DEUTSCHE
BUNDESBANK
EUROSYSTEM

Discussion Paper

Deutsche Bundesbank
No 27/2014

How is the low-interest-rate environment affecting the solvency of German life insurers?

Anke Kablau
Matthias Weiß

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

Internet http://www.bundesbank.de

ISBN 978–3–95729–070–0 (Printversion)
ISBN 978–3–95729–071–7 (Internetversion)

Non-technical summary

Research Question

German life insurance companies are constantly faced with interest rate risks due to their business model. Generally, they provide policyholders with a long-term promise of payment in the form of a guaranteed return. In a low-interest-rate environment, life insurers may find themselves in a position in which they are forced to tap into their own funds to fulfil the guarantees promised to policyholders. Therefore, we analyse how the prevailing low-interest-rate environment affects the solvency of German life insurers using a scenario analysis. The analysis was conducted on the basis of the currently applicable solvency regime (Solvency I).

Contribution

In contrast to other literature in this field of research we use a unique data set comprising prudential individual data from 85 German life insurers. Hence, our analysis is not limited to publicly available data or an aggregated view. Therefore, we can account for the heterogeneity in the life insurance sector.

Results

In a baseline scenario using today's Bund yields to forecast future net returns, the impact remains manageable. However, even in a mild stress scenario, in which low yields – such as those that prevailed in Japan for an extended period – are simulated, 12 life insurers, with a combined market share of some 14%, would no longer be able to fulfil the Solvency I own funds requirements by 2023. Under more severe stress conditions, especially if yields on investments were also to come under pressure, 32 enterprises would no longer meet the own funds requirements. This points to a potential solvency risk in the life insurance industry. Sensitivity analyses, each altering an individual basic assumption of the scenario analysis, can be used to quantify the impact of discretionary leeway offered by law. The results show that a generous distribution policy making full use of legally permissible discretionary leeway with regard to allocations to the bonus and rebate provisions would lead to a significant rise in the number of defaults.

Nichttechnische Zusammenfassung

Fragestellung

Lebensversicherer sind aufgrund ihres Geschäftsmodells mit langfristig zugesicherten Garantien Zinsrisiken ausgesetzt. In einem Niedrigzinsumfeld können Lebensversicherer in eine Situation geraten, in der sie Eigenmittel aufzehren müssen, um die versprochenen Zinsgarantien zu erfüllen. Deshalb analysieren wir in dem vorliegenden Papier anhand einer Szenarioanalyse die Auswirkungen des vorherrschenden Niedrigzinsumfelds auf die Solvabilität der deutschen Lebensversicherer. Die Analyse wurde auf Grundlage der aktuell gültigen Solvabilitätsvorschriften Solvency I durchgeführt.

Beitrag

Im Gegensatz zu anderen Studien auf diesem Forschungsgebiet verwenden wir einen einzigartigen Datensatz mit aufsichtlichen Einzeldaten von 85 deutschen Lebensversicherern. Somit ist unsere Analyse weder auf öffentlich verfügbare Daten noch auf eine aggregierte Sichtweise beschränkt. Hiermit können wir für die im Lebensversicherungssektor bestehende Heterogenität kontrollieren.

Ergebnisse

In einem Basisszenario, das heutige Renditen von Bundesanleihen zur Prognose der künftigen Nettoverzinsung heranzieht, bleiben die Auswirkungen überschaubar. Aber schon in einem milden Stressszenario, in dem niedrige Renditen simuliert werden, wie sie in Japan längere Zeit vorherrschten, könnten zwölf Lebensversicherer, die immerhin zusammen einen Marktanteil von rund 14% haben, bis zum Jahr 2023 die Eigenmittelanforderungen von Solvency I nicht mehr erfüllen. Unter verschärften Stressbedingungen, insbesondere wenn auch die Renditen auf andere Anlagen verstärkt unter Druck gerieten, würden 32 Unternehmen die Eigenmittelanforderungen nicht mehr erfüllen. Dies weist auf ein Gefährdungspotenzial für die Solvabilität der Lebensversicherungsbranche hin. Mit Sensitivitätsanalysen, in denen jeweils einzelne Grundannahmen der Szenarioanalyse verändert werden, kann der Einfluss gesetzlich gewährter Spielräume quantifiziert werden. Die Ergebnisse zeigen, dass eine großzügige Ausschüttungspolitik aufgrund einer Ausnutzung gesetzlich erlaubter Spielräume bei der Zuführung zur Rückstellung für Beitragsrückerstattung die Anzahl der Ausfälle deutlich erhöhen würde.

BUNDESBANK DISCUSSION PAPER No 27/2014

How is the low-interest-rate environment affecting the solvency of German life insurers?*

Anke Kablau
Deutsche Bundesbank

Matthias Weiß
Deutsche Bundesbank

Abstract

Life insurance companies are affected directly by the impact of the low-interest-rate environment. To fulfil promised guarantees they may be forced to tap into their own funds, say if the current income generated is no longer sufficient to cover the policyholders' profit participation share as defined by the enterprises or even guaranteed benefits. They may then find themselves in a position in which their solvency is at risk.

A scenario analysis is used to examine the stage at which German life insurers would no longer be able to fulfil the currently prevailing Solvency I own funds requirements owing to the low-interest-rate environment. In contrast to other literature in this field of research we use prudential individual data from 85 German life insurers. Even in a mild stress scenario 12 life insurers, with a combined market share of some 14%, would no longer be able to fulfil the own funds requirements by 2023. Under more severe stress conditions, especially if yields on investments were also to come under pressure, 32 enterprises would no longer be able to meet the Solvency I own funds requirements. This points to a potential solvency risk in the life insurance industry.

Keywords: life insurance, low-interest-rate environment, financial stability

JEL classification: G17, G22, G28.

*Contact address: Wilhelm-Epstein-Str. 14, 60431 Frankfurt am Main. Phone: +49(0)6995667068, +49(0)6995665134. E-Mail: anke.kablau@bundesbank.de, matthias.weiss@bundesbank.de. The authors thank Till Foerstemann, Ulrich Krueger, Christoph Memmel, Wolfgang Rippin and an anonymous referee.

1 Introduction

Insurance companies are important players in the financial system, a fact that was never clearer than during the financial crisis when the interconnectedness between insurers, financial markets and other financial intermediaries became obvious.[1] Experience with the distress of the American International Group (AIG) illustrated that insurance companies can impact the financial system.[2] At the same time, developments on the financial markets also spill over onto insurance companies.

The risks arising from the life insurance segment are a particularly important factor for the stability of the insurance sector. The significance of life insurers in Germany is evident from the fact that they account for around 48% of the premium income and about 62% of the total capital investment of all German primary insurance companies.[3]Interest rate risk is of particular relevance to life insurers. It is the risk that, in the event of unfavourable market developments, income from investment may not be sufficient to make agreed guaranteed payments to policyholders and to fulfil any additional profit participation commitments. This is a particular problem for new investment undertaken in a persistent low-interest-rate environment.

Market value changes are not recognized adequately under the currently applicable solvency regime Solvency I. Hence, risks stemming from changes in market conditions are not appropriately reflected. To analyze the effect of a low-interest-rate environment on the solvency of German life insurers we conduct a scenario analysis. In contrast to other literature in this field of research we use a unique data set comprising prudential individual data from 85 German life insurers. Since our analysis is not limited to publicly available data or an aggregated view, we can account for the heterogeneity in the life insurance sector.

Our analysis shows that only minor effects for the German life insurance sector can be expected in a baseline scenario. However, a long lasting and more severe low-interest-rate environment harbours a potential risk to the stability of the life insurance segment.

The paper is structured as follows: In Section 2, we begin by introducing the issue under review and providing a brief overview of the literature, before moving on to a detailed description of the German life insurance segment in Section 3. In Section 4 we describe the bonus and rebate provisions as a key component of own funds. The scenario analysis of the low-interest-rate environment's impact on German life insurers is explained in depth in Section 5. The impact on the solvency will be analysed by the development of the coverage ratio.[4] We present the results of our analysis in Section 6. We also conduct sensitivity analyses in which various basic model assumptions are changed in order to test the effects of certain adjustment measures on the part of insurers. In addition, we examine the net return which enterprises must generate for their respective coverage ratios to remain at their 2012 levels. In Section 7, we then evaluate whether Protektor Lebensversicherungs-AG, the protection facility for life insurance companies, would be able to bear the losses which we have calculated. Finally, section 8 concludes.

