from 01/2011 – 12/2015.

Similar to scenario A, the profit-maximizing portfolio (g) in scenario B does not result in the maximum RoRAC figure. However, the latter is also not generated by portfolio (i), which requires the lowest capital buffer. In fact, it becomes apparent that the almost similarly composed and undiversified portfolio (l) (DI: 0.077) leads to the maximum RoRAC of 69.9 percent. A comparison with portfolio (h) reveals severe shortcomings of the Solvency II market risk standard formula and its distorting effect on the RoRAC. That is, given its reasonable shares in stocks, corporate bonds, and real estate, portfolio (h) is well-diversified (DI: 0.730) and generates a healthy expected profit of EUR 249.08 mn. Portfolio (l), in contrast, exhibits a much higher asset risk (3.57 percent vs. 1.60 percent), but results in a lower expected profit (EUR 224.10 mn). Against all expectations, however, portfolio (h) requires a substantially larger capital buffer than portfolio (l), i.e. EUR 1 bn compared to EUR 320.8 mn. This surprising fact can be explained by the design of the Solvency II market risk standard formula. Owing to the stress factors within its equity, property, and spread risk sub-modules, it penalizes portfolio (h), irrespective of its high level of diversification. This, in turn, has important consequences for the RoRAC. To be more specific, while the profit in the numerator is almost the same, the SCR in the denominator turns out to be the major driver (cf. Equation 11).[16]

Besides stress factors, the Solvency II market risk standard formula also aims to reward a proper asset-liability matching via its interest rate risk sub-module (EIOPA, 2014d). That is, portfolios leading to low duration gaps should require less capital than unbalanced portfolios with significant differences between the durations of assets and liabilities. Our results, however, do not support this hypothesis. In light of the fixed liability duration of 10 (see Section 2), portfolios (g) and (h) in scenario B lead to totally different duration gaps, i.e. 5.9 and 7.11, respectively. The corresponding capital charges, however, are almost identical (EUR 1.09 bn vs. EUR 1.0 bn). The same holds true for portfolios (b) and (d) in scenario A. While their asset durations are almost similar (5.27 vs. 5.82), the capital charges and the RoRAC figures differ substantially. Hence, it can be concluded that the stress factors are the dominant drivers behind the Solvency II market risk capital charges, whereas the asset-liability matching plays only a subordinate role.

Our analysis demonstrates that the Solvency II market risk standard formula provides odd incentives for the asset management of an insurance company, if their evaluation is based on the RoRAC. That is, instead of striving to maximize the expected profit, managers do significantly better when minimizing the SCR. As illustrated by Figures 3(e) and (f), this effect is stronger in scenario A, but still present in the after-crisis scenario B, which is characterized by a less steep rise of the RoRAC figures. Generally, due to the lower expected profits in scenario B (Figure 3b), the RoRAC figures are on a lower level than in scenario A.[17] Thus, independent from the considered time horizon, risk-return profiles, and number of asset classes, the RoRAC is mainly driven by the Solvency II market risk capital charges. To minimize the

[16] This also becomes apparent when comparing portfolios (a) and (e) in scenario A. Although the expected profits are similar, the capital charges vary substantially. Again, the well-diversified portfolio with less asset risk requires much more capital than the portfolio with a significant share of government bonds. As a consequence, portfolio (a) results in a much higher RoRAC figure than portfolio (e).

[17] Recall from Figure 3 that irrespective of the different patterns of the expected profits across the scenarios, the shapes of the RoRAC almost inversely reflect the shapes of the capital requirements.

latter and achieve attractive RoRAC figures, the standard formula provides strong incentives to extend government bonds holdings. In the current interest environment with the corresponding returns being approximately 1 percent, such an investment strategy represents a severe threat for the insurer's equity holders, policyholders, as well as the whole financial sector. More specifically, besides being less-diversified and exposed to greater asset risk, it becomes almost impossible for insurers to fulfill their contractual obligations. In light of these severe distortions, insurers should refrain from a performance measurement based on the RoRAC.

5 Summary and Conclusion

This paper analyzes the impact of the Solvency II capital charges for market risk on a life insurer's return on risk-adjusted capital (RoRAC). Our discussion starts with a brief representation of the market risk standard formula and a parsimonious model of the insurer's assets and liabilities. In the next step, we resort to historical time series data for five asset classes and construct a large number of hypothetical asset allocations by taking into account short-sale constraints as well as current portfolio shares of the German life insurance industry. Finally, for each portfolio, the insurer's expected profit, the Solvency II capital charge, and the resulting RoRAC are calculated.

Our analysis reveals several important insights for European life insurance companies subject to the Solvency II regulation. First, the design of the market risk standard formula is distorted in such a way that the stress factors applicable to risky asset classes, clearly dominate the dampening effect of a proper asset-liability matching. That is, well-diversified portfolios with healthy risk-return profiles need to be backed by high capital charges, even if they only include small allocations to stocks, property, and corporate bonds. The opposite holds true for less-diversified asset compositions that mainly comprise government bonds holdings. Second, an insurer's RoRAC is primarily driven by the market risk capital charges of Solvency II, while the expected profit generated by the asset portfolio has only a minor impact. This, in turn, provides misleading incentives for insurance companies that base their performance measurement on the RoRAC. Instead of investing in well-diversified portfolios that maximize the expected profits, asset managers do better with asset compositions that require less solvency capital, irrespective of their risk-return profiles. Hence, in light of the importance of life insurers among institutional investors, such distorted portfolio choices might entail severe consequences for the financial sector and the economy as a whole. Finally, it remains an open political question whether life insurance companies and pension funds should be given such clear incentives to take over responsibility for the enormous public debt.

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