Pension Protection Schemes, Contagion and the Economy

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Abstract

Protection schemes shield economic subjects against financial shocks. Their premiums and services influence corporate behavior and even the depth of economic cycles. We assess the relationship between protection schemes and corporate activity using a granular risk model which builds on an expansive set of micro data and explicitly models contagion effects. We find that protection schemes should establish fair and non-cyclical premium schemes if they pursue the aims of incentive compatibility and economic stability.

1 Introduction

The effects of protection schemes on the economy have long been discussed. When the first U.S. deposit insurance was established in the Federal State of New York in 1829, its foundation drew consequences from several bank failures which had caused economic disruptions. The institution's direct objective of protecting depositors was also meant as a measure to shelter the real economy.[1] Hence, the founders of the first deposit insurance were already conscious about their impact on the real economy.

The many failures of early protection schemes show, however, that little was known at this time about incentives (cf. *Cummins (1988)*). Great progress has been made since then. Theoretical studies have shown how incentives affect insurers and protection schemes via moral hazard and adverse selection. Empirical evidence supports the view that excessive risk-taking is encouraged by risk-insensitive premium schemes. Important contributions in this field have been made, among others, by *Niehaus (1990), Chan, Greenbaum and Thakor (1992), Lee, Mayers and Smith (1997), Downs and Sommer (1999), Pennacchi (2006)* and *Crossley and Jametti (2013).*[2] Fair, incentive-compatible prices of protection were derived, among others, by *Merton (1977)* for deposit insurance and *Boyce and Ippolito (2002)* for pension protection.[3]

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1 For example, the *Committee on Banks and Insurance Companies (1829)* stated that the "loss by the insolvency of banks, generally falls upon the farmer, the mechanic and the laborer [...]. The protection and security of this valuable portion of our population, demands from us, in their favor, our most untiring exertions". More evidence is provided by *Golembe (1960)*.

2 *Niehaus (1990)* spots an increase in promised pension benefits after the introduction of the insurance program due to a moral hazard problem. *Cummins (1988)* derives risk-based premiums for various scenarios of guarantee funds. *Chan, Greenbaum and Thakor (1992)* explore private information and moral hazard in deposit insurance and show that incentive-compatible, risk-sensitive premiums are not feasible under deregulated, perfectly competitive markets. *Downs and Sommer (1999)* detect a positive relation between risk-taking and insider ownership due to risk-subsidy incentives in guaranty funds (cf. also *Lee, Mayers and Smith (1997)*). *Pennacchi (2006)* finds that the risk-based premium scheme proposed in deposit insurance incentivizes a change in investment decisions towards higher systematic risk and suggests an alternative form of government insurance in order to mitigate this moral hazard problem. *Crossley and Jametti (2013)* test moral hazard in pension benefit guarantee mechanisms empirically and identify that covered pension plans will hold riskier investment portfolios.

3 The work of *Merton (1977)* is based on the framework for pricing options by *Black and Scholes (1973)*. A large strand of literature adopts this approach. For pension insurance, e.g., *Hsieh, Chen and Ferris (1994)* derive put option values.

However, there is still little evidence how premiums and services of protection schemes affect corporate activity at a macroeconomic level, especially regarding contagion effects in times of crises. Our paper tries to fill this gap. It finds that incentives are important, but that cyclical effects due to contagion should not be disregarded. For example, expected loss (EL) premiums are considered to be fair, but they can aggravate economic fluctuations ('pro-cyclicality'). These findings suggest that protection schemes should leave their main objective of incentive-compatible consumer protection unchanged. However, they should additionally consider their contribution to a stable economy as a supplementary condition.

Our concern about pro-cyclicality in protection schemes relates to a financial stability perspective. This paper extends the literature in this field. Since *Billio et al. (2012)* have highlighted the importance of the insurance sector for financial stability, more work in this field has evolved. For example, *Koijen and Yogo (2018)* demonstrate that insurance against market risk is inherently fragile if it is voluntary and smooths aggregate risk over time. The aspect of contagion in insurance is studied theoretically by *Chotibhak et al. (2018)* who relate the interconnectedness of the insurance institutions emerging from asset side vulnerability to systemic risk in the broader financial sector. *Cummins and Weiss (2014)* empirically investigate the contagion effects and the systemic risk potential of the U.S. insurance industry to other sectors of the economy.

This paper uses Pension Protection Schemes (PPS) as an example for several reasons: i) PPS exhibit diverse institutional setups, ii) PPS are directly linked to the real economy, and iii) PPS reflect corporate insolvencies. All of these features help identifying how the institutional setup of protection schemes is connected to economic activity.

Based on an expansive set of micro data, we model one of the biggest real-world pension protection schemes, the German Pensions-Sicherungs-Verein (PSVaG) in full complexity. We design a granular risk model which builds on the Pension Insurance Modeling System (PIMS) of the Pension Benefit Guarantee Corporation (PBGC). This microsimulation model, introduced by *Boyce and Ippolito (2002)*, is widely perceived as state of the art among risk models (*Mitchell (2013)*).[4] It considers explicitly that PPS are a long-term insurance against market risk. We add contagion and feedback mechanisms to the PIMS methodology in order to capture differences between the factual institutional setup and counterfactual alternatives. Furthermore, we use the fair pricing scheme presented by *Boyce and Ippolito (2002)* as a benchmark. While their proposal *disburdens* the PPS from systematic risk, we recommend a fair premium which *compensates* the PPS for bearing systematic risk, instead. Moreover, we compare the impact of both institutional setups on real economic activity, as measured by GDP.

The article is structured as follows. The second section begins with an overview of PPS in major industrialized countries. This stocktaking exercise illustrates different institutional setups of protection schemes. Based on this comparison, we draw theoretical conclusions on how ownership and risk pricing relate to risk sharing and the transmission of shocks. Furthermore, we compare different fair pricing schemes. The third section presents the risk model built on the PIMS methodology which we apply to analyze the PPS's risk profile under different hypothetical fair pricing schemes. The fourth section starts with a snapshot of the portfolio structure of the PPS and continues with an examination of its long-term risk profile. Furthermore, the impact of different pricing schemes on the national GDP is explored. In the fifth section, the conclusion, we also derive policy recommendations on the basis of the empirical results.

2 Key institutional determinants of pension protection schemes

[4] The PIMS was reviewed by a panel of experts in 2013. The final report prepared by *Mitchell (2013)* concludes that there is "no other model that can do a comparable job". Previous attempts to measure the overall long-term risk of PPS were made by *Estrella and Hirtle (1988)* and *Lewis and Cooperstein (1993)*, among others. Illustrative solutions are provided for hypothetical pension plans (Bodie and Merton, 1993; Pennacchi and Lewis, 1994) or a sample of insured plan sponsors (Marcus, 1987; Lewis and Pennacchi, 1999). Many of the risks involved are exemplified by the savings and loan crisis of the late 1980s (Bodie and Merton, 1993; Bodie, 1996). *Broeders and Chen (2013)* compare PPS to other security mechanisms of pension benefits.

This section illustrates key institutional determinants of pension protection schemes (PPS). On this basis, we discuss how ownership and risk pricing relate to risk sharing and the transmission of shocks. Furthermore, we present fair premium schemes which consider market risk and whose impact on PPS and the real economy are compared in the fourth section.

2.1 Pension Protection Schemes

Pension Protection Schemes (PPS) protect the members and beneficiaries of occupational pension plans against the insolvency of employers. They guarantee that the promised pensions will be provided in full, even if these are not completely covered by the proceedings from a corporate insolvency or restructuring.[5]

PPS exist in several major industrial countries. They typically reflect the national pension system. For example, the Pension Benefit Guarantee Corporation (PBGC) in the USA and the Pension Protection Fund (PPF) in the UK are about of the same size. Their gross exposure amounts to USD 2,979 bn and USD 2,288 bn, respectively (cf. Table 1, third row). The German Pensions-Sicherungs-Verein (PSVaG) follows at large distance; it covers gross pension obligations worth USD 501 bn at book values. These differences mirror that occupational pensions are far more important in Anglo-Saxon countries than in Germany, where public pensions are higher.

However, the PSVaG and the PPF have a comparable size in terms of net exposure (cf. Table 1, fourth row). The PSVaG covers pension obligations less plan assets worth USD 346 bn, compared with USD 628 bn covered by the PBGC and USD 362 bn covered by the PPF. For both Anglo-Saxon countries the large difference between gross and net exposure reflects that corporate pension obligations are mostly externally funded. Employers are obliged to invest

5 From a theoretical perspective, pension insurance arrangements are equivalent to sponsors holding pension put options on the assets underlying the claim, with a striking price equal to the gross value of the claim (*Treynor (1977)*).

the deferred compensation of their employees in earmarked plan assets which exclusively back the promised occupational pensions. To the contrary, Germany has traditionally had a book-reserve system. Employers are still allowed to use the deferred compensation of their employees to fund their own businesses. Such a book-reserve system leaves the members and beneficiaries of occupational pension plans with greater risk in case of an insolvency of their employer. In the German case, this risk is diversified at the level of a PPS instead. Hence, PPS play a more important role in a book-reserve system than in a system of external funding of the Anglo-Saxon type, which exhibits a first stage of diversification at the firm-level.

From a political economy perspective, the linkage between the ownership and the track record of PPS is worth noticing. The PSVaG is privately owned by German employers, and it operates without any state support since its foundation in 1974. To the contrary, the PBGC is a federal agency which has relied on several state interventions in order to perform its tasks (cf. *Bodie (2006)*, *Stewart (2007)* and *Brown (2008)*).[6]

From the perspective of risk sharing, another dimension of ownership is important. The PSVaG is a mutual insurance. This organizational form limits the issuance of equity to the collective of risk-takers. Its Anglo-Saxon counterparts are both stock insurers, which extends the scope of risk sharing to external providers of equity. The ownership is reflected accordingly in the premium schemes. The PSVaG has evolved from a pay-as-you-go system, where premiums are set ex-post based on incurred losses. To the contrary, the PBGC and the PPF are mostly financed by ex-ante premiums which are set according to expected losses. The PBGC sets flat-rate premiums according to approximate claims which are expected from its aggregate exposure and the number of participants in a pension plan.[7] The PPF has risk-

6 The PPF is a relatively new institution which was established in 2004. Although it has been set up as a public corporation, it is designed to operate without taxpayers' support in the long run. Due to its short track record, it is still unclear whether it will reach this aim (*Stewart (2007)*, p. 24).