[1] See Podlich and Wedow (2013).

[2] See also Stolz and Wedow (2010).

[3] Premium revenue in life insurance, including pension funds and Pensionskassen. See Gesamtverband der deutschen Versicherungswirtschaft e. V. (2013).

[4] The coverage ratio is the ratio of actual own funds to required regulatory own funds.

2 Motivation

The interest rate risks result from the life insurers' business model, which is geared towards providing policyholders with a long-term promise of payment in the form of a guaranteed return.[5] This business model reaches a critical point when the investment income generated falls short of the guaranteed return promised. The longer the low-interest-rate environment persists, the more serious the problems become as the enterprises usually have no means of prematurely terminating the often decades-long contracts or reducing the guaranteed rates of interest.

The losses that arise in a low-interest-rate environment must then be offset against future profits.[6] Hence enterprises are under pressure to generate above-average profits in the future. This can lead to behavioural changes, inducing enterprises to invest in more risky products in a low-interest-rate environment.[7] Such a change in life insurers' risk profile could make them more vulnerable to disruptions in the financial markets and may lead to more volatile earnings, which in turn is likely to make it harder for them to generate the guaranteed return over the entire period of insurance cover. If insurers' risk management systems were unable to keep pace with these greater risks, this would have to be considered as a negative development in terms of financial stability.

The low-interest-rate environment has prevailed for several years now. Kablau and Wedow (2012) already examined how low interest rates are likely to impact German life insurers at the aggregate level. A key finding was that a protracted low-interest-rate environment would have a destabilising effect on the life insurance segment as a whole. In the medium term, problems could be expected to arise in terms of fulfilling payment commitments to policyholders. However, the aforementioned analysis draws only on aggregated and publicly available data, meaning that the information value of the findings is inevitably limited. The analysis showed that, in the aggregate, German life insurers would probably not be in a position to meet their mid-term interest payment obligations. Owing to insurers' very diversified size and earning power, Kablau and Wedow (2012) already premised that the problems are likely to become evident at the individual insurance companies at completely different points in time. Moreover, lack of data meant that it was also not possible to include certain income components in the analysis.

Under the Deutsche Bundesbank's new macroprudential mandate, the Bundesbank now has access to microdata on insurance companies.[8] For this reason, and also because the low-interest-rate environment is persisting, the aggregated analysis has now been conducted at single-entity level with the involvement of 85 German life insurers. The expanded data base makes it possible to factor hitherto missing income components into the calculation. Furthermore, the additional interest provision (Zinszusatzreserve), which was introduced in 2011, has been integrated into the analysis, as has the policyholders' participation in the valuation reserves required by law since 2008. As data are now available on the individual insurers' own funds, we can compute – based on certain assumptions regarding the net return on investment – when each company will no longer be able to fulfil the regulatory own funds requirements . The deciding factor in this is the

[5] See Holsboer (2000).

[6] See also Dickinson (2000) and Siglienti, Susinno, Buttarazzi, and Stamegna (2000).

[7] See Trichet (2005).

[8] See Financial Stability Act (Finanzstabilitätsgesetz).

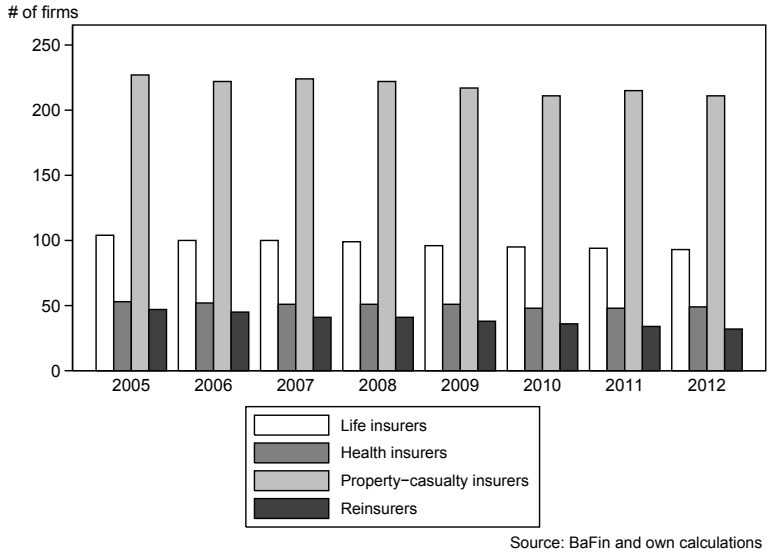


Figure 1: Number of supervised insurance enterprises in Germany

bonus and rebate provisions, as they form a key component of own funds.

A study by Serra and Harris (2013) examines the possible impact of a low-interest-rate environment on the life insurance sector on the basis of a representative life insurer. The authors reach the conclusion that losses on the part of German life insurance companies will prove unavoidable if interest rates remain at their current low level. They suggest that life insurers will encounter problems not only owing to their high guaranteed returns, but also because of the duration mismatch between their long-term liabilities and their shorter-term investments. They say that the additional interest provisions required to be set up by law since 2011 will probably heighten the enterprises losses. They further project that, with the given interest rate level, the additional interest provisions could grow to a total volume of €40-90 billion by 2023. The study also demonstrates that not all market participants will be affected in equal measure. However, Serra and Harris (2013) follow a different approach than we do as they seek to determine what level of return on new investment would generate losses for the enterprises. This would be the case if funds were continuously invested at less than 2.6% p.a. We will use sensitivity analyses to examine the minimum net return which enterprises must generate to maintain a constant coverage ratio, whereby our data set – in contrast to Serra and Harris (2013) – allows an analysis for the considered life insurers at solo level.

3 The German life insurance segment

In 2012, 93 German life insurance companies were subject to supervision by the Federal Financial Supervisory Authority (BaFin). This makes life insurers numerically the German insurance sector's second biggest segment in the insurance sector (see Figure 1). The number of life insurers is slightly down on previous years.

At the end of 2012, German life insurers held investments to the value of €768.9 billion. Fixed-income securities in the form of Pfandbriefe, loans as well as government and corporate bonds account on aggregate constantly for almost 90% of total assets (see

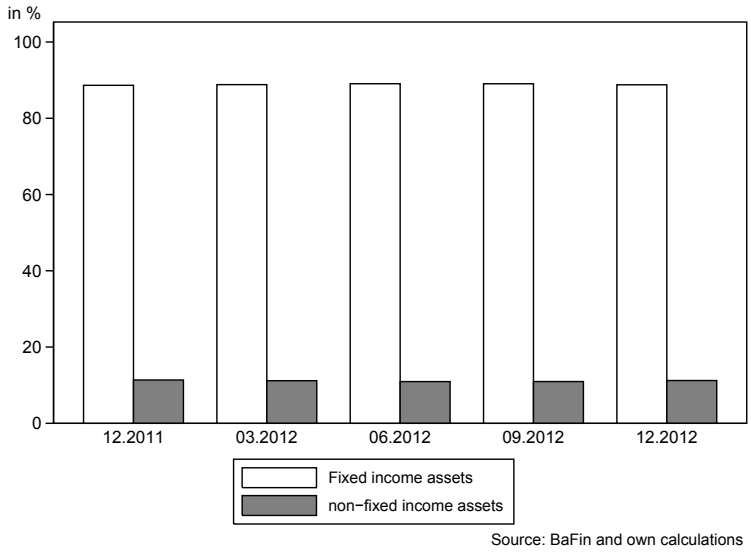


Figure 2: Assets of German life insurers

Figure 2). Almost three quarters thereof are held directly, the residual is held indirectly in investment funds. The current low interest rates are creating – in some cases, substantial – valuation reserves for bonds with high coupons in life insurers' portfolios. Since 2008, life insurers have been legally obliged to give policyholders a half share of the accrued valuation reserves when their contract ends or is terminated.

Owing to their investment strategy, German life insurance companies are impacted directly by the current low-interest-rate environment. In 2011, the yield on German government bonds with an agreed maturity of more than four years fell below the maximum technical interest rate for life insurers' new business for the very first time.[9] In 2013, the yield declined to an average of 1.3% p.a. Thus, it remained at almost the same level as in 2012, albeit with a slight increase in the course of the year. At the same time, life insurers' obligations to service outstanding policies are high as the maximum technical interest rate in the industry's portfolio averages around 3.2% p.a.

