ICIR Working Paper Series No. 12/12

Edited by Helmut Gründl and Manfred Wandt

The Risk-Shifting Behavior of Insurers under Different Guarantee Schemes*

Ming Dong, Helmut Gründl, Sebastian Schlütter**

February 16, 2013

Abstract

Insurance guarantee schemes aim to protect policyholders from the costs of insurer insolvencies. However, guarantee schemes can also reduce insurers' incentives to conduct appropriate risk management. We investigate stock insurers' risk-shifting behavior for insurance guarantee schemes under the two different financing alternatives: a flat-rate premium assessment versus a risk-based premium assessment. We identify which guarantee scheme maximizes policyholders' welfare, measured by their expected utility. We find that the risk-based insurance guarantee scheme can only mitigate the insurer's risk-shifting behavior if a substantial premium loading is present. Furthermore, the risk-based guarantee scheme is superior for improving policyholders' welfare compared to the flat-rate scheme when the mitigating effect occurs.

Keywords: Insurance guarantee schemes, risk-shifting, consumer protection

*Earlier versions of this paper were presented at the 39th Seminar of the European Group of Risk and Insurance Economists (EGRIE) 2012 and at the Annual Congress of the German Insurance Science Association 2012.

**The authors are with the International Center for Insurance Regulation, Goethe University, Frankfurt am Main, Germany. Contact author: Ming Dong, Email: dong@finance.uni-frankfurt.de.

1 Introduction

Insurance guarantee schemes (IGSs) have been adopted throughout the world.[1] They are important implements for consumer protection, despite the existence of other solvency regulatory tools. This is due to the fact that no matter how solvency regulation and supervision attempt to reduce the default risk of insurance undertakings, it is not possible to eliminate altogether the possibility of failures. Furthermore, policyholders face high costs for diversifying insurers' default risk.[2] By pooling the default risks of several insurance companies in the market, IGSs lower the costs of the insolvency risk to which policyholders are exposed. Besides the risk pooling function, IGSs can—depending on their premium principle—significantly influence the behavior of insurance companies. Flat-rate IGS premiums charge a fixed percentage of insurers' premium income and thus do not reflect the insurers' risk-taking.[3] In contrast, a risk-based IGS is based on the insurer's risk profile, and insurers are therefore punished for taking high risks. The literature has discussed the pricing of risk-based IGSs, their impact on the insurers' risk situation, the possible wealth transfer among stakeholders, and the question of to what extent IGSs are beneficial to policyholders.[4] However, it is not yet clear how a risk-based scheme influences insurers' risk-taking, and consequently policyholders' welfare, compared to a flat-rate scheme.

In corporate finance theory, the risk-shifting problem denotes the phenomenon of firms transferring welfare from bondholders to shareholders by increasing the firm risk after bonds have been issued.[5] As long as the shareholders cannot commit to a low-risk strategy, this may lead to a situation that is disadvantageous for bondholders as well as for shareholders. This agency-theoretic setting obviously maps the shareholder-policyholder conflict for a stock insurance company as well.[6] The risk-shifting behavior of a stock insurer can be captured, for example, by a change towards a riskier investment portfolio[7], a riskier reinsurance strategy[8] or a reduced capital endowment[9]. Without loss of generality, risk-shifting in the sense of an altered investment strategy is the principal focus of this article.

Risk-shifting through a change of the investment strategy has recently been discussed in a theoretical format by Filipovic et al. (2011), who determine insurers' optimal investment and premium policies. Our contribution includes IGSs and investigates in a theoretical

---

[1] See Oxera (2007, pp. 5-12, 93-96).
[2] See Merton (1997, p. 2).
[3] See Cummins (1988, p. 823).
[4] A more comprehensive overview is provided in Section 2.
[5] See, for example, Jensen and Meckling (1976), Green (1984) and MacMinn (1993).
[6] See, for example, Mayers and Smith (1981, pp. 425-426).
[7] See, for example, the empirical studies by Lee et al. (1997), Downs and Sommer (1999).
[8] See Cummins (1988, p. 824).
[9] See Schmeiser and Wagner (2010).

model how different IGS premium principles affect an insurer's risk-shifting incentive, captured by the change of the investment policy. We analyze the insurer's risk-shifting behavior in the absence of any regulatory constraints on the investment policy, in which case we can observe the influence of guarantee schemes on risk-shifting without distortion from other regulations. Our model incorporates shareholders of both the insurance company and the IGS level[10]. The insurance premium and the IGS premium have to ensure that both shareholder groups receive at least a risk-adequate return on their equity capital provision. By measuring the welfare level for policyholders that results from a chosen investment policy, we are able to deduce the welfare effects of different IGS premium principles.

Our results show that the risk-based guarantee fund premium does not necessarily induce a safe strategy of the insurance company: the insurer might still find it optimal to take excessive risk after collecting the insurance premiums. This is because the risk-based IGS premium only ensures that the insurer's shareholders do not exploit those of the IGS. Risk-shifting still allows the insurer to transfer wealth from policyholders to its shareholders. We also show that the risk-based premium must include a substantial loading in order to deter the insurer from risk-shifting. For small markups on the IGS premium, in turn, the flat-rate premium and the risk-based premium do not differ in their influence on policyholders' welfare. Only relatively high premium loadings can thus improve policyholders' welfare. Therefore, the risk-based IGS weakly dominates the flat-rate IGS in the sense of improving policyholders' welfare even though it increases the primary insurance premiums.