7 For single-employer plans, the flat-rate premium is supplemented by an additional variable-rate premium (VRP). This risk component bases on the amount of unfunded vested benefits. However, income derived from this provision is negligible.

adjusted premiums: at least 80 percent of the premium account for the insured firm's likelihood of insolvency and the level of underfunding of its pension plan.

2.2 The interrelation of ownership, risk sharing and pricing

This subsection considers theoretically how the institutional setup is related to risk sharing mechanisms which determine the transmission of shocks. The institutional setup of PPS varies substantially, particularly with regard to their ownership structure and premium schemes (see Table 2).

The *premium scheme* of a PPS translates losses into premiums. Premiums can be set either based on expected losses, i.e. before losses occur (ex-ante), or afterwards, based on incurred losses (ex-post). Differences between premium income and incurred losses have to be borne by the PPS and ultimately its owners.[8] The relationship between the premium system and the *ownership structure* is clearly evident in a single-period model, because risks are only shared in the cross-section and not over time. In the case of a mutual insurance, there is no external risk-taker. Therefore, incurred losses have to be distributed within the system of risk carriers at the end of the period. In a single-period model, mutual insurance thus has to be based on ex-post pricing.[9] In the case of stock insurers, the use of external equity enables the insurer to transfer unexpected losses to external risk-takers which bear deviations between premium income and incurred losses. Therefore, only stock insurers can provide an ex-ante premium scheme in a single-period model.

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8 In the case of mutual insurers, the collectives of owners and risk-carriers coincide. The consequences for risk sharing are explained below.

9 *De jure*, mutual insurance can be based on ex-ante pricing in a single-period model, too. *In economic terms*, however, the sum of ex-ante premiums and profits or losses on the side the PPS are equivalent to ex-post premiums. The reason is that, in the case of mutual insurers, deviations between ex-ante premiums and incurred losses, which are borne by the insurer in the first instance, ultimately remain in the collective of risk-takers.

In a multi-period model, risks can be shared intertemporal.[10] Buffers and credit can be used to smooth temporary deviations between premium income and incurred losses. These instruments complement external equity, thereby blurring the distinction between mutual and stock insurers which can both offer ex-post and ex-ante pricing schemes. However, the creditworthiness of a mutual insurer depends crucially on the *nature of membership*. Credit will only be provided if the mutual insurer can guarantee that the collective of risk-takers will repay the debt. A repayment, however, cannot credibly be assured if risk-takers have an option to quit the collective. Therefore, intertemporal risk sharing may only be available for mutual insurers which offer mandatory and not voluntary insurance schemes.[11]

We conclude that ex-post pricing is more natural for mutual insurers which have no external providers of capital. To the contrary, ex-ante premium schemes are more natural for stock insurers, because they require a risk sharing between external providers of capital and the insured parties. The premium schemes of the existing PPS, which we will evaluate later, are to be seen in this institutional context.

2.3 Market risk and fair premium schemes

Protection schemes typically cover risk which is largely systematic, not idiosyncratic. For example, deposit insurance schemes typically bear extreme losses during banking crises which are related to economic downturns and high funding costs. The same applies to PPS which cover losses from corporate insolvencies that peak during recessions.[12] Therefore, protection schemes typically have to bear the highest losses when these are most costly to finance.

10 Intertemporal risk sharing can also generate an insurance against aggregate risk (*Hombert and Lyonnet (2017)*). We will show later that this finding is important for the case of protection schemes.

11 *Hombert and Lyonnet (2017)* put it another way: “The implementation of intergenerational risk sharing requires some market friction. An extreme form of friction is to force households to participate […]”

12 *McCarthy and Neuberger (2005)* and *Bodie (2006)* point to the fact that not only the companies’ probability of default increases during economic downturns, but also the funding of pension plans. Therefore, a PPS is indirectly exposed to market risk, too, because it covers losses which are correlated with market performance.

Boyce and Ippolito (2002) propose to *disburden* the PPS from systematic risk. They suggest a short-term premium scheme which resets premiums each year based on ex-ante expected losses of the following year. Under short-term expected loss (EL) pricing, premiums are cyclical. They increase or decrease with the probability of bankruptcy, and they peak in economic downturns. The price of protection $P^i_{t,t+1}$ for company *i* in the period from *t* to *t+1* equals the expected claims of this company against the PPS:[13]

$$P^i_{t,t+1} = E\left(\tilde{C}^i_{t,t+1}\right). \qquad (1)$$

We derive a long-term flat premium scheme which *compensates* the PPS for bearing systematic risk. Leaving the market risk with the PPS, such a premium scheme is not affected by the business cycle. The constant fair long term premium, which we derive in Appendix 1, gives

$$P^i_{t,t+s} = \frac{E\left(\tilde{C}^i_{t,t+s}\right) - \left(E\left(\tilde{r}^M_{t,t+s}\right) - r^f_{t,t+s}\right) \frac{Cov\left(\tilde{C}^i_{t,t+s}, \tilde{r}^M_{t,t+s}\right)}{Var\left(\tilde{r}^M_{t,t+s}\right)}}{\left(1 + r^f_{t,t+s}\right)}\;, \qquad (2)$$

where $P^i_{t,t+s}$ is the premium charged by the PPS from corporation *i* in the period *t,t+s* with *s>1*, $E\left(\tilde{C}^i_{t,t+s}\right)$ are the expected claims of corporation *i* in this period, $\left(E\left(\tilde{r}^M_{t,t+s}\right) - r^f_{t,t+s}\right)$ denotes the market risk premium, $\frac{Cov\left(\tilde{C}^i_{t,t+s}, \tilde{r}^M_{t,t+s}\right)}{Var\left(\tilde{r}^M_{t,t+s}\right)}$ is the contribution to market risk of corporation *i* and $r^f_{t,t+s}$ is the riskless interest rate.

Both premium schemes are fair, but the first short-term premium scheme transfers the market risk to the corporations. The second premium scheme leaves the market risk over the period from *t* to *t+s* with the PPS. We propose it as a possibility of reducing the cyclicality of PPS. Otherwise, the premiums are the higher the less corporates can afford to pay for pension

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13 *Boyce and Ippolito (2002)* propose *term-renewable* premiums which only increase or decrease if the *overall* probability of bankruptcy of all insureds increases or decreases. Such premiums do not reflect the firm-specific but only the average default risk. Hence, term-renewable premiums introduce an additional redistribution between corporations in the cross-section. We use fair *term* premiums instead which price protection according to the firm-specific expected loss.

protection, thereby increasing the default risk even further. Cyclical premium schemes can thus aggravate economic fluctuations and even induce corporate insolvencies by themselves.

3 A granular risk model of an existing PPS

This section presents the data and the methodology which we use to assess the effects of the institutional setup of a PPS on the real economy. We use the German PSVaG to investigate this matter. The risk model projects a set of corporate financial statements into the future in order to capture credit risks and the transmission of shocks to the real economy in their full complexity and on a granular level.

The simulation is based on two different sets of financial statement data of which one is used to calibrate the simulation and the other one as a basis for the simulation. Both sets of data are complemented by our own extensive surveys. This database allows us to assess the exposure of the PSVaG, standardize the plan obligations and consider the composition of plan assets in the simulation.

3.1 Data

Our simulations are based on two different sets of financial statement data, the Financial Statement Data Pool (FSDP) of Deutsche Bundesbank and the DAFNE dataset of Bureau van Dijk (BvD).[14] The FSDP covers financial statements of German corporates from 1971 to 2009. It is widely regarded as the best source of financial statements of this time span, and it includes several financial and political shocks and business cycles. As the data is anonymized, we use it for calibration of our simulation only. The DAFNE data set of Bureau van Dijk contains non-anonymized financial statements from 1994 to 2015, and it covers the vast majority of German corporates since 2005. We complement the DAFNE data set by our own

[14] A detailed description of the data we use can be found in Appendix 2.

survey data[15] and use it as the basis to project the financial statements into the future. Both the FSDP and the DAFNE dataset cover a large number of companies, which represent the vast majority of the gross exposure of the PSVaG.

All data are thoroughly checked and revised. The revisions and corrections affect only a minority of financial statements, which illustrates the high quality of the datasets.

3.2 Methodology

Pension Protection Schemes (PPS) cover long-term risks from corporate pension plans. These risks depend crucially on corporate default risks, which mirror the business cycle. A risk model for a PPS should thus cover at least a medium term, and it should consider market risk. Our methodology builds upon the Pension Insurance Modeling System (PIMS) which is presented in *Boyce and Ippolito (2002)*. It is specifically designed with reference to these features. Compared to the short-term risk models of banks, which typically have a horizon of one year, it is thus far better suited to assessing the risk profile of PPS.

The risk model builds upon firm-specific financial ratios which are jointly forecasted with macroeconomic variables on a year-by-year basis in each run (cf. Figure 1). This simulation in the *SUREG module*, which is described in detail in Appendix 3, assumes that all variables follow AR(1)-processes. The dynamics of the simulation and the interrelation between the financial ratios and the macroeconomic variables result from the disturbance terms being drawn from their joint historical distribution.

In the *pension module*, the simulated macroeconomic variables determine the market values of the firm-specific plan assets (PA) and pension benefit obligations (PBO) and ultimately the firm-specific exposures at default (EAD) of the PSVaG. Whereas the market value of PBO and fixed-income PA depend on the market rates, the value of equities in each pension plan is

15 We conducted extensive surveys on pension plans and on corporate networks in order to expand the database and make the simulations as realistic as possible. Furthermore, our figures on corporate defaults are used to estimate probabilities of default (PDs).

assumed to mirror an equity price index.[16] The resulting funding status of every single corporate pension plan determines the firm-specific EAD of the PSVaG.

The *rating module* derives firm-specific probabilities of default (PD) from the simulated financial ratios. Our corporate rating model incorporates the equity ratio as a solvency measure, the EBTDA per total assets as a cash flow measure, the liquid assets per liabilities as a liquidity measure and the natural logarithm of total assets as a size variable. Two industry dummies correct for special characteristics of trade and other service companies. The logit estimation is calibrated by weighting the observations according to the historical losses of the PSVaG per five size classes.[17] Companies with total assets of less than €1 million are excluded from the estimation due to a sample bias.[18] Table 3 shows that all estimates have the expected sign and are highly significant. The discriminatory power of the rating model, as measured by the area under the ROC curve (AUC) of 79.5%, is in line with common commercial products such as Moody's Risk Calc™.[19]

In the *default module*, the PDs from the rating module are used to simulate corporate defaults. For this purpose, random numbers are drawn for each company and year from independent uniform distributions between zero and one. If the company-specific random number is lower than the individual probability of default, the company is considered to default in this year of this simulated run.[20]

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16 Our estimations are based on the historical growth rates of PA and PBO, the firm-specific asset allocation and the interest sensitivity of PA and PBO.