In 2012, life insurance companies managed to raise their net return on investment year-on-year to 4.6%; this was a temporary phenomenon, however, owing to the realisation of parts of their valuation reserves. The increase in the net return was due partly to write-ups and partly to life insurers realising valuation reserves in order to be able to make the required allocations to the additional interest provision.

The additional interest provision is a reserve which life insurers are required to set up by law to ensure that they remain able to finance agreed guaranteed payments in the future. The additional interest provision has to be set up if the benchmark interest rate – derived from the ten-year average yields on European government bonds with an AAA rating and a residual maturity of ten years – is lower than the original maximum

[9]The maximum technical interest rate is the maximum rate that life insurers can use as a basis when calculating the premium reserves required for new contracts. Insurance companies usually set this rate as the guaranteed return. The average maximum technical interest rate in insurers' portfolios is, therefore, a good gauge of the average guaranteed return in insurers' portfolios. The yield on public bonds basically comprises the yield on bonds outstanding with an agreed maturity of more than four years pursuant to the terms of issue.

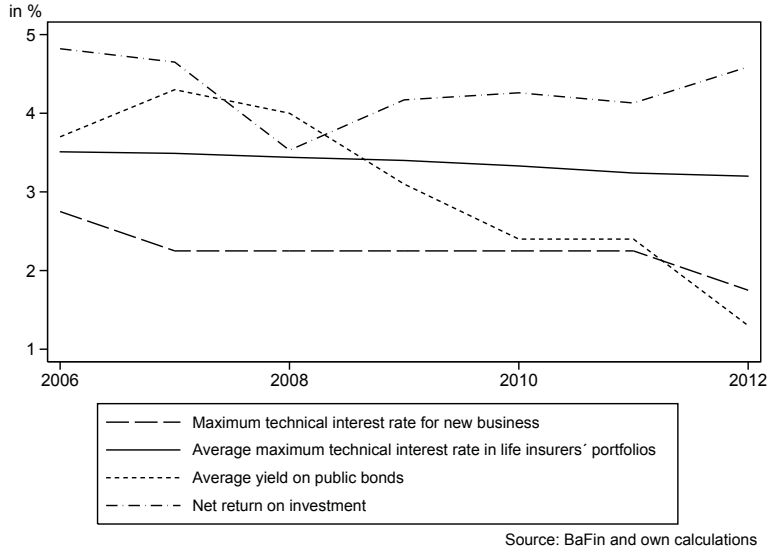


Figure 3: Interest rates

technical interest rate.[10] In 2011, funds had to be transferred to the additional interest provision for the first time as the benchmark interest rate, at 3.92% p.a., was lower than the maximum technical interest rate of 4% p.a. applicable to certain outstanding policies. A total of around €1.5 billion was thus allocated to additional interest provisions. In 2012, the benchmark rate fell to 3.62% p.a., leading to further transfers of about €5.7 billion to the additional interest provisions. In view of the low-interest-rate environment, the net return on investment is likely to come under further pressure in the future as, in realising valuation reserves, high-yielding assets have been sold and are therefore no longer available to boost the net investment income result. Figure 3 plots the historical evolution of the aforementioned interest rates.

The low-interest-rate environment has already had an effect on the solvency of life insurance companies. Figure 4 charts the aggregate solvency path of life insurers since 2009 according to the currently applicable solvency regime (Solvency I). The coverage ratio is the most important solvency metric. It is the ratio of eligible regulatory own funds to the regulatory own funds requirements. The aggregate coverage ratio fell from around 186% in 2009 to just under 169% at the end of 2012. Thus, the German life insurance segment had a capital buffer of 69 percentage points at the end of 2012.

The two components of the coverage ratio are depicted in the lower part of the diagram. The regulatory own funds requirements, known as the solvency margin, consist essentially of 4% of the premium reserve and 0.3% of capital at risk[11], and have been growing continuously since 2009. The growth in the solvency margin since 2011 is attributable predominantly to the additional interest provisions as they constitute a part

[10] See section 5 of the Regulation on the Principles Underlying the Calculation of the Premium Reserve (Deckungsrückstellungsverordnung).

[11] The capital at risk with regard to an insurance policy is the difference between the agreed insured amount which would be payable upon the occurrence of an insured loss on the relevant date for the calculation of the solvency margin and the sum of the premium reserve available and unearned premiums less cost components (see section 4 (1) (b) of the Capital Resources Regulation (Kapitalausstattungs-Verordnung)).

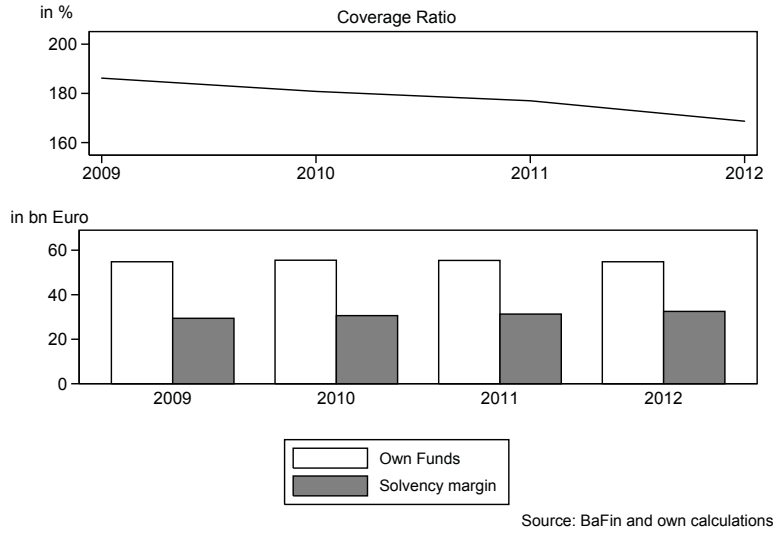


Figure 4: Aggregate solvency

of the premium reserve. The diagram shows the volume of eligible regulatory own funds alongside the own funds requirements. Regulatory own funds consist primarily of equity and bonus and rebate provisions eligible as own fund.

4 Bonus and rebate provisions as a key component of own funds

The majority of the bonus and rebate provisions are eligible as own funds and they form the main element of the total own funds of a German life insurer. Therefore, the focus of the analysis lies on this position. Moreover, the bonus and rebate provisions are a balance sheet instrument used to smooth the policyholders' profit participation share. Profits generated by life insurers are usually not credited directly to policyholders; instead, they are allocated first to the bonus and rebate provisions. The profit shares payable to policyholders are taken from the bonus and rebate provisions at a later point in time and paid out.[12] The bonus and rebate provisions thus serve as a buffer. This mechanism allows insurers to keep the policyholders' profit participation share relatively stable even when earnings vary. The bonus and rebate provisions thus ebb and flow over time. They are depleted in a low-interest-rate environment, when allocations are lower than withdrawals for the policyholders' profit participation share, and they are topped up again in a high-interest-rate environment.

As already mentioned before, the bonus and rebate provisions consist of provisions

[12]The policyholders' profit participation share comprises the current profit participation share, the maturity bonus and participation in the valuation reserves. The first two components are redefined by the insurance companies every year. The current profit participation share is withdrawn from the bonus and rebate provisions annually and allocated irrevocably to each individual insurance policy. The maturity bonus is allocated as a one-off payment upon maturity of the policy; the decisive factor in this case is the declaration of the insurers which is valid at maturity. Participation in the valuation reserves is also due upon maturity and is not guaranteed in advance.