The paper is organized as follows: Section 2 reviews the literature on insurers' risk-shifting and on policyholders' welfare in the presence of IGSs. Section 3 formulates our model framework, including the payoffs to the three stakeholder groups, the IGS premium principles, the welfare measures and the timeline for decision-making. In Section 4, we conduct a numerical analysis to detect the influence of IGS premium principles on the insurer's risk-shifting behavior and the policyholders' welfare. Section 5 provides a conclusion.

[10] Our approach of explicitly considering guarantee fund's shareholders reflects the situation in Germany, where the life insurance IGS is run as a stock company. In the U.S., IGSs are nonprofit state-based systems without explicit equity capital (see the website of the National Conference of Insurance Guarantee Funds). However, there is the possibility that the state may additionally compensate policyholders (using tax income) if the guarantee funds are not sufficient. This would be analogous to losing the equity capital in a stock company. We thus expect that taxpayers in the long run require a risk-adequate return from an IGS, reflecting such additional payment liability.

2 Literature Overview

Literature on Insurers' Risk-Shifting under IGSs

There are several empirical studies for the U.S. insurance market which examine the impact of flat-rate IGSs—the prevalent form of IGSs in the U.S.—on property-liability insurers' risk-shifting. Lee et al. (1997) provide evidence that the risk of stock insurers' asset portfolios increases following enactments of the flat-rate ex-post IGS[11]. Downs and Sommer (1999) find that the flat-rate ex-post IGS induces stock insurers to take more risk, and furthermore that less capitalized insurers are more likely to conduct risk-shifting. Lee and Smith (1999) find that the flat-rate IGS induces insurers to lower their reserves and substitute IGS coverage for capital. In a theoretical study, Schmeiser and Wagner (2010) find that in a competitive market setting, introducing a flat-rate ex-ante IGS entails a shift of the insurer's equity capital towards minimized solvency requirements. The change of the insurer's equity capital strategy leads to higher insolvency probabilities.

Literature on Policyholders' Welfare under IGSs

Policyholders' welfare is affected by the introduction of IGSs. On the one hand, pooling funds from insurers and then investing them in low-risk assets improves policyholders' protection. On the other hand, the implementation of IGSs can be costly to some policyholders as a result of a wealth-transfer between policyholders of different insurance companies. In their theoretical work, Han et al. (1997) show that the flat-rate ex-ante financing approach reduces the wealth-transfer problem, compared to the flat-rate ex-post funding practice. Referring to the U.S., they show that the flat-rate ex-post funding mechanism tends to foster the wealth transfer from either taxpayers or policyholders of one state to policyholders of another state. A more recent theoretical work by Rymaszewski et al. (2011) analyzes under what conditions an ex-ante IGS is beneficial for policyholders. Their results show that risk-averse policyholders benefit from the introduction of a risk-based IGS if insurers are homogeneous and if policyholders exhibit the same risk preferences and are charged identical premiums. However, a wealth transfer takes place if there are heterogeneous insurers. Therefore, not all policyholders benefit from the introduction of IGSs.

[11] An ex-post IGS collects its premiums from the surviving insurance companies only if an insurer has defaulted, whereas under an ex-ante IGS premiums are collected in advance from all insurers covered by the IGS.

3 The Model Setup

3.1 Payoffs to the three stakeholder groups

In line with Cummins (1988) and Schmeiser and Wagner (2010), we consider an insurance company and a guarantee fund in a one-period time horizon.

At time t=0, shareholders endow the insurer with the equity capital K^{ins}, policyholders pay the insurance premium P^{ins} and the guarantee fund premium P^{GF} is gathered from the insurer. The initial assets A_0^{ins}, available for the insurer to invest, are thus

$$A_0^{ins} = K^{ins} + P^{ins} - P^{GF}. \tag{1}$$

The insurer invests the portion α of these assets into risky investments and the portion $(1-\alpha)$ into risk-free securities. Correspondingly, the initial assets of the guarantee fund A_0^{GF} are composed of the guarantee fund premiums P^{GF} and the guarantee fund's equity capital K^{GF}:

$$A_0^{GF} = K^{GF} + P^{GF}. \tag{2}$$

The guarantee fund invests all assets into risk-free securities.[12] At time t=1, the insurer receives investment returns, and thus the final assets of the insurer A_1^{ins} comprise

$$A_1^{ins} = A_0^{ins} \cdot [\alpha \cdot e^{r_{risky}} + (1-\alpha) \cdot e^{r_f}], \tag{3}$$

with r_{risky} being the (stochastic) rate of return of the risky investments and r_f the risk-free rate of return. Correspondingly, the final assets of the guarantee fund A_1^{GF} are given by

$$A_1^{GF} = A_0^{GF} \cdot e^{r_f}. \tag{4}$$

Policyholders file their claims at time t=1 with the (stochastic) nominal amount of L_1^{ins}. The insurer's indemnity payments I_1^{ins} depend on whether the insurer is solvent at time t=1. If so, policyholders are indemnified at the amount of their nominal claims L_1^{ins}, otherwise, policyholders receive all the insurer's final assets A_1^{ins}. In total, the payoff from the insurer to policyholders is given by

$$I_1^{ins} = min\{L_1^{ins}, A_1^{ins}\}. \tag{5}$$

[12] To demonstrate the effectiveness of the guarantee fund it is not necessary to involve more than one insurance company, because we model the guarantee fund as a stock insurance company which takes care of its risk management by providing sufficient equity capital.