17 The PSV publishes the historical losses and overall exposure per five classes of its premium base in its Annual Report. The exposure and the losses are aggregated for firms with pension provisions for tax purposes below € 0.1 million, from € 0.1 to 0.5 million, from € 0.5 to 1 million, from € 1 to 5 million and above € 5 million.

18 The DAFNE dataset incorporated very few defaults of companies with pension provisions whose total assets are below €1 million. Such very small companies have limited legal duties to publish their financial data in Germany, and consequently there seems to be a severe quality bias in this size class. Therefore, we excluded these companies which account for far less than one percent of the pension provisions in our sample from the estimation. Interestingly, all size classes of the weighted logit regression still contain a representative number of observations after this revision, as the pension provisions are not necessarily proportionate to the total assets of companies. Most notably, many medium sized corporates have small pension plans.

19 As a reality check, we randomly selected public ratings of German corporates and compared them with the ratings which are assigned according to our rating model. This crosscheck confirms the performance of the rating model.

20 For example, according to this procedure, a company with a constant PD of 1% defaults in 1% of the simulated years.

While the gross value added (GVA) of the defaulted companies determines the periodical reduction of the gross domestic product (GDP), the EADs of the defaulted companies sum up to the periodical loss of the PPS. In the *premium module*, the PPS sets its periodical premiums according to the assumed pricing scheme, based on expected or incurred losses. The difference between the simulated losses and premiums changes the credit balance of the PSVaG. Premium payments also affect the financial ratios of the companies which have not defaulted. For example, losses impact the equity ratio and the EBTDA of the remaining companies.[21] These modified financial ratios are the starting position for the next sequence of the loop, i.e. the next simulated year.

This simulation is run for a 10,000 macroeconomic scenarios with 10 runs each. In this way, we derive a loss distribution function (LDF) of the PPS. Furthermore, we measure the reduction of the German GDP which results from insolvencies. The simulation considers the full granularity of the panel data. Additionally, it allows non-linear relationships between the institutional setup of a PPS, the firm-specific PDs, EADs and GVA and macroeconomic variables. These relationships may even be path-dependent, for example if higher premiums of the PSVaG result in additional corporate defaults. Despite its capability to consider complex relationships, the model is based on simple AR(1)-processes, and, consequently, it is scarce in its parameters.

4 The institutional setup of a PPS and its impact on the transmission of shocks

[21] The PSVaG premiums under the historical pricing scheme are covered by the assumed AR(1)-processes and the simulated disturbance terms. Consequently, only deviations of premiums from their counterpart under the status quo are considered as additional shocks. Such shocks are assumed to alter financial ratios that represent cash flow and liquidity in the short term. For flows and liquidity ratios (EBTDA and liquidity) shocks are considered temporary. Those variables are projected without considering such shocks and only adjusted afterwards in the period in which a shock occurs. For all solvency measures (e.g. equity ratio), shocks are considered as persistent. These financial ratios are corrected before being used as a new basis for the forecast of the following period, thereby creating path-dependencies.

This section presents the current risk-profile of the PSVaG and its evolution under the two counter-factual fair premium schemes. Furthermore, the impact of different pricing schemes on the national GDP is explored.

4.1 A snapshot of the portfolio of the PSVaG

The risk profile of a PPS at one single point of time is determined by the rating and contribution structure related to the exposure. Figure 2 presents the estimated portfolio structure of the PSVaG. While the bulk of the premiums – which reflect the PBO as the gross exposure – is in the investment grade (BBB or higher), the majority of companies is assigned a non-investment grade rating (BB or lower).[22] This reflects the fact that the PSVaG has no size cap on individual exposures. The bulk of the gross exposure relates to big companies, which mostly have an investment grade rating. These are, however, outnumbered by small and medium-sized companies, which tend to be assigned a lower credit rating and which contribute to a lower share of the gross exposure.

4.2 The impact of pricing schemes on the PSVaG's risk profile

The loss distribution function of the PSVaG over a long-term horizon of ten years is shown in Figure 3 for the current premium scheme and the two hypothetical fair premium schemes presented in Subsection 2.3.[23] For all three premium schemes, the PSVaG's loss distribution function has a positive skewness and a heavy right tail. There is a considerable probability of extreme losses: the Value at Risk (VaR) at the 99th percentile stands at about €36 bn for all premium schemes. This VaR is about four times higher than the median losses of about €9 bn.

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22 The rating classes are assigned on the basis of the following lower boundaries for the annual PDs: AAA 0.01 per cent, AA 0.04 per cent, A 0.1 per cent, BBB 0.5 per cent, BB 2 per cent, B 10 per cent, CCC below.

23 Under the status quo, premiums are set ex-post, whereas both fair premium schemes set premiums ex-ante based on company-specific expected losses. In the case of constant premiums, these expected losses (EL) are averaged over the cycle and a market risk premium is added in order to compensate the PPS for bearing the additional market risk.

Compared with the status quo, the two ex-ante pricing schemes shift the distribution of losses moderately to the right.

Table 4 presents the results in more detail. The current ex-post pricing scheme yields the lowest average portfolio loss of €10.6 bn (upper subtable). Under constant fair premiums the average loss increases to €10.9 bn. This surge results from the loss of cross subsidies. High-risk firms which are no longer subsidized by low-risk firms under a risk-adjusted premium scheme have higher default rates. Under expected loss-pricing, the average portfolio losses increase further to €11.3 bn. The higher cyclicality of expected loss premiums eventually leads to higher default rates and thus to higher claims towards the PSVaG.

Premiums are the income account on the PSVaG's balance sheet. Under the current scheme, premium income has a mean of €10.7 bn and a standard deviation of €4.6 bn (Table 4, central subtable). Ex-ante pricing schemes exhibit a lower standard deviation, because premiums are set based on expected losses and external capital providers bear the risk of unexpected losses. If premiums are constant over time for individual firms, average premium income is €12.0 bn with a standard deviation of €0.8 bn.[24] With expected loss premiums, the PSVaG's income has a lower mean of €11.4 bn and a higher standard deviation of €2.5 bn. The average fair EL premiums have a lower average value, because EL premiums fluctuate with the financial cycle and do not expose the PSVaG to systematic risk. The most remarkable difference between the two fair pricing schemes becomes obvious when mean losses and premiums are compared: although constant premiums are on average higher, they still generate smaller average portfolio losses due to their lower cyclicality.

The net worth of the PSVaG, i.e. its terminal balance, is the difference between premiums and portfolio losses of the PSVaG. Both under the current premium scheme and under EL pricing

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[24] Even if the premium per company is constant over time, the premium income of the PSVaG still differs between the simulation runs, because different firms default. Therefore, the standard deviation of the PSVaG's premium income is greater than zero.

the average terminal balance is about zero (lower subtable of Table 4).[25] Under the constant pricing scheme the average terminal balance of €1.1 bn is significantly higher, because the equity holders are compensated for bearing market risk. The market risk component of premium schemes is shown in Table 5 by means of market risk regressions. For each premium scheme, the net terminal balance is regressed on the riskless rate and the stock market return over all simulation runs. As expected, the coefficients of both market variables are highly significant except for the cyclical EL premium scheme. The impact of stock market returns on the PSVaG's terminal balance thus becomes insignificant if the premium 'breathes' with the business cycle. For example, premiums increase in a recession. The PSVaG thus fully passes on the market risk to the insured companies.

The variation in the PSVaG's net worth is considerably higher under the ex-ante pricing schemes than under the current premium scheme. The reason is that if premiums are set ex-ante before losses occur, the PSVaG needs to bear all unexpected losses be they lower or higher than expected.

4.3 The impact of the institutional setup on the real economy

We measure the impact of the institutional setup of the PSVaG on the real economy in terms of gross domestic products (GDP). For this purpose, we compare the loss of GDP due to insolvencies under different premium schemes.

Each company in our dataset contributes to overall GDP by its value added. We capture all contributions to GDP from the financial statements and forecast them jointly with other financial ratios in the SUREG module (see Figure 1 and Appendix 3). For each premium scheme, we then compare the gross domestic product which is lost due to insolvencies.

The introduction of fair premiums would decrease annual GDP in comparison with the current premium scheme (see Figure 4 and Table 6). With constant premiums, the mean loss is

[25] For EL pricing, an average terminal balance of zero follows from its construction, because premiums are set equal to expected losses.

€0.18 bn, and it increases further to €0.34 bn with firm-specific EL premiums. In five percent of all simulations (5th percentile), the additional loss of annual GDP exceeds €0.6 bn for constant premiums and €1.0 bn for EL premiums. For both premium schemes, the distribution of the additional loss in GDP is positively skewed with a heavy right tail. Such a distribution implies a relatively high probability of both minor events and extremely adverse events.

A change from the current premium scheme to constant fair premiums would be characterized by the elimination of cross-subsidies.[26] Companies with a high default risk would, then, no longer be subsidized by companies with a low risk. The negative correlation between the size and the default risk of a company (see Table 3) illustrates that under the current premium scheme it is mainly bigger companies which subsidize smaller companies. The very high probability of a small increase of losses in GDP under a fair constant premium scheme is explained by smaller companies which would exhibit higher default rates. To the contrary, the relief provided to bigger companies would limit insolvencies only at very rare occasions.

If fair constant premiums were replaced by fair EL premiums, the mean losses in GDP would nearly double. This finding makes a strong case against cyclical premiums. While the owners of the PPS are indifferent between both premium schemes, the economic activity is more stable if premiums are stable, too.