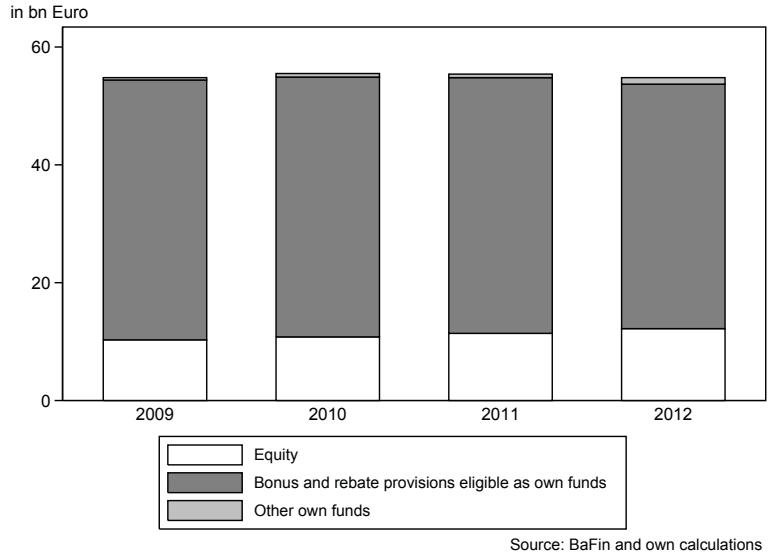


Figure 5: Composition of own funds

eligible as own funds as well as earmarked provisions.[13] Policyholders do not have any actual entitlements to provisions eligible as own funds, which means that, provided they have the approval of the supervisory authority, insurers can draw on these provisions in the event of distress.[14] The maturity bonus fund is also allocated to the share of the bonus and rebate provisions that are eligible as own funds, as policyholders have no entitlement to the maturity bonus until their policy ends. Earmarked provisions, by contrast, are allocated irrevocably to the policyholders and, therefore, do not qualify as own funds. Figure 5 depicts the composition of own funds.

5 Scenario analysis of the impact of the low-interest-rate environment

We use a scenario analysis to examine the low-interest-rate environment's impact on life insurance companies operating in Germany. It focuses on the question of when – given low interest rates and high guaranteed payments – life insurers would no longer be able to satisfy the own funds requirements under the Solvency I regime. Section 53c (1) of the Insurance Supervision Act (Versicherungsaufsichtsgesetz) lays down the solvency requirements of relevance to insurers. In order to ensure that they are always able to fulfil their commitments under insurance contracts, insurance companies are obliged to set aside free, unencumbered own funds in the amount of the solvency margin. One-third of the required solvency margin is deemed to be a guarantee fund.

Where an insurance company's own funds fall short of the solvency margin, the com-

[13] At the end of 2012, the aggregate share of bonus and rebate provisions eligible as own funds made up 80% of total bonus and rebate provisions.

[14] The following analysis is based on the assumption that, in the event of imminent distress, supervisors will generally agree to the component of the bonus and rebate provisions that is eligible as own funds being used to cover losses.

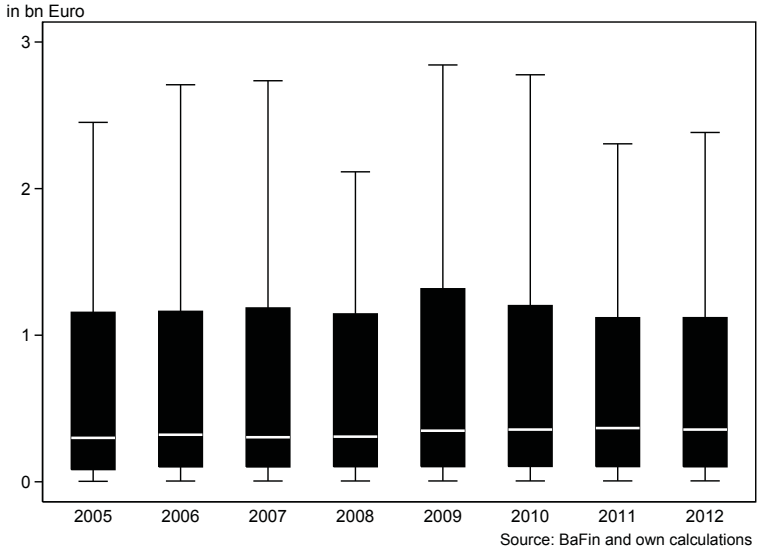


Figure 6: Gross premiums earned

pany must submit to the supervisory authority for its approval a plan for the restoration of a sound financial situation (solvency plan) pursuant to section 81b of the Insurance Supervision Act. If the insurer's financial situation deteriorates further, the supervisory authority may restrict or prohibit the free disposal of the company's assets. If the insurer's own funds actually fall below the amount of the guarantee fund, the company must, upon request, submit to the supervisory authority for its approval a plan for the short-term procurement of the necessary own funds (financing plan). Furthermore, the supervisory authority can restrict or prohibit the free disposal of the company's assets.

In the present analysis, an enterprise is classified as having defaulted if it has a coverage ratio of less than 100% and thus no longer fulfils the own funds requirement. In addition, the analysis identifies when enterprises will no longer be able to maintain the guarantee fund.

The model is a refinement of the one set up by Kablau and Wedow (2012), as it provides not only statements on the development path of the bonus and rebate provisions but also maps the impact on solvency. In contrast to the analysis conducted by Kablau and Wedow (2012), the available data set enables the analysis to be carried out at the single-entity level with the involvement of 85 life insurers. This is important for two reasons. First, in an aggregate analysis, a – in reality, non-existent – transfer of funds between the individual life insurers is implicitly assumed, which would present the solvency situation more favourable than it actually is. Second, the life insurance industry is very heterogeneous. This is illustrated in Figure 6. With regard to their size or significance – measured in terms of gross premiums earned – there are considerable differences between the various enterprises. For instance, a large proportion of life insurance companies are relatively small, yet a few life insurers account for the lion's share of the market.

The individual model components are presented in detail in the following subsections.

5.1 Development of the coverage ratio

The coverage ratio is calculated as a function of the eligible regulatory own funds and the required regulatory own funds (solvency margin). The eligible regulatory own funds EM_t are given by

$$EM_t = EK_{konst} + RfB_t^{EM}, \tag{1}$$

where

$$RfB_t^{EM} = \delta RfB_t. \tag{2}$$

As it is assumed that there are no increases in equity EK, it is held constant in the model. The share of the bonus and rebate provisions eligible as own funds RfB_t^{EM} is estimated on the basis of the evolution of the bonus and rebate provisions as a whole. The share of bonus and rebate provisions eligible as own funds δ in the bonus and rebate provisions as a whole is determined using the historical mean.

The solvency margin $Solv_t$ specifies the required regulatory own funds and is derived in the analysis using the following formula[15]

$$Solv_t = 0.003 \cdot RK_{konst} + 0.04 \cdot (DR_{konst} + ZZR_t). \tag{3}$$

Both the capital at risk RK and the premium reserve DR are held constant as it is assumed that expiring policies are replaced with an equal number of new policies. The average maximum technical interest rate in the insurer's portfolio falls corresponding to the historical (negative) growth rate as the maximum technical interest rate applicable to expiring policies is usually higher than that for new policies. It is assumed that there is no new business other than the replacement of expiring policies. Therefore, a change in the solvency margin results solely from a change in the additional interest provision ZZR_t. The additional interest provision is forecasted with data taken form a survey conducted by the BaFin. In this survey the participating life insurance companies had to calculate the amount of the additional interest provision for various reference interest rates. The transfers to the additional interest provision are derived from the difference between two points in time

$$\Delta ZZR_t = ZZR_t - ZZR_{t-1}. \tag{4}$$

It is assumed that the transfers to the additional interest provision are channelled from the valuation reserves (BWR). If, however, the valuation reserves prove insufficient, then net investment income or the bonus and rebate provisions are drawn upon.[16]

The coverage ratio BQ_t gives the ratio of eligible regulatory own funds to required regulatory own funds and is defined as

$$BQ_t = \frac{EM_t}{Solv_t}. \tag{5}$$

[15] The solvency margin is calculated in accordance with section 4 (1) of the Capital Resources Regulation (Kapitalausstattungs-Verordnung).

[16] See equation (9).

5.2 Maintenance of the guarantee fund

As already explained above, the guarantee fund amounts to one-third of the own funds requirement (solvency margin). If the guarantee fund falls short of this level, the insurance company must, upon request, submit to the supervisory authority for its approval a plan for the short-term procurement of own funds (financing plan). Only financing measures which enhance the actual solvency situation are permitted. Furthermore, if the guarantee fund falls short of the stipulated level, the supervisory authority can restrict or prohibit the free disposal of the insurer's assets.