In the case of the insurer's insolvency, policyholders receive an additional indemnity payoff I_1^{GF} from the guarantee fund. This payoff is limited by the guarantee fund's final assets A_1^{GF} and by the nominal claim L_1^{GF} that the guarantee fund promised to pay out to policyholders in the case of the insurer's default, i.e. the default put:

$$L_1^{GF} = L_1^{ins} - I_1^{ins} = max\{L_1^{ins} - A_1^{ins}; 0\}.^{13} \quad (6)$$

In total, the payoff from the guarantee fund to policyholders is given by

$$I_1^{GF} = min\{L_1^{GF}; A_1^{GF}\}. \quad (7)$$

The insurer's shareholders receive the final equity capital of the insurance company, or nothing in the case of insolvency:

$$E_1^{ins} = max\{A_1^{ins} - L_1^{ins}; 0\}. \quad (8)$$

Correspondingly, shareholders of the guarantee fund receive its final equity capital E_1^{GF}. The total payoff to the guarantee fund's shareholders is therefore:

$$E_1^{GF} = max\{A_1^{GF} - L_1^{GF}; 0\}. \quad (9)$$

3.2 Guarantee fund premium principles

We distinguish between two guarantee fund premium principles. Firstly, we consider the flat-rate guarantee fund premium $P^{GF}(\beta)$ that is charged to the insurer as a predetermined percentage β of its premium income P^{ins}:

$$P^{GF}(\beta) = \beta \cdot P^{ins}. \quad (10)$$

Secondly, we consider the risk-based guarantee fund premium $P^{GF}(\alpha, \gamma)$, depending on the insurer's asset allocation α and a premium loading γ that can be set by the risk-based guarantee fund. An actuarially fair guarantee fund premium is equal to the present value of the guarantee fund's indemnity payment (I_1^{GF}). This fair premium is given by

$$P^{GF}(\alpha) = \exp(-r_f) \cdot E[I_1^{GF}]. \quad (11)$$

Since A_1^{ins} and thus I_1^{GF} depend on α, the fair risk-based premium is also affected by α. We assume that the asset allocation of the insurer is not observable for all stakeholders; however, the shareholder-value-maximizing asset allocation α^* is predictable by the guarantee fund which can adjust the premium accordingly. In our subsequent analysis, we

[13] In reality, guarantee funds frequently indemnify policyholders only at a percentage of the defaulted claims payments. See Oxera (2007, pp. 146-147) for the EU guarantee fund schemes and the NCIGF brochure (2011) for the US guarantee fund mechanism. The NCIGF brochure can be retrieved from http://www.ncigf.org/.

will also investigate the influence of a proportional loading factor γ on the risk-based premium. Including the proportional loading, the risk-based guarantee fund premium is defined by

$$P^{GF}(\alpha,\gamma) = (1+\gamma)\cdot \exp(-r_f)\cdot E[I_1^{GF}]. \qquad (12)$$

3.3 Welfare measures

With Equation (8) and assuming risk neutrality of shareholders, the net shareholder value of the insurer is

$$SHV^{ins} = \exp(-r_f)\cdot E\left[max\{A_1^{ins} - L_1^{ins}; 0\}\right] - K^{ins}. \qquad (13)$$

When deciding on its asset allocation, the insurer aims to maximize shareholder value.

Using Equation (9), the net shareholder value of the guarantee fund is given by

$$SHV^{GF} = \exp(-r_f)\cdot E[max\{A_1^{GF} - L_1^{GF}; 0\}] - K^{GF}. \qquad (14)$$

In order to ensure that the guarantee fund can be established without external subsidies, the premium principle must lead to a situation in which the guarantee fund's shareholders receive a risk-adequate return, i.e. one which fulfills the participation constraint $SHV^{GF} \geq 0$.

For the sake of simplicity we consider the collective of all policyholders rather than mapping each individual insured client. The policyholder collective is endowed with an initial wealth w_0 (after consumption). It pays out the insurance premium P^{ins} and invests the remaining funds risk-free. At time t=1, random losses L_1^{ins} occur that can be covered by indemnity payments from the insurer I_1^{ins} as well as from the guarantee fund I_1^{GF}:

$$w_1 = (w_0 - P^{ins})\cdot \exp(r_f) - L_1^{ins} + I_1^{ins} + I_1^{GF}. \qquad (15)$$

The policyholder collective has an exponential utility function with constant absolute risk aversion parameter a.[14] Its expected utility is thus:

$$EU(w_1) = E[-\exp(-a\cdot w_1)]. \qquad (16)$$

For our analyses below, we will convert the expected utility into the certainty equivalent CE_1, and the policyholders' welfare is measured by the discounted certainty equivalent CE_0:

$$CE_0 = \exp\left(-r_f\right)\cdot\left\{-\frac{1}{a}\cdot \ln[-EU(w_1)]\right\}. \qquad (17)$$

[14] See, for example, Eisenführ, Weber and Langer (2010, pp. 270-273).