5 Conclusion

Protection schemes have been established on a broad front over the past 200 years. Nevertheless, the institutional differences between existing protection schemes are not fully explored, neither regarding the rationale behind them, nor with respect to their effects on corporate activities. To fill this gap, we study Pension Protection Schemes (PPS) and their diverse institutional setup. In a first step, we explain why ownership, risk-sharing and premium schemes are theoretically linked. We show that ex-post premiums (pay-as-you-go)

[26] The current premium scheme already has a relatively low cyclicality; therefore, the introduction of a constant premium scheme would have a rather limited effect in this respect.

are more typical for mutual insurers which exhibit limited risk-sharing, whereas ex-ante premiums are more natural for stock insurers. In a second step, we assess the risk-profile of one of the biggest real-world PPS using an extensive set of granular corporate data and a micro-simulation risk model. We use the case of the German Pension Protection Scheme (Pensions-Sicherungs-Verein, PSVaG) to study these issues, because it is privately owned, has a sound track record and directly links corporates by insuring their insolvencies. We observe that, despite its private ownership, the PSVaG subsidizes high risk firms and exhibits high cluster risks. Its premiums are not fair, but, being less cyclical than expected loss premiums, they limit contagion. We propose a new premium scheme which is both fair and non-cyclical and therefore combines incentive compatibility with a positive effect on economic cycles.

Literature

Billio, M., M. Getmansky, A. W. Lo and L. Pelizzon (2012), Econometric Measures of Connectedness and Systemic Risk in the Finance and Insurance Sectors, *Journal of Financial Economics*, Vol. 104, No 3, pp. 535-559.

Black, F. and M. Scholes (1973), The Pricing of Options and Corporate Liabilities, *Journal of Political Economy*, Vol. 81, No 3, pp. 637-659.

Bodie, Z. (1996), What the Pension Benefit Guaranty Corporation Can Learn from the Federal Savings and Loan Insurance Corporation, *Journal of Financial Services Research*, Vol. 10, No 1, pp. 83-100.

Bodie, Z. (2006), On Asset-Liability Matching and Federal Deposit and Pension Insurance. *Federal Reserve Bank of St. Louis Review*, Vol. 88, No 4, pp. 323-329.

Bodie, Z. and R. C. Merton (1992), On the Management of Financial Guarantees, *Financial Management*, Vol. 21, No 4, pp. 87-109.

Boyce, S. and R. A. Ippolito (2002), The Cost of Pension Insurance, *Journal of Risk and Insurance*, Vol. 69, No 2, pp. 121-170.

Broeders, D. W. G. A. and A. Chen (2013), Pension Benefit Security: A Comparison of Solvency Requirements, a Pension Guarantee Fund, and Sponsor Support, *Journal of Risk and Insurance*, Vol. 80, No 2, pp. 239-272.

Brown, J. R. (2008), Guaranteed Trouble: The Economic Effects of the Pension Benefit Guaranty Corporation, *Journal of Economic Perspectives*, Vol. 22, No 1, pp. 177-198.

Buser, S. A., A. H. Chen and E. J. Kane (1981), Federal Deposit Insurance, Regulatory Policy, and Optimal Bank Capital, *Journal of Finance*, Vol. 36, No 1, pp. 51-60.

Chan, Y.-S. and K.-T. Mak (1985), Depositors' Welfare, Deposit Insurance, and Deregulation, *Journal of Finance*, Vol. 40, No 3, pp. 959-974.

Chan, Y.-S., S. I. Greenbaum and A. V. Thakor (1992), Is Fairly Priced Deposit Insurance Possible?, *Journal of Finance*, Vol. 47, No 1, pp. 227-245.

Chotibhak, J., A. Ellul, A. Kartasheva, C. Lundblad and W. Wagner (2018), Insurers as Asset Managers and Systemic Risk, *CEPR Discussion Paper No 12849*, April 2018.

Committee on Banks and Insurance Companies (1829), Report of the Committee on Banks and Insurance Companies made to the Assembly, Feb 13, 1829.

Crossley, T. and M. Jametti (2013), Pension Benefit Insurance and Pension Plan Portfolio Choice, *Review of Economics and Statistics*, Vol. 95, No 1, pp. 337-341.

Cummins, J. D. (1988), Risk-Based Premiums for Insurance Guaranty Funds, *Journal of Finance*, Vol. 43, No 4, pp. 823-839.

Cummins, J. D. and M. A. Weiss (2014), Systemic Risk and the US Insurance Sector, *Journal of Risk and Insurance*, Vol. 81, No 3, pp. 489-528.

Downs, D. H. and D. W. Sommer (1999), Monitoring, Ownership, and Risk-Taking: The Impact of Guaranty Funds, *Journal of Risk and Insurance*, Vol. 66, No 3, pp. 477-497.

Estrella, A., B. Hirtle and J. A. Brehm (1988), Estimating the Funding Gap of the Pension Benefit Guaranty Corporation, *Federal Reserve Bank of New York Quarterly Review Autumn*, pp. 45-59.

Gerke, W., F. Mager, T. Reinschmidt and C. Schmieder (2008), Empirical Risk Analysis of Pension Insurance: The Case of Germany, *Journal of Risk and Insurance*, Vol. 75, No 3, pp. 763-784.

Golembe, C. H. (1960), The Deposit Insurance Legislation of 1933: An Examination of Its Antecedents and Its Purposes, *Political Science Quarterly*, Vol. 75, No 2, pp. 181-200.

Hombert, J. and V. Lyonnet (2017), Intergenerational Risk Sharing in Life Insurance: Evidence from France, *HEC Research Papers Series No 1237*, Mai 2018.

Hsieh, S.-J., A. H. Chen and K. R. Ferris (1994), The Valuation of PBGC Insurance Premiums Using an Option Pricing Model, *Journal of Financial and Quantitative Analysis*, Vol. 29, No 1, pp. 89-99.

Koijen, R. and M. Yogo (2018), The Fragility of Market Risk Insurance, *NBER Working Paper No 24182*, January 2018.

Lee, S.-J., D. Mayers and C. W. Smith Jr. (1997), Guaranty Funds and Risk-Taking: Evidence from the Insurance Industry, *Journal of Financial Economics*, Vol. 44, No 1, pp. 3-24.

Lewis, C. M. and R. L. Cooperstein (1993), Estimating the Current Exposure of the Pension Benefit Guaranty Corporation to Single-Employer Pension Plan Terminations, in: R. Schmitt, ed., The Future of Pensions in the United States (Philadelphia: University of Pennsylvania Press of the Pension Research Council), pp. 247-276.

Lewis, C. M. and G. G. Pennacchi (1999), Valuing Insurance for Defined-Benefit Pension Plans, *Advances in Futures and Options Research*, Vol. 10, pp. 135-168.

Marcus, A. (1987), Corporate Pension Policy and the Value of PBGC Insurance, in: Z. Bodie, J. B. Shoven, and D. A. Wise, eds., Issues in Pension Economics (Chicago: University of Chicago Press).

McCarthy, D. and A. Neuberger (2005), The Pension Protection Fund, *Fiscal Studies*, Vol. 26, No 2, pp. 139–167.

Merton, R. C. (1977), An Analytical Derivation of the Cost of Deposit Insurance and Loan Guarantees, *Journal of Banking and Finance*, Vol. 1, pp. 3-11.

Mitchell, O. S. (2013), Technical Review Panel for the Pension Insurance Modeling System (PIMS): An Overview, *University of Michigan Retirement Research Center (MRRC) Working Paper No 290*, September 2013.

Niehaus, G. R. (1990), The PBGC's Flat Fee Schedule, Moral Hazard and Promised Pension Benefits, *Journal of Banking and Finance*, Vol. 14, pp. 55-68.

Pennacchi, G. G. (2006), Deposit Insurance, Bank Regulation, and Financial System Risks, *Journal of Monetary Economics*, Vol. 53, No 1, pp. 1-30.

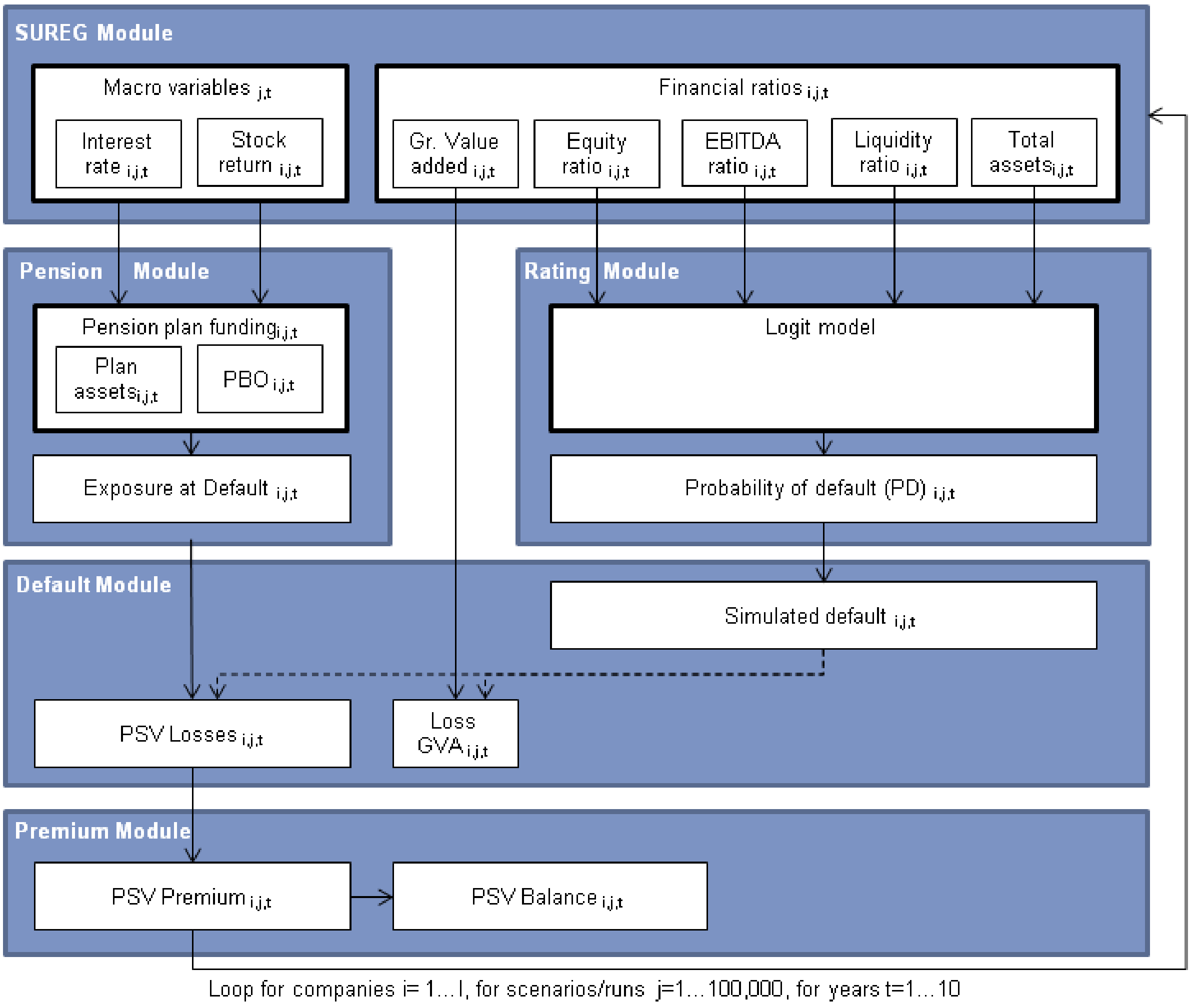
Pennacchi, G. G. and C. M. Lewis (1994), The Value of Pension Benefit Guaranty Corporation Insurance, *Journal of Money, Credit and Banking*, Vol. 26, No 3, pp. 735-753.