The guarantee fund G_t is thus given by

$$G_t = \frac{1}{3} \cdot Solv_t = \frac{1}{3} \cdot (0.003 \cdot RK_{konst} + 0.04 \cdot (DR_{konst} + ZZR_t)). \tag{6}$$

The coverage ratio BQ_t^G shown below must be more than 100% for the enterprise to be able to maintain the guarantee fund.

$$BQ_t^G = \frac{EM_t}{\frac{1}{3} \cdot Solv_t}. \tag{7}$$

5.3 Development of the bonus and rebate provisions

As Figure 5 shows, the bonus and rebate provisions eligible as own funds account for the bulk of an insurer's own funds. As investment income traditionally is the most important earnings component of a life insurer, the development of the bonus and rebate provisions is materially dependent on the level of net investment income and, therefore, on the interest rate level. It is, thus, possible to draw conclusions about insurers' own funds situation based on certain assumptions regarding the development of the bonus and rebate provisions.[17]

Equations (8) and (9) are the core components of the analysis.

Case 1 ($BWR_{t-1} \geq ZZR_t - ZZR_{t-1}$):

$$\begin{aligned} RfB_t =& RfB_{t-1} + \alpha_t ni_t inv_{konst} + \beta_t mr_t + \gamma_t or_t \\ & - (gr_t + cs_{konst} + dc_{konst}) DR_{konst} \end{aligned} \tag{8}$$

Case 2 ($BWR_{t-1} < ZZR_t - ZZR_{t-1}$):

$$\begin{aligned} RfB_t =& RfB_{t-1} + \alpha_t ni_t inv_{konst} + \beta_t mr_t + \gamma_t or_t \\ & - (gr_t + cs_{konst} + dc_{konst}) DR_{konst} \\ & - BWR_{t-1} - ZZR_t + ZZR_{t-1} \end{aligned} \tag{9}$$

Apart from investment income, given as the net return ni_t, the risk result mr_t and other earnings or_t are allocated to the bonus and rebate provisions.[18] The parameter

[17] The model considers the bonus and rebate provisions as a whole. Allocations and withdrawals are imputed to the share of the bonus and rebate provisions that is eligible as own funds on a pro rata basis.

[18] The formula for allocation to the bonus and rebate provisions and the associated minimum values for the relevant parameters are laid down in the Regulation Concerning Bonus and Rebate Minimums in Life

inv_{konst} denotes the constant investment portfolio. Pursuant to the Minimum Allocation Regulation α_t represents the minimum amount allocated from net investment income, whereby $\alpha_t \geq 0.9$ applies. For the allocation from the risk result $\beta_t \geq 0.75$ applies.[19] From other earnings γ_t will be allocated and $\gamma_t \geq 0.50$ applies.[20] Full allocation is assumed ($\alpha_t = \beta_t = \gamma_t = 1$). This means that there is no profit participation by shareholders.

The guaranteed return gr_t, the current surplus cs_t and the direct credit amount dc_t, are withdrawn, in each case calculated on the basis of a constant premium reserve DR_{konst}. The profit participation share $cs_t + dc_t$ is reduced to zero as soon as the coverage ratio falls below the threshold of 130% as it is assumed that this value will be the trigger for enterprises to take more resolute countermeasures.[21]

Since 2011, enterprises have been obliged to set up an additional interest provision under certain circumstances. The model assumes that enterprises realise valuation reserves in order to be able to make the required allocations to the additional interest provision. If, however, realisations should prove insufficient, then investment income is drawn upon, which means that correspondingly fewer funds are allocated to the bonus and rebate provisions. For this reason, a distinction is made between two cases of a change in the bonus and rebate provisions. In the first case, the valuation reserves available from the previous year are sufficient to cover the transfers to the additional interest provision in the current year; in the second case, the valuation reserves are not sufficient, which means that funds have to be channelled from the bonus and rebate provisions to the additional interest provision.

5.4 Scenarios analysed for the net return

As the key equations (8) and (9) show, the net return on investment has a material impact on the bonus and rebate provisions. The net return achieved by the enterprises in the scenarios is thus the main component of the model. As already mentioned, German life insurers place almost 90% of their investments in fixed-income securities. For that reason, we examined various bonds to determine their explanatory value for the net returns achieved in the past. German Federal bonds (Bunds) of different maturities were considered especially suitable for this purpose. The yield on Bunds with a residual maturity of six years provides the best fit for the historical evolution of the net return on investment, both in the aggregate and for the majority of the enterprises analysed. As the life insurance companies operating in Germany have placed their resources not only in Bunds, they have in the past often generated a return on investment that was higher than the interest paid on the government bonds under review. The projected net return in the scenarios takes this interest rate differential (excess return) into account.

In the baseline scenario, the net return is mapped using Bunds with a residual ma-

Insurance – the Minimum Allocation Regulation (Verordnung über die Mindestbeitragsrückerstattung in der Lebensversicherung - Mindestzuführungsverordnung).

[19] On 7 August 2014 the Lebensversicherungsreformgesetz (LVRG) came into force. The LVRG requires, inter alia, an allocation from the risk result equal to 90%. This corresponds to an increase equal to 15 percentage points. Our analysis does not take into account the LVRG.

[20] The risk result is the difference between calculated risk costs and actual risk expenditure. Other earnings consist mainly of the cost result.

[21] Enterprises would presumably not wait for the coverage ratio to drop to 100% before responding. Supervisors could also be expected to urge enterprises to take countermeasures in good time.

turity of six years. For this purpose, we obtain forward rates by using the yield curve parameters suggested by Nelson and Siegel (1987) and further developed by Svensson (1994). It is assumed that the computed forward interest rates match the future spot rates. The key net return variable is then calculated as the sum of the computed six-year moving average forward rates[22] and the excess return. The enterprise-specific excess return thereby gradually shrinks by 15% per year to its historical mean before being extrapolated from that level.[23] The excess return is eroded as, with a given investment risk, it becomes increasingly difficult to achieve an above-average return in a low-interest-rate environment.

In a mild stress scenario, the Bunds with a residual maturity of six years are extrapolated using historical yields on Japanese government bonds.[24] This is intended to plot a conceivable development path during a protracted period of low interest rates – as experienced in Japan since the late 1990s. The net return aligns with the Japanese interest rate level over a time horizon of six years as the insurance companies progressively restructure their portfolios. As in the baseline scenario, the excess return is added in order to forecast the net return on investment.

In a more severe stress scenario, the excess return generated shrinks by 25% per year and therefore faster than in the other two scenarios, although not abruptly. Additionally, in the future, enterprises are not able to achieve the mean excess return but rather only the minimum historical excess return.[25] This simulates an increase in the severity of the low-interest-rate environment across the entire capital market, making it ever more difficult to achieve higher excess returns.

Figure 7 plots the net return on investment in the three scenarios described. The average guaranteed return in German life insurers' portfolios is also shown for comparison.[26]

5.5 Development of the valuation reserves

The assumed interest rate scenarios lead to market value changes resulting in valuation reserves on the assets side of the balance sheet. A BaFin calculation can be used to determine the average duration on the assets side for each life insurer. For this purpose, changes in the market values of the assets are assumed in various scenarios. The underlying assumption of our analysis is that of a constant duration for all points in time. This is plausible for two reasons. First, it can be proven empirically that stable business models

[22]We assume that the insurer annually replaces about 10 per cent of its maturing investment portfolio with newly issued ten-year government bonds. This amounts to using forward rates with a six-year maturity as an average over 10-years.

[23]In the model, the enterprises produce the 90% quantile of the values observed as the excess return in 2013. This excess return shrinks to the respective enterprise-specific historical mean level over the course of several years. If the mean is negative, it is fixed at zero for the purposes of the projection.

[24]The yields on Bunds with a residual maturity of six years were extrapolated from mid-2013 onwards using yields on Japanese government bonds generated in 2003. Hence, the interest rate remains extremely low in both the mild scenario and the more severe scenario. In the extrapolation using the forward interest rates derived from the yield curve for Bunds in the baseline scenario, however, the interest rates rise gradually.

[25]If the minimum value is negative, it is fixed at zero for the purposes of the projection.

[26]Enterprises earn the net return on the entire investment portfolio. The guaranteed return, by contrast, is paid only on the saving component, which makes up around 80% of premiums. For reasons of comparability, therefore, the guaranteed return was extrapolated to the entire investment portfolio.