3.4 Timeline of decision-making

The following actions of the three stakeholder groups take place at time 0: (1) the guarantee fund chooses a premium principle (flat-rate versus risk-based) including the pricing parameter (rate or loading factor); (2) consumers decide on whether to purchase insurance or not, and pay the premium P^{ins}; (3) the insurer decides on the portion of risky stock investments α; (4) the guarantee fund monitors the insurer's asset allocation and determines the premium P^{GF}.

When deciding on its asset allocation, the insurer is aware of the guarantee fund premium principle and anticipates the consequences for the size of the guarantee fund premium. Therefore, the insurer's optimization problem is given by

$$SHV^{ins} = \exp(-r_f) \cdot E\left[max\left\{\left(K^{ins} + P^{ins} - P^{GF}(\alpha)\right) \cdot \left(\alpha \cdot e^{r_{risky}} + (1-\alpha) \cdot e^{r_f}\right) - L_1^{ins}; 0\right\}\right] - K^{ins} \rightarrow \max_{\alpha \in [0,1]}! \quad (18)$$

4 Numerical Analysis

4.1 Model specification

In the following section, we identify situations in which the guarantee fund is effective or ineffective in deterring the insurer from risk shifting. Based on these results, we can determine the guarantee fund premium principle that leads to the greatest welfare for policyholders and at the same time satisfies the participation constraints of the guarantee fund's shareholders (i.e. a non-negative net shareholder value according to Eq. 14).

The complex payoff-structures for each stakeholder group, caused by the limited liability of both the insurer and the guarantee fund, as well as the influence of the limited liability on the insurance premium and the guarantee fund premium, prevent us from deriving closed form solutions for this problem. We therefore apply a numerical analysis.

To model the asset and liability risks, we assume that both the risky asset and liability processes follow geometric Brownian motions with drifts μ_A and μ_L, and volatilities σ_A and σ_L. The processes can be represented by the following formulas:[15]

[15] See, for example, Schmeiser, Wagner and Zemp (2011, pp. 11-12).

$$dA_t = \mu_A A_t dt + \sigma_A A_t dW_{A,t}, \tag{19}$$

$$dL_t = \mu_L L_t dt + \sigma_L L_t dW_{L,t}, \tag{20}$$

$$E\left[dW_{A,t} \cdot dW_{L,t}\right] = \rho_{A,L} dt, \tag{21}$$

i.e., the Wiener processes $W_{A,t}$ and $W_{L,t}$ are correlated with the correlation coefficient $\rho_{A,L}$.

The solutions to the stochastic differential Equations (19) and (20) in the one-period-setting are[16]

$$A_1 = A_0 \cdot \exp\left[(\mu_A - \frac{\sigma_A^2}{2}) + \sigma_A W_{A,1}\right], \tag{22}$$

$$L_1 = L_0 \cdot \exp\left[\left(\mu_L - \frac{\sigma_L^2}{2}\right) + \sigma_L W_{L,1}\right]. \tag{23}$$

Combining Equations (22) and (3), the insurer's final assets at time t=1 can be expressed as

$$A_1 = A_0 \cdot \alpha \cdot \exp\left[\left(\mu_A - \frac{\sigma_A^2}{2}\right) + \sigma_A W_{A,1}\right] + A_0 \cdot (1-\alpha) \cdot \exp(r_f). \tag{24}$$

The parameters in the numerical analysis are shown in Table 1. We assume initial equity capital endowments for the insurer and the guarantee fund of K^{ins} = 10 and K^{GF} = 40. The initial value of the liabilities is L_0^{ins} = 40, policyholders' initial wealth is w_0 = 70, and the policyholder collective's risk aversion is[17] a = 1. The risk-free rate of return r_f is calibrated corresponding to the Quantitative Impact Study 5 (QIS5) by the Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS) (2010)[18]. The asset drift μ_A and asset volatility σ_A are calibrated using the historical data of Euro Stoxx 50 price (€)[19] from 1997 to 2012. The liability volatility σ_L = 0.2 is consistent with the calibration in Yow and Sherris (2008). The correlation coefficient between the insurer's asset and liability risks $\rho_{A,L}$ is assumed to be 0. The numerical results are derived by Monte Carlo simulation using 5,000,000 iterations.

[16] See Bjoerk (2009, p. 69).
[17] See Laux and Muermann (2010, pp. 342-343).
[18] See QIS5: Calibration paper. CEIOPS-SEC-40-10 (2010, p. 11).
[19] We assume that the insurer's investment assets are mainly stocks, and thus the insurer's asset drift and volatility are calibrated by the annual return and the standard deviation (correspondingly) of the Euro Stoxx 50 for the last 15 years. The historical data of Euro Stoxx 50 Price Euro can be retrieved from http://www.stoxx.com/indices/index_information.html?symbol=SXXE.

Table 1: Parameters applied in the numerical analysis.