Stewart, F. (2007), Benefit Security Pension Fund Guarantee Schemes, *OECD Working Papers on Insurance and Private Pensions No 5*, January 2007.

Treynor, J. L. (1977), The Principles of Corporate Pension Finance, *Journal of Finance*, Vol. 32, No 2, pp. 627-638.

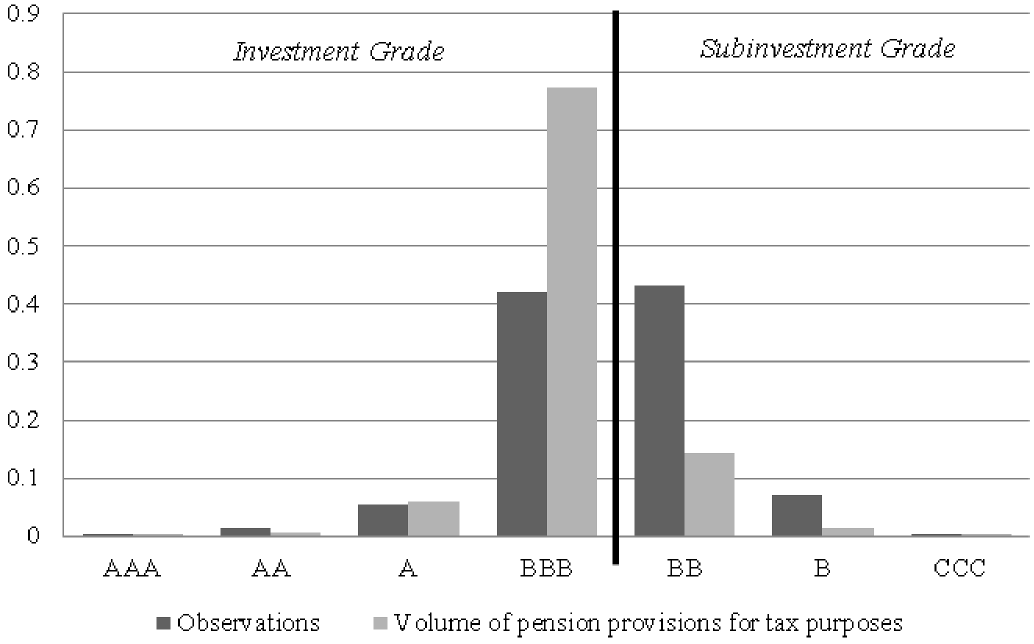
Figures

Figure 1: Flow chart of the simulation model



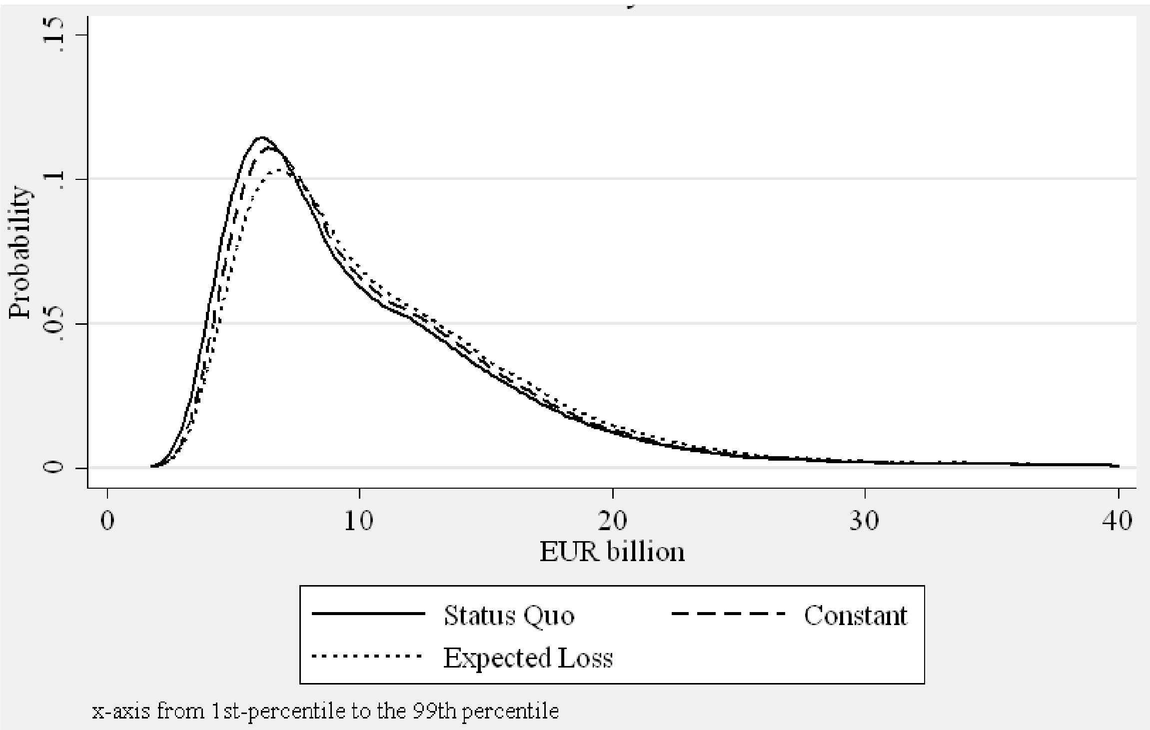
Notes. The flow chart describes the relation between the different modules in our simulation in one loop.

Figure 2: Portfolio structure of the PSVaG



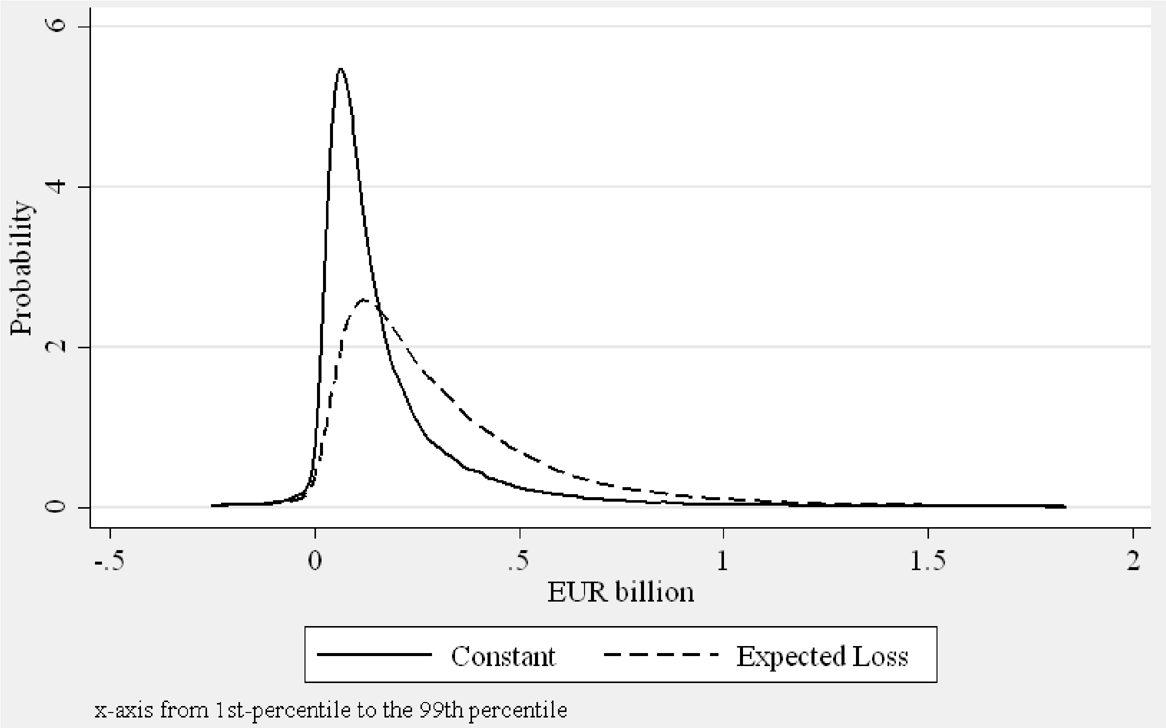
Notes. The figure shows the distribution of ratings in the PSVaG's portfolio non-weighted and exposure-weighted. Both distributions are own estimations.

Figure 3: Loss distribution function of the PSVaG



Notes. The figure shows the loss distribution function of the PSVaG over 10 simulated years as of 2016 for the current pricing scheme (Status Quo, SQ), a fair constant premium scheme (Constant) and a fair expected-loss premium scheme (EL).

Figure 4: Absolute change in loss of annual GDP due to insolvencies compared with the status quo



Notes. The figure shows the distribution of changes in annual GDP after 10 simulated years if the PSVaG's current premium scheme was changed to a fair constant premium scheme (Constant) or to a fair expected loss premium scheme (Expected Loss).

Tables

Table 1: Institutional differences between Pension Protection Schemes.