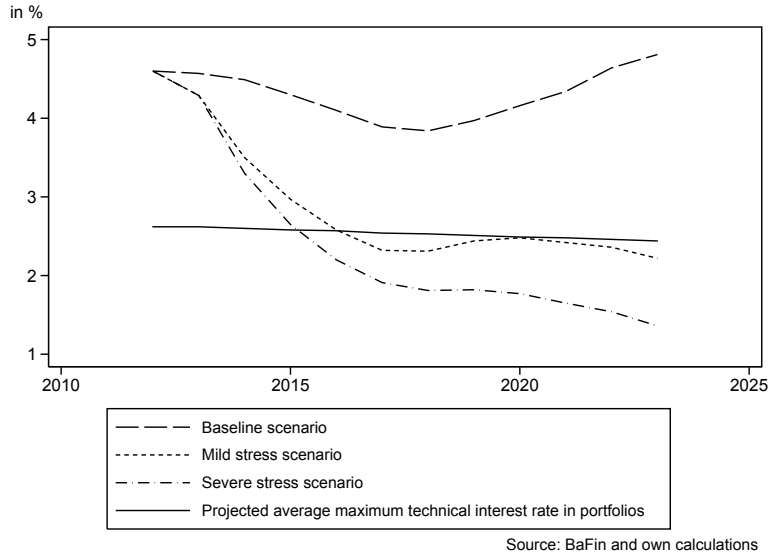


Figure 7: Net return in the scenarios

in the case of banks lead to a barely changing duration. As insurers are conservative and thus probably maintain unchanged business models, a constant duration over time appears justified. Second, it can be assumed that life insurance companies hold an optimal portfolio. After the asset shock, ie the pro rata distribution of the valuation reserves, this portfolio is still optimal and consequently remains unaltered.

The following formula can be used to calculate the dynamic of the valuation reserves per annum in our model's three interest rate scenarios.

$$\Delta MW_t = Duration \Delta r_t \cdot MW_t \tag{10}$$

In the formula, ΔMW_t represents market value changes and $\Delta r_t = r_{t-1} - r_t$ the interest rate shock.

Valuation reserves are realised not only to make the required allocations to the additional interest provision but also to give policyholders their legally prescribed share of the valuation reserves.

As the valuation reserves also diminish owing to maturing investments, we assume that the opening balance of the valuation reserves is automatically run down over a period of 10 years. It can be assumed that insurers first use those investments that are due to mature in the next period to fund the additional interest provision. If the interest rate level falls further, new valuation reserves cumulate for assets purchased in the meantime.

Data made available by BaFin reveal that, over time, around 3% of the valuation reserves are regularly paid out to policyholders whose contracts expire.[27]

The enterprises fulfil this participation requirement by realising valuation reserves through the sale of securities. They would otherwise have to fund the payouts for the

[27]This tallies approximately with the common estimate that the average period of insurance cover is around 20 years. This would mean that 5% of policies expire per annum. Consequently, 2.5% of the valuation reserves would have to be paid out to policyholders. According to the recently approved LVRG the companies are in the future only obliged to pay out valuation reserves as they exceed hidden losses. This change is not taken into account in the analysis.

participation share of the valuation reserves directly from their income, which would in turn lead to defaults occurring much sooner or in greater numbers. Realisation of valuation reserves appears plausible, as falling interest rates are assumed in the scenarios and thus, in some cases, substantial valuation reserves exist.

We assume that the enterprises realise valuation reserves BWR in order to be able to make the required allocations to the additional interest provision. Moreover valuation reserves shrink over time, so we assume a total decrease of 10% per year. Is the allocation to the additional interest provision in period t lower than this decrease (case 1), the valuation reserves in period t are calculated by the valuation reserves of the previous period minus the 10% decrease and the 3% policyholders' participation in valuation reserves plus the change in the market value in period t.

Case 1 ($0.1 \cdot BWR_{t-1} \geq ZZR_t - ZZR_{t-1}$):

$$\begin{aligned} BWR_t &= BWR_{t-1} - 0.1 \cdot BWR_{t-1} - 0.03 \cdot BWR_{t-1} + \Delta MW_t \\ &= 0.87 \cdot BWR_{t-1} + \Delta MW_t \end{aligned} \tag{11}$$

In case 2 the assumed decrease amounting to 10% of valuation reserves is lower than the allocation to the additional interest provision. In this case the total amount for the allocation to the additional interest provision has to be withdrawn in addition to the 3% policyholders' participation in valuation reserves. Thus the valuation reserves in period t will be calculated according to the following formula.

Case 2 ($0.1 \cdot BWR_{t-1} < ZZR_t - ZZR_{t-1}$):

$$\begin{aligned} BWR_t &= BWR_{t-1} - 0.03 \cdot BWR_{t-1} + \Delta MW_t - (ZZR_t - ZZR_{t-1}) \\ &= 0.97 \cdot BWR_{t-1} + \Delta MW_t - (ZZR_t - ZZR_{t-1}) \end{aligned} \tag{12}$$

6 Results

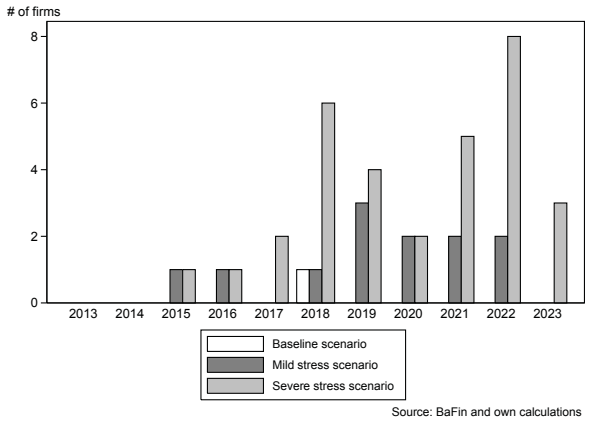
In the following section, we first present the empirical findings of the scenario analysis using the basic assumptions described earlier in this paper. We then alter individual basic assumptions in order to quantify the effect of discretionary leeway granted by legislators.

6.1 Basic assumptions: maintenance of the coverage ratio

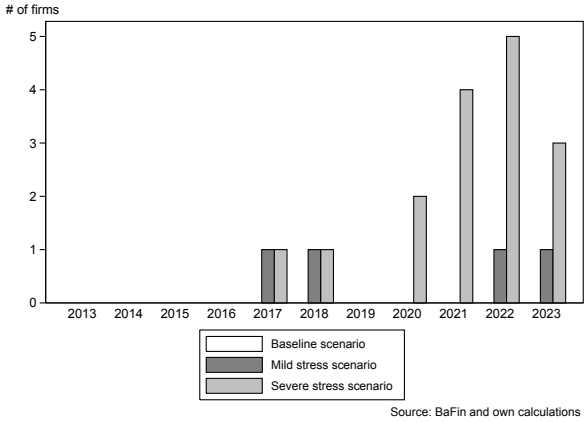
In the baseline scenario, only one life insurer no longer meets the own funds requirements pursuant to Solvency I (see Figure 8).In the mild stress scenario, 12 of the 85 life insurance companies analysed would no longer be able to do so by 2023. Measured in terms of their premium revenue, this group holds a market share of around 14%. In the more severe stress scenario, 32 enterprises, ie more than one-third of the life insurers analysed, would default by 2023. Together, these enterprises have a market share of about 43%.

Table 1 shows the capital required by defaulted enterprises up to 2023 in order to restore a coverage ratio of 100%, ie to fulfil the regulatory own funds requirements.

The capital needs in the baseline scenario are negligible, but already in the mild stress scenario €2.4 billion of capital would be required. This amounts to 4.4% of own funds



(a) Coverage ratio of less than 100%



(b) Guarantee fund requirements

Figure 8: Life insurers with a coverage ratio of less than 100% or which do not fulfil the guarantee fund requirements

	Baseline scenario	**Mild stress scenario**	**Severe stress scenario**
Coverage ratio 100%			
Total capital needs up to 2023 in € bn	0,0	2,4	10,6
Guarantee fund			
Total capital needs up to 2023 in € bn	–	0,2	2,7

Table 1: Capital needs of defaulted enterprises

as of 31.12.2012. This figure jumps to €10.6 billion, respectivly 19.2% of own funds in 2012, in the more severe stress scenario.

6.2 Basic assumptions: maintenance of the guarantee fund

In the baseline scenario, all life insurers are able to fulfil the guarantee fund requirements. In the mild stress scenario, four enterprises – with a market share of just under 1.8% – are not able to maintain the guarantee fund. The enterprises concerned require approximately €200 million to top their own funds back up to the guarantee fund level. In the more severe stress scenario, 16 enterprises are no longer able to maintain the guarantee fund. These enterprises hold a market share of just over 21% in this scenario. €2.7 billion is needed for them to fulfil the guarantee fund requirements.