Parameter	Notation	Value
Insurer's equity capital endowment	K^{ins}	10
Guarantee fund's equity capital endowment	K^{GF}	40
Initial liabilities	L_0^{ins}	40
Asset drift	μ_A	0.05
Asset volatility	σ_A	0.264
Liability drift	μ_L	0.08
Liability volatility	σ_L	0.2
Correlation between asset and liability risk	$\rho_{A,L}$	0
Risk-free rate of return	r_f	0.022
Policyholders' initial wealth	w_0	70
Policyholders' risk aversion	a	1

4.2 Insurance Premium with a Fixed Mark-Up

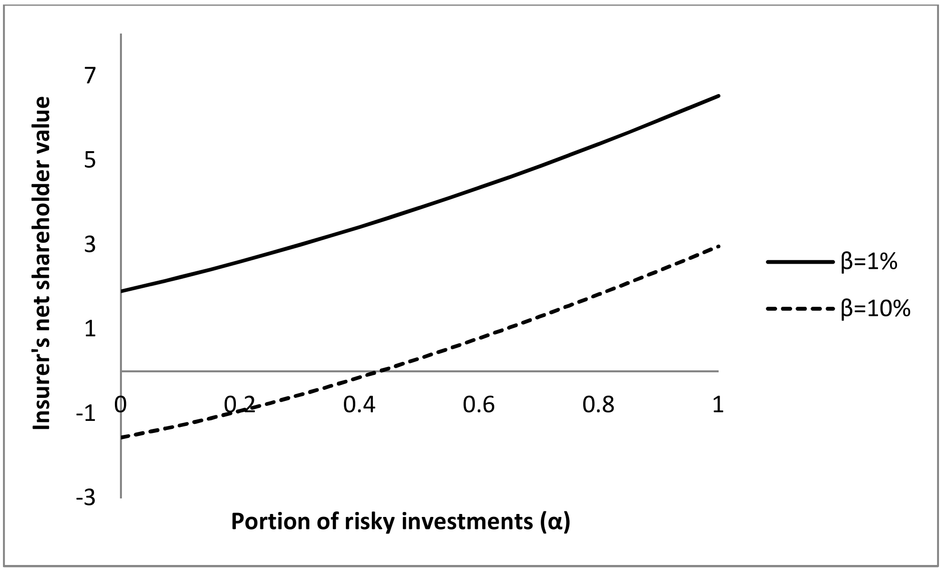
We first present the implications of different IGSs on the insurer's risk-shifting and the welfare of each party. In order to demonstrate the gain in net shareholder value of the insurer by conducting risk-shifting, we assume in a first step that policyholders do not anticipate the insurer's risk-shifting behavior and pay a fixed insurance premium P^{ins} = 45. According to this assumption, the insurer charges to policyholders a fixed premium that includes a premium mark-up of 5.

4.2.1 Flat-rate IGS

As shown in Figure 1, the insurer's net shareholder value under the flat-rate IGS increases for larger portions of risky assets. Therefore, full investment in risky assets (α = 1) leads to the maximal net shareholder value regardless of the flat rates (β) of the guarantee fund premium. In addition, some flat rates (e.g., β = 10% in Figure 1) can lead to negative net shareholder value; however, the shareholder-value-maximizing portion of risky asset investment is still 100%. Therefore, the insurer's risk-shifting behavior is apparently not mitigated under the flat-rate IGS.[20]

[20] See Cummins (1988, p. 825).

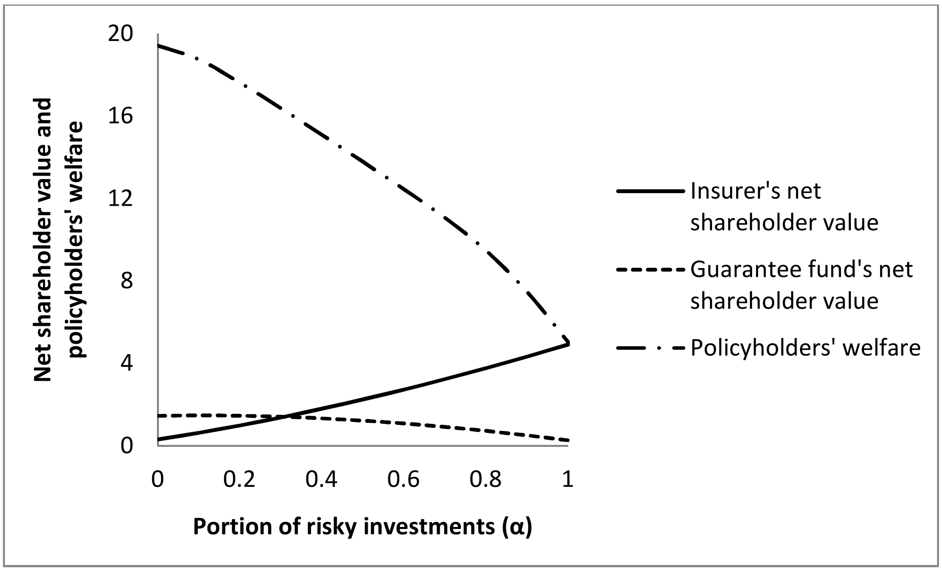
Figure 1: Insurer's risk-shifting behavior under the flat-rate IGS.



This figure illustrates the insurer's net shareholder value (SHV^{ins}) for different portions of risky asset investments α. The solid and dashed lines represent cases with different flat rates (β =1% and 10%, respectively).

Figure 2 illustrates that with a flat rate of β = 5% as an example, the insurer's risk-shifting behavior leads to a declining guarantee fund's net shareholder value: a more risky investment leads to a higher default risk which is not reflected by higher guarantee fund premiums. Moreover, policyholders' welfare also decreases as the insurer's investment risk increases. On the one hand, a high-risk policy results in more volatile investment returns for the insurer, which reduces its safety level. On the other hand, the insolvency probability of the guarantee fund also increases due to the occurrence of severe asset losses, in which case policyholders' unpaid claims from the insurer cannot be (fully or largely) compensated through the protection of the guarantee fund. In summary, both the guarantee fund and policyholders are exploited by the insurer's risk-shifting under the flat-rate IGS.