Country	Germany	United States	United Kingdom
Pension Protection Scheme	PSVaG - Pensions-Sicherungs-Verein auf Gegenseitigkeit	PBGC - Pension Benefit Guarantee Corporation	PPF - Pension Protection Fund
Occupational Pension System	Book Reserve & External Funding	External Funding	External Funding
Gross Exposure (in bn USD)	501	2,979	2,288
Net Exposure (in bn USD)	346	628	362
Ownership Structure	Private, mutual insurer	Public, stock insurer	Public, stock insurer
Premium Scheme	Ex-post	Ex-ante	Ex-ante
Contribution Base	Occurred losses	Loss given default (plan underfunding), number of participants	Expected losses (probability of default and level of plan underfunding)

Notes. The table reports for Germany, the United Kingdom and the United States of America the name of the national *Pension Protection Scheme*, a classification of the *occupational pension system*, the *gross exposure* of the PPS as measured by the covered pension obligations, its *net exposure* as measured by the covered pension obligations less pension assets, its *ownership structure*, *premium scheme* and *contribution base*. The PPS' gross and net exposure at book values are our own estimations at the end of 2015 based on data from PBGC, PPF, PSVaG.

Table 2: The interrelation of ownership, risk pricing and risk sharing.

		Ownership structure	
		Mutual insurer	**Stock insurer**
Premium schemes	Single-period	ex-post	ex-ante or ex-post
	Multi-period	ex-ante or ex-post	
Risk sharing	Cross-section (within one period)	Only within the collective	Within the collective and external equity holders
	Intertemporal (over multiple periods)	Buffers (equity/debt)	

Notes. The table reports for two types of ownership structures (*mutual insurer* and *stock insurer*) which *premiums schemes* and which *risk sharing* models can be implemented if the insurer exists for a single period or more periods.

Table 3: Rating model

Variable	Coef.		Std. Err.	*P>z*
Equity / assets	-2.118	***	0.073	*0.000*
EBTDA / assets	-4.676	***	0.129	*0.000*
Liquidity / assets	-3.012	***	0.229	*0.000*
Log assets	-0.168	***	0.011	*0.000*
Trade	-0.414	***	0.039	*0.000*
Other	-0.817	***	0.117	*0.000*
Constant	-2.149	***	0.097	*0.000*

Notes. The rating model is estimated using a logistic regression. The underlying dataset contains 124,078 financial statements of privately owned firms from 1994 to 2009. The insolvency dummy is set in 718 cases for the last financial statement 1y to 2.5y before bankruptcy. The estimation is weighted according to historical portfolio losses of the PSVaG.

***, **, and * indicate statistical significance at the 1%, 5% and 10% levels.

Table 4: Simulation results

Losses	mean	sd	min	p1	p5	p10	p25	p50	p75	p90	p95	p99	max
Status Quo	10.6	6.4	1.8	3.4	4.3	4.9	6.2	8.8	13.2	18.1	22.1	36.1	72.5
Constant	10.9	6.4	1.9	3.6	4.5	5.1	6.6	9.2	13.5	18.4	22.4	36.2	72.5
Expected Loss	11.3	6.5	1.8	3.6	4.6	5.3	6.9	9.6	14.0	19.0	23.2	36.8	73.0

Premiums	mean	sd	min	p1	p5	p10	p25	p50	p75	p90	p95	p99	max
Status Quo	10.7	4.6	3.8	5.9	6.7	7.2	8.1	9.4	11.7	15.6	18.9	31.2	65.1
Constant	12.0	0.8	9.1	10.4	10.8	11.1	11.5	12.0	12.5	13.0	13.3	14.0	15.3
Expected Loss	11.4	2.5	5.2	6.9	7.9	8.5	9.6	11.1	12.7	14.5	15.7	18.6	52.0

Net worth	mean	sd	min	p1	p5	p10	p25	p50	p75	p90	p95	p99	max
Status Quo	0.1	2.7	-37.8	-9.0	-4.3	-2.8	-1.3	0.5	2.3	2.8	2.9	3.1	3.7
Constant	1.1	6.7	-62.4	-24.7	-11.1	-6.9	-1.8	2.8	5.7	7.4	8.3	9.7	12.8
Expected Loss	0.0	6.3	-60.1	-25.3	-10.9	-7.1	-2.6	1.6	4.1	5.7	6.7	8.5	19.4

Notes. The three subtables show the mean, the standard deviation (SD), the minimum, the first, 5th, 25th, 50th, 75th, 95th and 99th percentile and the maximum of the distribution of portfolio losses, premiums and the terminal balance of aggregate losses, premiums and terminal balances of the Pensions-Sicherungs-Verein (PSVaG) under different pricing schemes. The percentiles of the portfolio losses can be read as the Value at Risk (VaR) at the respective levels. The analysis covers the current pricing scheme (status quo), Expected Loss (EL) pricing and a fair constant premium.

Table 5: Market risk regressions

	Status Quo		Constant		Expected Loss
Riskless rate	11.262	***	22.210	***	0.088
Equity return	0.229	***	0.478	***	-0.029
Constant	-1.764	***	-2.617	***	0.003
N	100000		100000		100000
R2	0.22		0.14		0.00

Notes. The regression table shows determinants of the terminal balance of the PSVaG under different premium schemes. The dependent variable is the net terminal balance of the PSVaG under different premium schemes. The analysis covers the current pricing scheme (status quo), fair time-constant premiums based on the Capital Asset Pricing Model (Constant) and Expected Loss (EL) pricing. The regressors are the riskless rate and the simulated return of the Eurostoxx over each full simulation period of ten years.

***, **, and * indicate statistical significance at the 1%, 5% and 10% levels.

Table 6: The impact of fair premiums on portfolio losses and on loss of annual GDP

			Change in Portfolio Losses										
Pricing scheme	mean	sd	min	p1	p5	p10	p25	p50	p75	p90	p95	p99	max
Constant	0.3	0.7	-25.3	0.0	0.1	0.1	0.1	0.2	0.3	0.6	0.8	4.1	14.2
Expected Loss	0.8	1.2	-24.3	0.0	0.1	0.1	0.2	0.5	0.9	1.4	2.0	6.8	25.1

			Change in Loss of GDP										
Pricing scheme	mean	sd	min	p1	p5	p10	p25	p50	p75	p90	p95	p99	max
Constant	0.2	1.0	-122.2	-0.3	0.0	0.0	0.1	0.1	0.2	0.4	0.6	1.8	19.3
Expected Loss	0.3	1.1	-122.1	-0.3	0.0	0.1	0.1	0.2	0.4	0.7	1.0	2.4	138.7

Notes. The three subtables show the mean, the standard deviation (SD), the minimum, the first, 5th, 25th, 50th, 75th, 95th and 99th percentile and the maximum of the PSVaG's losses and of loss in GDP under different pricing schemes compared to the current pricing scheme. The analysis covers the current pricing scheme (Status Quo), fair constant premiums (Constant), and a fair expected loss premium scheme (Expected Loss).

Table 7: Datasets upon which the risk model is based.

Data	Source	Time	Observations	
Financial statements	Financial Statements Data Pool (FSDP), Deutsche Bundesbank	1971-2009	Raw Clean	840,945 712,649
Financial statements	DAFNE database, BvD	1994-2015	Raw Clean	215,017 168,186
Pension plans	Own survey	2010-2015		1,066
Corporate networks	DAFNE database, BvD	2005-2015	Subsidiaries	4,780
State-ownership	Own survey	2011-2015	State-owned firms	3,468
Corporate defaults	Own survey	1994-2009	Insolvent firms	1,139

Notes. The table presents the panel datasets which have been combined in order to build the risk model of the PSVaG. The columns present the datasets, their sources, the covered period of time and the observations. For the two sets of data on financial statements, the upper row shows the number of firm-year-observations in the original dataset and the lower row show the number of firms which are either classified as a subsidiary, state-owned or insolvent in at least one year.

Table 8: SUREG

Variable	Lagged coefficient		Constant		RMSE	R^2
Yield	0.935	***	0.003	***	0.007	0.789
Stock returns	0.027	***	0.045	***	0.248	0.000
Value added growth	-0.075	***	0.019	***	0.188	0.011
Equity ratio	0.972	***	0.008	***	0.062	0.880
EBTDA ratio	0.822	***	0.019	***	0.069	0.623
Liquidity ratio	0.803	***	0.012	***	0.052	0.630
Asset growth	0.017	***	0.028	***	0.116	0.001

Notes. The table presents the coefficients, the root-mean-square error (RMSE) and the R-squared of seemingly unrelated regressions (SUREG) of first order autoregressive processes of the following variables: the annual log-yield on German government bonds with a residual maturity of ten years *(yield)*, the annual log-return on the FAZ100 stock market index *(stock return)*, the firm-specific log-growth of value added *(value added growth)*, equity per total assets *(equity ratio)*, EBTDA per total assets *(EBTDA ratio)*, the liquid assets per liabilities *(liquidity ratio)* and the log-growth of total assets *(asset growth)*.

***, **, and * indicate statistical significance at the 1%, 5% and 10% levels.

Table 9: Cross correlation of the disturbance terms

	Yield	Stock return	Value added growth	Equity ratio	EBTDA ratio	Liquidity ratio	Asset growth
Yield	1.000						
Stock return	0.410	1.000					
Value added growth	0.131	0.088	1.000				
Equity ratio	-0.027	-0.037	0.151	1.000			
EBTDA ratio	0.080	0.061	0.627	0.294	1.000		
Liquidity ratio	-0.024	-0.028	0.066	0.080	0.123	1.000	
Asset growth	0.124	0.087	0.238	-0.185	0.005	0.087	1.000

Notes. The table presents the cross correlations between the disturbance terms from the seemingly unrelated regressions of the following variables: the annual log-yield on German government bonds with a residual maturity of ten years *(yield)*, the annual log-return on the FAZ100 stock market index *(stock return)*, the firm-specific log-growth of value added *(value added growth)*, equity per total assets *(equity ratio)*, EBTDA per total assets *(EBTDA ratio)*, the liquid assets per liabilities *(liquidity ratio)* and the log-growth of total assets *(asset growth)*.