Table 1 shows the capital required by defaulted enterprises up to 2023 in order to once more fulfil the guarantee fund requirements.

	Baseline scenario	Mild stress scenario	Severe stress scenario
Profit participation			
No payouts to shareholders	1	12	32
Maximum payouts to shareholders	3	36	56
Policyholder profit participation			
Slow reduction	1	12	32
Only guaranteed return	1	12	28

Table 2: Impact of changes in profit participation

6.3 Sensitivity analyses

In the following section, we alter individual assumptions and explain the impact on the findings. We also examine the net return which enterprises must generate to match their coverage ratios of 2012.

6.3.1 Maximum payout to shareholders

In the baseline model, the enterprises pay no dividends to shareholders.This assumption appears plausible, as enterprises anticipate the low-interest-rate environment and therefore act rationally, retaining maximum funds in the enterprise.

In the following analysis, this assumption is set aside so that only the minimum volume of income laid down in the Minimum Allocation Regulation is added to the bonus and rebate provisions in each case, ie 90% of investment income, 75% of the risk result and 50% of other earnings. It is further assumed that the residual income is not allocated to own funds in the form of revenue reserves, but is distributed to shareholders instead.

If insurers were to allocate only the minimum volume of income to the bonus and rebate provisions, the number of defaults would rise considerably. In the baseline and the mild stress scenario, there would be three times as many defaults. In the severe stress scenario, 56 life insurance companies would default, thus, almost twice as many enterprises when compared to the defaults in the baseline model.

The figures in Table 2 reveal that the enterprises and their shareholders have considerable discretionary scope in applying the Minimum Allocation Regulation and can significantly influence the enterprises' solvency situation by applying a distribution policy that is commensurate with a low-interest-rate environment.

6.3.2 No profit participation

A smaller policyholders' profit participation share can alleviate an excessive depletion of the part of the bonus and rebate provisions that is eligible as own funds. In the basic assumptions, enterprises reduce the profit participation share in accordance with their historical growth rate and lower it to the level of the guaranteed return as soon as their coverage ratio falls below 130%. This threshold appears plausible as, at this juncture, the enterprises, in principle, still have enough time to take countermeasures. This might not be quite so easy at a lower threshold. Now we assume that the enterprises respond

directly to the low-interest-rate environment and distribute only the guaranteed return in the first year.The maximum effect of this measure in comparison with the baseline model can thus be quantified.

An immediate reduction in the profit participation share has an impact on the total number of defaults among insurance companies only in the severe stress scenario (see Table 2). Owing to lower payouts and the accompanying greater volume of own funds, four companies less would default in this scenario. In the other scenarios, several of the enterprises default at a later point in time, although the overall number of defaults remains the same.

We only see marginal effects since a reduction of the profit participation is already assumed in the baseline model. Due to market competition and uncertainty about the future interest rate path it is not implausible that life insurers would lower the profit participation less than we assumed. In this case the defaults in the baseline model would be higher and thus the effect of a reduced profit participation larger.

6.3.3 Net return to ensure solvency

In this section, we determine the average minimum net return which the life insurers analysed need to generate if they wish to keep their coverage ratio at the level achieved in 2012. Equation (13) is used to compute annually for each of the enterprises considered the implied net return that would have to be generated.[28] The calculation was carried out for each of the three scenarios owing to the scenarios' varied assumptions about the change in the additional interest provision and the resulting differences in the solvency margins.

$$r_t = \frac{EK_{konst}}{\delta \overline{KA}} \left(\frac{Solv_t}{Solv_{t-1}} - 1 \right) - \frac{Zuf_{Rest,t}}{\overline{KA}} + \frac{Ent_t}{\overline{KA}} + \frac{RfB_{t-1}}{\overline{KA}} \left(\frac{Solv_t}{Solv_{t-1}} - 1 \right) \qquad (13)$$

Figure 9 depicts the distribution of the average net return in the three scenarios. It shows that the majority of the enterprises analysed would have to generate an average net return of between 2% and 3% p.a. to be able to keep their coverage ratio at the 2012 level. If the figures for all of the enterprises analysed are aggregated, the required average net return is 2.3% or 2.4% p.a. This, the net return identified here is slightly lower than that found in the study by Serra and Harris (2013). At the single-entity level, there are – in some cases, considerable – differences in the net return required by the enterprises. While there are some insurance companies that need only an average net return of less than 1% p.a., there are others that would require a return of more than 5% p.a. on average in order to sustain their 2012 coverage ratio in the years ahead. A persistent low-interest-rate environment poses a particularly serious challenge to these enterprises.

In the histograms for the stress scenarios, it can be observed that, at times, a lower net return than in the baseline scenario is required. This can be explained by the fact that the allocations to the additional interest provision - where possible - are being funded through realising valuation reserves.[29] As, for some enterprises, the valuation reserves in

[28] The derivation of the formula is given in the Appendix.

[29] When calculating the valuation reserves, the same interest rate path as used in the scenario analysis is assumed.

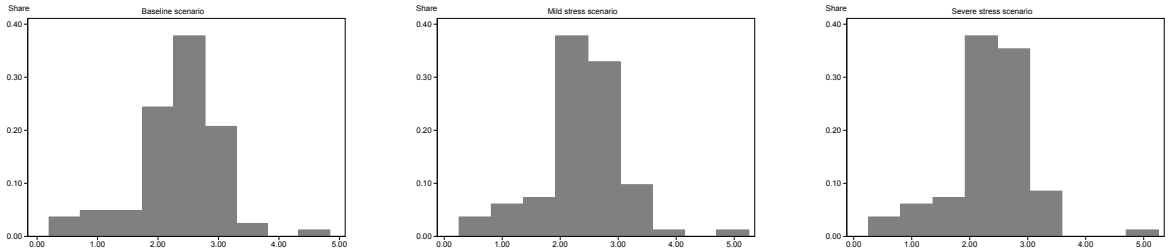


Figure 9: Distribution of the implied net return in the scenarios

the stress scenarios grow at a much stronger pace than the likewise increasing allocations to the additional interest provision, the additional interest provision must be replenished from income at a later date, thereby lowering the overall average implied net return.

7 Absorption by the protection fund for life insurance companies (Protektor)

In this section, we examine whether the protection facility for life insurance companies would be able to bear the losses which we have calculated. All life insurance companies or branches of life insurance companies that conduct life insurance business in the Federal Republic of Germany are members of the Protektor protection fund.

BaFin decides whether a protection event has occurred and orders the transfer of a company's insurance contracts to the protection fund. A protection event is deemed to have occurred if a member company is no longer in a position to durably fulfil its obligations, ie in the event of balance sheet overindebtedness, and if all recovery options using the distressed enterprise's own resources have failed.

The Protektor guarantee fund is financed through annual contributions of a maximum of 0.02% of the net insurance technical reserves which are levied on the member companies until cover funds equivalent to 0.1% of the net insurance technical reserves have been accumulated (level in December 2012: about €813 million). The cover funds have been at full capacity since 2010. Furthermore, special contributions in the amount of a further 0.1% of the net insurance technical reserves can be levied on the members for recovery purposes. If these funds are still not sufficient for a recovery, BaFin reduces the obligations under the insurance policies by up to 5% of the contractually guaranteed benefits. If a recovery is still not feasible, the members of Protektor have undertaken to make available resources -including the contributions paid to the protection fund - in an amount of up to 1% of the net insurance technical reserves (level in December 2012: about €8.1 billion). A limit has been placed on the maximum volume of funds to be paid per year or per protection event in order to mitigate the annual burden on the member companies.[30]

As failure to fulfil the solvency margin or guarantee fund requirements does not automatically signify a balance sheet shortfall, we calculated whether the companies that we identified as having defaulted really were overindebted. We subsequently analysed whether the protection fund would be able to absorb these defaults with the resources at its disposal.

[30] See www.protektor-ag.de.

Balance sheet overindebtedness exists in the model when the enterprises' own funds have been entirely eroded. Shortfalls beyond this point would have to be borne by Protektor once the enterprise's insurance contracts have been transferred.