Figure 2: Welfare effects under the flat-rate IGS.

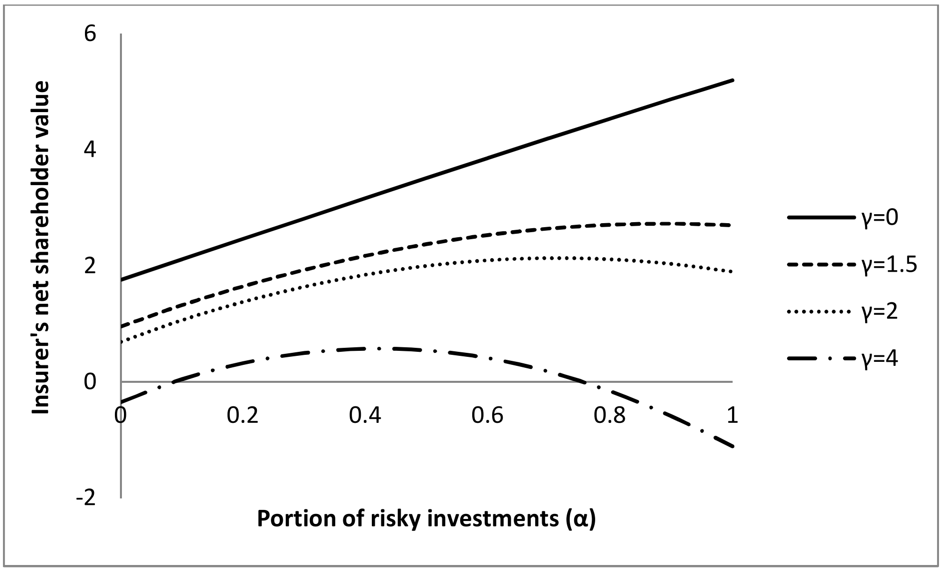


This figure shows the welfare effects of the insurer's risk policy on its net shareholder value (SHV^{ins}), the guarantee fund's net shareholder value (SHV^{GF}) and the policyholders' welfare CE_0. The flat rate imposed on insurance premium income for calculating the guarantee fund premium is 5%.

4.2.2 Risk-based IGS

Unlike the flat-rate IGS, the risk-based IGS with an appropriate premium loading deters the insurer from going entirely risky. Figure 3 illustrates that when the guarantee fund premium loading γ equals zero the insurer still benefits from risk-shifting, and thus the optimal risk strategy is α^* = 1. However, if the premium loading increases, the insurer's incentive for conducting risk-shifting is gradually outweighed by the punishment it suffers from the guarantee fund premium. As a result, the optimal risky investment portion α^* decreases (see Table 2). Therefore, the mere presence of a risk-based guarantee fund is not sufficient for inducing a less risky firm policy. The advantages from risk-shifting must be outweighed by a higher guarantee fund premium, for which an adequate guarantee fund premium loading will be needed. In our example, significantly high loadings are needed to induce an optimal α^* below, for example, 0.5.

Figure 3: Insurer's risk-shifting behavior under the risk-based IGS.



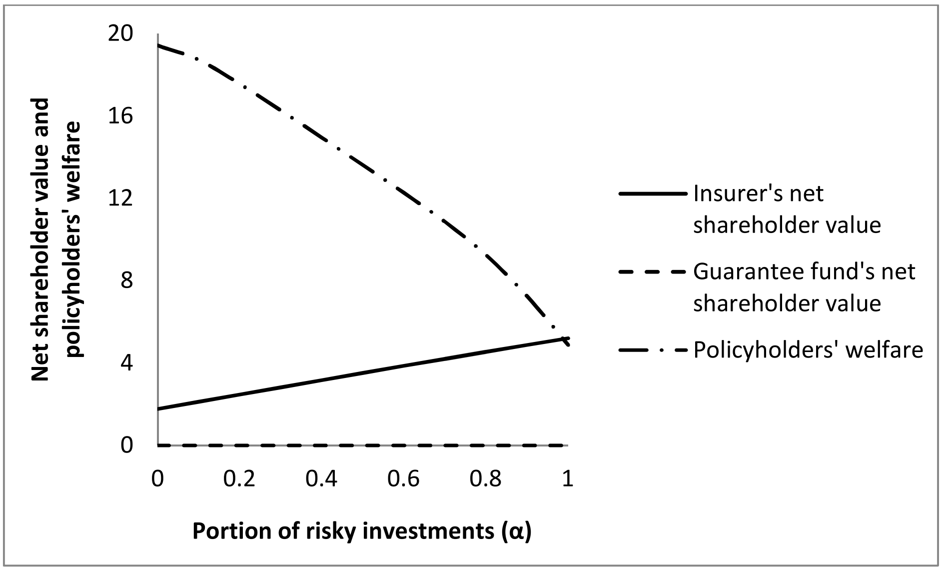
This figure illustrates the insurer's net shareholder value (SHV^{ins}) for different portions of risky asset investments α. Lines from the top to the bottom represent different premium loadings (γ is set to be 0, 1.5, 2 and 4, respectively). The insurer's optimal investment policies which maximize its net shareholder value change as the premium loading varies. Examples of the insurer's investment policies corresponding to different premium loadings are presented below in Table 2.