***, **, and * indicate statistical significance at the 1%, 5% and 10% levels.

Appendix 1: Premium schemes

The Capital Asset Pricing Model (CAPM) can be used to derive a fair constant premium scheme of a PPS. The CAPM states that in the capital market equilibrium the expected return $E\left(\tilde{r}_{t,t+s}^{i}\right)$ of a security depends solely on its systematic risk and on the riskless interest rate. It follows that

$$E\left(\tilde{r}_{t,t+s}^{i}\right) = r_{t,t+s}^{f} + \underbrace{\left(E\left(\tilde{r}_{t,t+s}^{M}\right) - r_{t,t+s}^{f}\right)}_{\widetilde{MRP}_{t,t+s}} \cdot \underbrace{\frac{Cov\left(\tilde{r}_{t,t+s}^{i}, \tilde{r}_{t,t+s}^{M}\right)}{Var\left(\tilde{r}_{t,t+s}^{M}\right)}}_{\tilde{\beta}_{t,t+s}^{i}},$$

where $r_{t,t+s}^{f}$ is the riskless interest rate, $\widetilde{MRP}_{t,t+s} = \left(E\left(\tilde{r}_{t,t+s}^{M}\right) - r_{t,t+s}^{f}\right)$ denotes the market risk premium, i.e. the additional expected return of the market portfolio $E\left(\tilde{r}_{t,t+s}^{M}\right)$ compared to the riskless interest rate $r_{t,t+s}^{f}$, and $\tilde{\beta}_{t,t+s}^{i} = \frac{Cov\left(\tilde{r}_{t,t+s}^{i}, \tilde{r}_{t,t+s}^{M}\right)}{Var\left(\tilde{r}_{t,t+s}^{M}\right)}$ measures the systematic risk of the security. Hence, the expected return of an investment $E\left(\tilde{r}_{t,t+s}^{i}\right)$ will be higher (lower) than the riskless interest rate if its return $\tilde{r}_{t,t+s}^{i}$ is positively (negatively) correlated to the returns $\tilde{r}_{t,t+s}^{M}$ of the well diversified market portfolio ($\tilde{\beta}_{t,t+s}^{i} < 0$). To put it differently, the price of a risky asset depends on the systematic risk of its future cash flows.

The CAPM states that investors will pay a lower (higher) price for assets which expose them to more (less) systematic risk. In the case of a PPS, the return $\tilde{r}_{t,t+s}^{i}$ of the protected persons of a firm i relates claims $\tilde{C}_{t,t+s}^{i}$ against the PPS[27] to the price of pension protection $P_{t,t+s}^{i}$

$$\tilde{r}_{t,t+s}^{i} = \frac{\tilde{C}_{t,t+s}^{i}}{P_{t,t+s}^{i}} - 1$$

The return of the protected person is positive in case of a corporate bankruptcy when a claim against the PPS arises which is typically greater than the PPS premium ($\tilde{C}_{t,t+s}^{i} > P_{t,t+s}^{i}$). The

[27] These claims mirror the losses $\tilde{L}_{t,t+s}^{i}$ with reversed sign. For example, if a firm i goes bankrupt, its employees would lose parts of their occupational pension in the absence of PPS. We analyze the resulting claim $\tilde{C}_{t,t+s}^{i} = \left(-\tilde{L}_{t,t+s}^{i}\right)$ of the employees against the PPS.

return is minus one if no insured event occurs. In this case the PPS receives a premium from the employees or their firm ($P^i_{t,t+s} > 0$) without a resulting claim ($\tilde{C}^i_{t,t+s} = 0$).[28]

Claims $\tilde{C}^i_{t,t+s}$ against the PPS are typically negatively correlated with market returns $\tilde{r}^M_{t,t+s}$. The reason is that in economic downturns the financial condition of the corporate sector worsens. There will be both low market returns and a higher number of insolvencies which induce higher claims against the PPS.

The firm-specific premium $P^i_{t,t+s}$ of the PPS determines whether this positive correlation between *claims* $\tilde{C}^i_{t,t+s}$ against the PPS and market returns translate into a positive correlation between PPS *returns* $\tilde{r}^i_{t,t+s}$ and market returns. We will consider three different cases: a pay-as-you-go premium scheme, constant premiums and time varying expected loss pricing.

First case: Pay-as-you-go

Under a pay-as-you-go system, the PPS always adjusts its aggregated premium $P_{t,t+s}$ ex-post to the claims which have arisen in the according period $C_{t,t+s}$, i.e.

$P_{t,t+s} = \sum_i P^i_{t,t+s} = \sum_i \tilde{C}^i_{t,t+s} = C_{t,t+s}$.

At least on an aggregate level it thus holds that

$$r^i_{t,t+s} = \frac{C_{t,t+s}}{P_{t,t+s}} - 1 = 0$$

and consequently the beta factor $\tilde{\beta}^i_{t,t+s}$ in the CAPM equation yields

$$\tilde{\beta}^i_{t,t+s} = \frac{Cov\left(\tilde{r}^i_{t,t+s},\ \tilde{r}^M_{t,t+s}\right)}{Var\left(\tilde{r}^M_{t,t+s}\right)} = \frac{Cov\left(0,\ \tilde{r}^M_{t,t+s}\right)}{Var\left(\tilde{r}^M_{t,t+s}\right)} = \frac{0}{Var\left(\tilde{r}^M_{t,t+s}\right)} = 0$$

This result shows that a PPS with a pay-as-you-go premium scheme does not bear any market risk on the aggregate level, because its premiums are cyclical themselves. In an economic

28 We assume that all wages are set to the marginal benefit of labor. Therefore, an employee's productivity always has to cover both its wage and non-wage labor cost. Consequently, it is irrelevant whether the employer or the employee pays the PPS premium (and the employee receives a lower nominal wage) or the employee pays the PPS premium (and negotiates are higher nominal wage).

downturn the premiums will be higher than in an upswing. Consequently, the fair price of protection does not contain an additional market risk premium.

Second case: Expected-Loss-Pricing

Under an EL pricing scheme, the *expected* loss from every single insured employer equals the firm-specific premium payments

$$P_{t,t+s} = \sum_i P^i_{t,t+s} = E\left(\sum_i \tilde{C}^i_{t,t+s}\right) = E\left(\tilde{C}_{t,t+s}\right)$$

Inserting this into the CAPM equation yields

$$E\left(\tilde{r}^i_{t,t+s}\right) = r^f_{t,t+s} + \left(E\left(\tilde{r}^M_{t,t+s}\right) - r^f_{t,t+s}\right) \frac{Cov\left(\frac{\tilde{C}^i_{t,t+s}}{P^i_{t,t+s}} - 1\,, \tilde{r}^M_{t,t+s}\right)}{Var\left(\tilde{r}^M_{t,t+s}\right)}$$

$$= r^f_{t,t+s} + \left(E\left(\tilde{r}^M_{t,t+s}\right) - r^f_{t,t+s}\right) \frac{E\left(\left(\frac{\tilde{C}^i_{t,t+s}}{E\left(\tilde{C}^i_{t,t+s}\right)} - 1\right) \tilde{r}^M_{t,t+s}\right) - E\left(\frac{\tilde{C}^i_{t,t+s}}{E\left(\tilde{C}^i_{t,t+s}\right)} - 1\right) E\left(\tilde{r}^M_{t,t+s}\right)}{Var\left(\tilde{r}^M_{t,t+s}\right)}$$

The premium fully captures market risk if

$$\frac{E\left(\left(\frac{\tilde{C}^i_{t,t+s}}{E\left(\tilde{C}^i_{t,t+s}\right)} - 1\right) \tilde{r}^M_{t,t+s}\right) - E\left(\frac{\tilde{C}^i_{t,t+s}}{E\left(\tilde{C}^i_{t,t+s}\right)} - 1\right) E\left(\tilde{r}^M_{t,t+s}\right)}{Var\left(\tilde{r}^M_{t,t+s}\right)} = 0$$

and, consequently,

$$E\left(\left(\frac{\tilde{C}^i_{t,t+s}}{E\left(\tilde{C}^i_{t,t+s}\right)} - 1\right) \tilde{r}^M_{t,t+s}\right) = E\left(\frac{\tilde{C}^i_{t,t+s}}{E\left(\tilde{C}^i_{t,t+s}\right)} - 1\right) E\left(\tilde{r}^M_{t,t+s}\right)$$

holds. That is the case if the variables $\frac{\tilde{C}^i_{t,t+s}}{E(\tilde{C}^i_{t,t+s})}$ and $\tilde{r}^M_{t,t+s}$ are independent. Whether this condition is fulfilled in a practical context is ultimately an empirical question. At least approximately, EL premiums fluctuate with the financial cycle. They offload market risk to the protection buyer without containing an explicit market risk premium.

Third case: Constant premiums

According to the Capital Asset Pricing Model (CAPM), the expected return $E\left(\tilde{r}_{t,t+s}^{i}\right)$ of a security depends solely on its systematic risk and on the riskless interest rate

$$E\left(\tilde{r}_{t,t+s}^{i}\right) = r_{t,t+s}^{f} + \underbrace{\left(E\left(\tilde{r}_{t,t+s}^{M}\right) - r_{t,t+s}^{f}\right)}_{\widetilde{MRP}_{t,t+s}} \cdot \underbrace{\frac{Cov\left(\tilde{r}_{t,t+s}^{i}, \tilde{r}_{t,t+s}^{M}\right)}{Var\left(\tilde{r}_{t,t+s}^{M}\right)}}_{\tilde{\beta}_{t,t+s}^{i}}.$$

If the PPS charges a premium which is constant over time, the return of the protection buyer $\tilde{r}_{t,t+s}^{i}$ can be decomposed into the uncertain claim $\tilde{C}_{t,t+s}^{i}$ against the PPS and the certain PPS premium $P_{t,t+s}^{i}$

$$E\left(\tilde{r}_{t,t+s}^{i}\right) = E\left(\frac{\tilde{C}_{t,t+s}^{i}}{P_{t,t+s}^{i}} - 1\right) = \frac{E\left(\tilde{C}_{t,t+s}^{i}\right)}{P_{t,t+s}^{i}} - 1$$