In the baseline scenario, no enterprise is overindebted. In the mild stress scenario, there would be a shortfall of around €293 million up to 2023. If BaFin were to reduce the obligations under insurance policies by 5%, the shortfall would be slightly smaller (just over €265 million. Protektor could offset this shortfall even without the contributions from the insolvent enterprises. However, once the shortfall has been made good at the enterprises concerned, their own funds would equal zero, meaning that these enterprises would still fail to meet the solvency requirements.

In the more severe stress scenario, the shortfall increases significantly to just under €1.8 billion. After BaFin has reduced the obligations under insurance policies by 5%, there is still a shortfall of just over €1.5 billion. According to our calculations, the Protektor protection fund would not be able to absorb this amount by means of the cover funds plus special contributions totalling 0.02% of the net insurance technical reserves as the insolvent enterprises' resources would probably be lacking. The solvent enterprises' additional capital obligations would have to be called in order to raise the level of the insolvent enterprises' own funds back to zero.

Our analysis shows that a persistent low-interest-rate environment could possibly overstretch the Protektor protection fund, even if its financial resources currently still appear to be sustainable. If it should be necessary to call the additional capital obligations, it is uncertain whether the funds could be made available to the protection fund in good time as the enterprises which must provide additional capital may possibly also have to cope with a considerable decline in their own funds as a result of the low-interest-rate environment.

8 Conclusions

The present analysis shows that a persistent low-interest-rate environment harbours a potential risk to the stability of the life insurance segment.

The scenario analysis was conducted on the basis of the currently applicable solvency regime (Solvency I). Solvency II will introduce a market valuation of assets and liabilities in order to better capture actual risks. Any problems in meeting the own funds requirements owing to low interest rates will then come to light much sooner. Therefore, a tendency towards poorer results is to be expected under Solvency II.

A less pronounced low-interest-rate environment would probably not overstretch the Protektor protection fund. However, if there were to be multiple insolvencies as, for example, in the more severe stress scenario, the financial resources which are normally at Protektor's disposal might no longer be sufficient. The solvent enterprises' additional capital obligations would have to be called. The question then would be how quickly these enterprises could actually provide the extra funds as they themselves would be suffering from the effects of the low-interest-rate environment.

Life insurers have several possible courses of action open to them in response to a protracted period of low interest rates. The analysis shows that not making distributions to shareholders has a significant positive impact on the number of defaults. Furthermore, enterprises could strengthen regulatory own funds by raising equity. Alternatively, through

assuming greater risks, they could try to increase the net return in order to enlarge the allocations to the bonus and rebate provisions, part of which is recognised as own funds. Increased risk-taking would have to be viewed critically in terms of financial stability. Insurers' risk management systems would certainly need to be progressively adapted.

Insurance companies could also curb the drain on own funds by substantially lowering their overall return at an early stage and, for instance, continuing to pay only the guaranteed return. Moreover, the enterprises could further extend their range of products with a flexible guaranteed return or no guaranteed return at all.

A Appendix

Formulae for calculating the net return required to keep the coverage ratio at the level of 2012

Starting point for the calculation is the formula for the coverage ratio:

$$BQ_t = \frac{EM_t}{Solv_t} = \frac{EK_{konst} + RfB_t^{EM}}{Solv_t} \tag{14}$$

To maintain a constant coverage ratio, the following must apply.

$$\begin{aligned}
&\Delta BQ_t = \Delta \frac{EK_{konst} + RfB_t^{EM}}{Solv_t} = 0 \\
&\Leftrightarrow \frac{EK_{konst} + RfB_t^{EM}}{Solv_t} - \frac{EK_{konst} + RfB_{t-1}^{EM}}{Solv_{t-1}} = 0 \\
&\Leftrightarrow \frac{EK_{konst} + RfB_t^{EM}}{Solv_t} = \frac{EK_{konst} + RfB_{t-1}^{EM}}{Solv_{t-1}} \\
&\Leftrightarrow \frac{RfB_t^{EM}}{Solv_t} + \frac{EK_{konst}}{Solv_t} = \frac{RfB_{t-1}^{EM}}{Solv_{t-1}} + \frac{EK_{konst}}{Solv_{t-1}} \\
&\Leftrightarrow RfB_t^{EM} - \frac{Solv_t}{Solv_{t-1}} RfB_{t-1}^{EM} = EK_{konst} \left(\frac{Solv_t}{Solv_{t-1}} - 1 \right)
\end{aligned} \tag{15}$$

The following applies to the share of the bonus and rebate provisions that is eligible as own funds.

$$RfB_t^{EM} = \delta RfB_t \tag{16}$$

Inserting equation (16) into equation (15) gives the following condition.

$$\delta RfB_t - \frac{Solv_t}{Solv_{t-1}} \delta RfB_{t-1} = EK_{konst} \left(\frac{Solv_t}{Solv_{t-1}} - 1 \right) \tag{17}$$

The bonus and rebate provisions at time t are derived from the bonus and rebate provisions

of the prior period adding allocations and substracting withdrawals. Only allocations originating from investment income are dependent on the net return generated, so all other allocations and withdrawals can be aggregated.

$$RfB_t = RfB_{t-1} + r_t\overline{KA} + Zuf_{Rest,t} - Ent_t \tag{18}$$

Inserting equation (18) into equation (17) gives the following condition.

$$\begin{aligned}
&\delta\left(RfB_{t-1} + r_t\overline{KA} + Zuf_{Rest,t} - Ent_t\right) - \frac{Solv_t}{Solv_{t-1}}\delta RfB_{t-1} = EK_{konst}\left(\frac{Solv_t}{Solv_{t-1}} - 1\right)\\
&\Leftrightarrow \delta r_t\overline{KA} = EK_{konst}\left(\frac{Solv_t}{Solv_{t-1}} - 1\right) - \delta Zuf_{Rest,t} + \delta Ent_t + \delta RfB_{t-1}\left(\frac{Solv_t}{Solv_{t-1}} - 1\right)\\
&\Leftrightarrow r_t = \frac{EK_{konst}}{\delta\overline{KA}}\left(\frac{Solv_t}{Solv_{t-1}} - 1\right) - \frac{Zuf_{Rest,t}}{\overline{KA}} + \frac{Ent_t}{\overline{KA}} + \frac{RfB_{t-1}}{\overline{KA}}\left(\frac{Solv_t}{Solv_{t-1}} - 1\right)
\end{aligned} \tag{19}$$

Equation (19) allows us to determine the net return required at any time t. We then use the annual values calculated to compute the mean for each enterprise over the forecast period.

$$\overline{r} = \frac{1}{T}\sum_{t=1}^{T} r_t = \frac{r_1 + ... + r_T}{T} \tag{20}$$

References

Dickinson, G. (2000). The Implications of Low Interest Rates for Insurers: A Comment. *The Geneva Papers on Risk and Insurance 25(1)*, 59–62.

Gesamtverband der deutschen Versicherungswirtschaft e. V. (2013, August). Statistisches Taschenbuch der Versicherungswirtschaft 2013.

Holsboer, J. H. (2000). The Impact of Low Interest Rates on Insurers. *The Geneva Papers on Risk and Insurance 25(1)*, 38–58.

Kablau, A. and M. Wedow (2012). Gauging the Impact of a Low-Interest Rate Environment on German Life Insurers. *Applied Economics Quarterly 85(4)*, 279–298.

Nelson, C. R. and A. F. Siegel (1987). Parsimonious modeling of yield curves. *Journal of Business 60(4)*, 473–489.

Podlich, N. and M. Wedow (2013). Are insurers SIFIs? A MGARCH model to measure interconnectedness. *Applied Economics Letters 20*, 677–681.

Serra, B. and S. Harris (2013, October). German Life Insurance Industry Faces Losses If Interest Rates Stay Low. Moody's investors service, Moody's.

Siglienti, S., G. Susinno, S. Buttarazzi, and G. Stamegna (2000). Consequences of the Reduction of Interest Rates. *The Geneva Papers on Risk and Insurance 25(1)*, 63–77.

Stolz, S. M. and M. Wedow (2010). Extraordinary Measures in Extraordinary Times: Public Measures in Support of the Financial Sector in the EU and the United States. Technical report, ECB.

Svensson, L. E. (1994). Estimating and Interpreting Forward Rates: Sweden 1992-1994. IMF Working Paper No 114, IMF.

Trichet, J.-C. (2005). Financial Stability and the Insurance Sector. *The Geneva Papers on Risk and Insurance - Issues and Practice 30*, 65–71.