Table 2: Insurer's optimal investment policies for different guarantee fund premium loadings.

Guarantee fund premium loading (γ)	0	1.5	2	4
Optimal portion of risky investment (α^*)	1	0.9	0.7	0.4

Figure 4 depicts the welfare effects on each party under the risk-based IGS without premium loading (γ = 0). Due to the risk-based guarantee fund premium, the guarantee fund shareholders obtain fair premiums regarding different risk strategies of the insurer. Therefore, the guarantee fund's net shareholder value is always zero. Policyholders cannot benefit from the actuarially fair risk-based premium. The insurer's risk-shifting has a similar negative effect on their welfare as under the flat-rate IGS. The policyholders' welfare decreases in α. The insurer, therefore, exploits policyholders through maximal risk-shifting to achieve the highest net shareholder value. In contrast to the previous situation, due to the risk-based premium, the guarantee fund's net shareholder value is protected from exploitation.

Figure 4: Welfare effects under the risk-based IGS.



This figure illustrates the welfare effects of the insurer's risk policy on its net shareholder value (SHV^{ins}), the guarantee fund's net shareholder value (SHV^{GF}) and the policyholders' welfare CE_0. The guarantee fund's premium loading γ is set to zero.

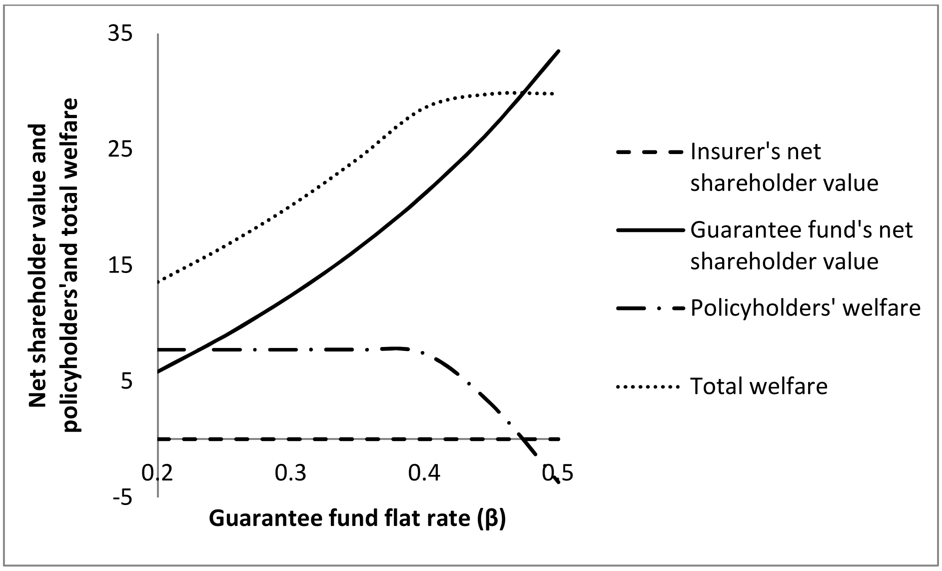
4.3 Competitive Insurance Market

We now assume that policyholders can anticipate the investment strategy of the insurer which, as a consequence, is reflected by the insurance premium. In a competitive insurance market, the insurance premium guarantees that the insurer's shareholders receive exactly the risk-adequate return on their invested equity capital, and end up with a net shareholder value SHV^{ins} = 0. We now answer turn to the question of which IGS proves to be optimal for policyholders. The policyholders' welfare is dependent on three variables: the fair insurance premium P^{ins}, the indemnity payments at time t=1 from the insurer I_1^{ins}, and the possible compensation from the guarantee fund I_1^{GF}. Furthermore, P^{ins}, I_1^{ins} and I_1^{GF} are associated with the insurer's solvency situation which is influenced by its risky investment policy.

4.3.1 Flat-rate IGS

Maximal risk-shifting is optimal for the insurer under the flat-rate IGS regardless of the flat rate size. Figure 5 demonstrates the welfare effects of different guarantee fund flat rates on each party with the insurer's optimal risk policy $\alpha^* = 1$. It also illustrates the total welfare which is the sum of policyholders' certainty equivalent CE_0 and the guarantee fund net shareholder value (SHV^{GF}). The insurer's net shareholder value is always zero under perfect competition, and consequently, the guarantee fund's net shareholder value increases by raising the flat rate while the policyholders' welfare declines at the same time. This is due to the fact that policyholders must pay a higher premium for a growing β to ensure a zero net shareholder value of the insurer; they also face the situation that parts of the premium are potentially retained by the guarantee fund's shareholders rather than being refunded to policyholders. Although policyholders obtain the advantage that more funds are invested risk-free by the guarantee fund, the disadvantage of paying a higher premium outweighs that advantage. Specifically, for $\beta \leq 0.4$, this disadvantage only slightly outweighs the advantage that policyholders experience through an improved safety of their claims. For $\beta > 0.4$, higher premiums reduce policyholder welfare without further improving the safety of the guarantee fund. Wealth is thus transferred from policyholders to the guarantee fund's shareholders. However, "total welfare" increases for a growing β, which could also, in principle, improve the policyholders' situation via side payments from the guarantee fund's shareholders. Therefore, the flat-rate IGS provides the opportunity for a Pareto-improvement of the stakeholders' welfare.