Extracting the premium both from the expected return and the beta yield in the CAPM equilibrium yields

$$\frac{E\left(\tilde{C}_{t,t+s}^{i}\right)}{P_{t,t+s}^{i}} - 1 = r_{t,t+s}^{f} + \left(E\left(\tilde{r}_{t,t+s}^{M}\right) - r_{t,t+s}^{f}\right) \frac{Cov\left(\tilde{r}_{t,t+s}^{i}, \tilde{r}_{t,t+s}^{M}\right)}{Var\left(\tilde{r}_{t,t+s}^{M}\right)}$$

$$= r_{t,t+s}^{f} + \left(E\left(\tilde{r}_{t,t+s}^{M}\right) - r_{t,t+s}^{f}\right) \frac{Cov\left(\frac{\tilde{C}_{t,t+s}^{i}}{P_{t,t+s}^{i}} - 1, \tilde{r}_{t,t+s}^{M}\right)}{Var\left(\tilde{r}_{t,t+s}^{M}\right)}$$

$$= r_{t,t+s}^{f} + \left(E\left(\tilde{r}_{t,t+s}^{M}\right) - r_{t,t+s}^{f}\right) \frac{\frac{1}{P_{t,t+s}^{i}} Cov\left(\tilde{C}_{t,t+s}^{i}, \tilde{r}_{t,t+s}^{M}\right)}{Var\left(\tilde{r}_{t,t+s}^{M}\right)}$$

and multiplication of both sides with P and rearrangement gives

$$P_{t,t+s}^{i} = \frac{E\left(\tilde{C}_{t,t+s}^{i}\right) - \left(E\left(\tilde{r}_{t,t+s}^{M}\right) - r_{t,t+s}^{f}\right) \frac{Cov\left(\tilde{C}_{t,t+s}^{i}, \tilde{r}_{t,t+s}^{M}\right)}{Var\left(\tilde{r}_{t,t+s}^{M}\right)}}{\left(1 + r_{t,t+s}^{f}\right)}$$

The fair price of the PPS can thus be derived using (i) the riskless market rate and the market risk premium which are known at inception of the contract and (ii) the relationship between market returns and losses of the PPS which can be derived from our simulation. The equation states that the fair premium is higher than the discounted expected loss if

$$\left(E\left(\tilde{r}^{M}_{t,t+s}\right) - r^{f}_{t,t+s}\right) \frac{Cov\left(\tilde{C}^{i}_{t,t+s}, \tilde{r}^{M}_{t,t+s}\right)}{Var\left(\tilde{r}^{M}_{t,t+s}\right)} < 0$$

holds. As we expect the market risk premium to be positive $\left(E\left(\tilde{r}^{M}_{t,t+s}\right) - r^{f}_{t,t+s}\right) > 0$, this will only occur if the covariance between the payments of the insurer and market returns is negative, and that is a plausible prior for PPS.

All necessary inputs are derived iteratively in our simulation. Given a certain premium scheme, the expected value of claims $E\left(\tilde{C}^{i}_{t,t+s}\right)$, the covariance between claims and the market return over the simulation horizon $Cov\left(\tilde{C}^{i}_{t,t+s}, \tilde{r}^{M}_{t,t+s}\right)$ and the variance of market returns $Var\left(\tilde{r}^{M}_{t,t+s}\right)$ can be estimated based on the simulated claims $\tilde{C}^{i}_{t,t+s}$ and market returns $\tilde{r}^{M}_{t,t+s}$. Based on these inputs, a constant premium $P^{i}_{t,t+s}$ can be calculated. Running the simulation again with these premiums gives different estimates of which are used to recalculate the constant premiums $P^{i}_{t,t+s}$. This procedure is repeated until the constant premiums have converged against their equilibrium value.[29]

[29] The premiums have to consider the average duration of firms in the sample. For example, a firm with an annual PD of 5% will survive the next five years with a probability of $(1-0.05)^5 = 77.4\%$, and it will survive the full simulation period of ten years with a probability of $(1-0.05)^{10} = 59.9\%$. The premiums have to reflect this. In our iterative pricing process, we only store the accrued losses of each firm at the end of each simulation run. From the output of each firm over all runs, we derive the empirical survival rate SR_{10} over 10 years as "no of runs without a default / runs". The one-year survival rate SR_1 is calculated as $\mathrm{SR}_1 = (\mathrm{SR}_{10})^{1/10}$. The sum formula for geometric series then gives the constant premium as $(\text{Average loss})^{-1}\ (\mathrm{SR}_1^{10} - 1)\ (\mathrm{SR}_1 - 1)^{-1}$.

Appendix 2: Data

We use the Financial Statements Data Pool (FSDP) of Deutsche Bundesbank to calibrate the simulations. This panel dataset covers the universe of German corporates from 1971 to 2009 over several financial and political shocks and over several business cycles. It incorporates more than 2.3 million financial statements, of which more than 840,000 (about 20,000 per year) contain pension obligations (cf. Table 7).[30] From the foundation of the PSVaG in 1974 until 2009, the FSDP covers, on average, 73% of the gross exposure of the PSVaG annually. We consider the FSDP as the best source of high-quality data on financial statements of German companies before 2005, and therefore we use it to calibrate our simulations.[31]

As of 2005, German corporations and big private firms are obliged by law to make their financial statement freely available in a standardized form in the German Electronic Federal Gazette (*elektronischer Bundesanzeiger*). This regulatory change has boosted the quantity and quality of financial statements provided by private data providers which gather high-quality data from this standardized source. We consider the DAFNE dataset of Bureau van Dijk (BvD) as the best source of high-quality data on financial statements of German companies as of 2005, and therefore we use it as the basis for our rating module and our simulation, i.e. the financial statements which are projected into the future stem from this source. The DAFNE dataset covers a wide cross section of German corporates and business combinations at least since 2005. It contains about 60,000 financial statements per year, of which about 15,000 per year contain pension provisions. From 2005 to 2015, the DAFNE dataset covers 83.3% of the

30 The financial statements contained in the Bundesbank Financial Statements Data Pool are anonymized. Therefore, we build our risk model upon the amended DAFNE dataset and use the Bundesbank Financial Statements Data Pool to calibrate the risk model only.

31 From the 1970s to the early 2000s, most financial statements in the FSDP were collected by the Deutsche Bundesbank itself in the bill-rediscount business. The Deutsche Bundesbank could purchase commercial bills from other banks at the discount rate if three solvent companies guaranteed the payment. It checked the solvency of the drawer by asking for the latest balance sheet, which was then incorporated into the so-called USTAN database. Although this business ended in 1997, many German firms, especially bigger firms, continued to submit their financial statements to the Deutsche Bundesbank.

gross exposure of the PSVaG in an average year. As the coverage improves over time, the simulation considers companies which make up 90% of the contribution basis.[32]

The DAFNE dataset includes firm names and it can thus be complemented by our own data. We conducted extensive surveys in order to make the simulations as realistic as possible:

(i) our survey of pension plans disentangles domestic and foreign pension plans, direct and indirect commitments, the composition of plan assets, and the modified duration of plan assets and pension obligations. These data allow us to assess the exposure of the PSVaG, which protects only certain parts of German pension plans, under different macroeconomic scenarios. They are also necessary to make corporate financial data comparable, irrespective of whether these have been prepared pursuant to IFRS or to the German Commercial Code (HGB).[33]

(ii) data on corporate networks allow mitigating a double counting of corporate groups as a whole and the contained parent companies and their subsidiaries. This correction is essential for gauging cluster risks appropriately.[34]

(iii) data on defaults are used to estimate corporate probabilities of default (PDs).

All data are thoroughly checked and revised. Institutions for which our simulation is unsuitable, i.e. municipalities, financial institutions (except holding companies) and property developers are removed, and duplicates in the firm identifiers are revised.[35] Incomplete or

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32 Whereas financial statements until 2010 are used to estimate the rating model, only the latest available data of firms and business combinations between 2014 and 2015 constitute the basis for the simulations.

33 For the remaining companies, the pension plans are assessed using the non-consolidated financial statements according to the German Commercial Code (HGB). According to the HGB, pension benefit obligations are reported at a fixed discount rate and without netting pension liabilities and assets until 2009. Since then, net pension obligations have been reported at certain smoothed market rates. This structural break is used to disentangle the pension benefit obligations and the plan assets using one single accounting variable in the DAFNE panel dataset.

34 In many cases, these data also helped to improve our survey on pension plans. For example, the domestic part of group plans can be estimated or at least be crosschecked using the unconsolidated financial statement data of German companies within corporate groups.

35 Most duplicates in firm identifiers result from mergers, acquisitions and liquidations. In most of these cases, corporations or corporate groups were given a new identifier. In some exceptional cases, group financial statements are assigned to different companies within the corporate group. The most important example is the Volkswagen Group which was consolidated in Porsche’s group financial statement of 2009 during a failed takeover. We correct such double counting using data on corporate networks.

inaccurate financial statements are excluded or, where possible, corrected.[36] These revisions affect only a minority of financial statements, which illustrates the high quality of both datasets.

36 Financial institutions (except holding companies) and property developers are eliminated because our simulation method seems unsuited to addressing specific characteristics of the business model in these industries. Financial statements are removed from the dataset if current assets, fixed assets, personnel costs, amortization and depreciation or the operational result are missing or do not meet plausibility checks. For these financial data our rating model would assign a wrong probability of default or none at all.

Appendix 3: Data SUREG module of the risk model

We assess the risk profile of the PSVaG using a microsimulation risk model (see Subsection 3.2). It bases on the Pension Insurance Modeling System (PIMS) which is presented in detail in *Boyce and Ippolito (2002)*.

This appendix presents the SUREG-module of our risk model in detail. It builds upon firm-specific financial ratios which are jointly forecasted with macroeconomic variables on a year-by-year basis in each run. It is assumed that all variables follow AR(1)-processes. The dynamics of the simulation and the interrelation between the financial ratios and the macroeconomic variables result from the disturbance terms being drawn from their joint historical distribution.

The coefficients are estimated in seemingly unrelated regressions (SUREG) on the basis of the Bundesbank Financial Statements Data Pool (cf. Table 8). The persistence of the processes differs significantly. For example, the yield on Bunds with a residual maturity of ten years is highly persistent with a steady state of 4.1%.[37] By contrast, the growth of the FAZ100 equity index is close to a martingale process with a steady state of 4.6%. Most financial ratios are also highly persistent.

The simulation draws error terms from a multidimensional normal distribution function based on their historical values. For this purpose, we use the covariance matrix of the error terms from the SUREG-regressions (cf. Table 9). This covariance matrix is decomposed into a first covariance matrix of the error terms of macroeconomic variables and the *average* financial ratios and into a second covariance matrix of the firm-specific (or idiosyncratic) error terms of the financial ratios. The joint developments in the macroeconomic scenarios are simulated on the basis of the first covariance matrix, while the second covariance matrix is used to simulate the company-specific error terms in each run.

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[37] The steady state of an AR(1)-process with a constant of the form $y_{t+1} = \alpha + \beta y_t + \varepsilon_{t+1}$ can be estimated by setting the disturbance term to zero and $y_{steady} \equiv y_{t+1} \equiv y_t$. For the steady state we obtain $y_{steady} = \frac{\alpha}{(1-\beta)}$.