Figure 5: Welfare effects under the flat-rate IGS in a competitive market.



This figure demonstrates the welfare effects of different guarantee fund flat rates (β) on the insurer's net shareholder value (SHV^{ins}), the guarantee fund's net shareholder value (SHV^{GF}), the policyholders' welfare CE_0 and the total welfare.

4.3.2 Risk-based IGS

Under the risk-based IGS without any guarantee fund premium loading, both the insurer's and the guarantee fund's net shareholder value is zero. A positive loading on the guarantee fund premium leads to a positive guarantee fund net shareholder value. It will also be reflected by a surcharge on the insurance premium to ensure the zero-shareholder-value situation of the insurer. Policyholders therefore face three welfare effects under a positive guarantee fund premium loading (γ): firstly, the loading on the guarantee fund premium will reduce the policyholders' welfare; secondly, the thus improved solvency situation of the guarantee fund is beneficial for the policyholders; thirdly, policyholders benefit from a possibly induced mitigation of the risk-shifting problem.

Table 3 demonstrates that higher guarantee fund premium loadings make the insurer inclined to lower its investment risk. However, for low guarantee fund premium loadings, the mitigating effect on the insurer's risk-shifting does not occur (again: the "punishment" by the guarantee fund premium is not sufficient to offset the advantage from risk-shifting).

Table 3: Insurer's optimal risk policies with different guarantee fund premium loadings.

Guarantee fund premium loading (γ)	0	0.5	1	1.5	2	2.5	3
Optimal portion of risky investment (α^*)	1	1	1	0.815	0.658	0.562	0.497

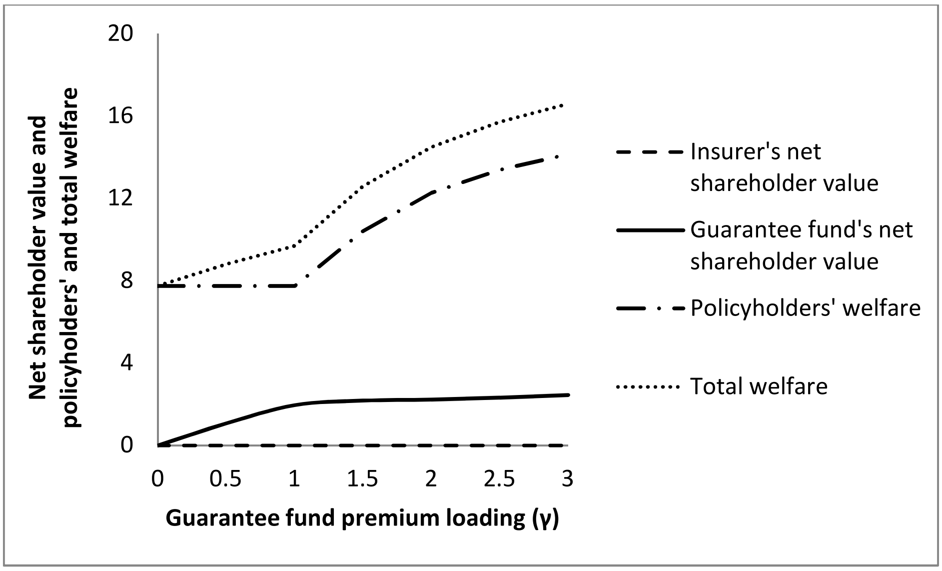
The insurer's optimal risk policies (α^*) determine the insurer's net shareholder value to be zero due to the competitive-market setting. Any other risk policy leads to a negative net shareholder value of the insurer.

Figure 6 shows the welfare effects on each party for different guarantee fund premium loadings. The insurer's net shareholder value is always zero due to perfect competition. As we increase the guarantee fund premium loading, the guarantee fund net shareholder value increases. Specifically, for low guarantee fund premium loadings, the insurer's risk-shifting behavior is not mitigated. The guarantee fund shareholders thus gain a positive net shareholder value through the implied surcharge on the primary insurance premium that is invested at the highest possible investment risk. The policyholders' welfare, therefore, slightly declines at first.[21] Again, the disadvantage from the higher premium is reduced by the advantage through an improved safety of the guarantee fund. As the guarantee fund

[21] The decline of policyholders' welfare for the guarantee fund premium loadings between 0 and 1 is very weak and hardly visible in Figure 6.

premium loading is raised further ($\gamma > 1$), the risk-shifting mitigation effect takes place. The net shareholder value of the guarantee fund keeps increasing, because the payments to policyholders in the event of defaults are reduced due to the higher safety level of the insurer. However, the lower risk of the insurer leads to lower amounts of guarantee fund premiums charged to the insurer. Therefore, the guarantee fund's net shareholder value increases with a flatter slope. Policyholders' welfare starts to increase due to the mitigated insurers' risk-shifting incentives. Although policyholders face increased primary insurance premiums, the advantage of obtaining the mitigating effect on the insurer's risk-shifting outweighs this disadvantage. Furthermore, if we assume that the net shareholder value of the guarantee fund would be redistributed to policyholders, policyholders' welfare can be captured by the "total welfare". Figure 6 illustrates that, when the mitigating effect does not take place, the total welfare increases (the same result as the "Pareto-improvement" explained in the previous sub-section). Once the insurer's risk-shifting incentive is mitigated, total welfare improves further with a steeper slope, since policyholders are also better-off.

Figure 6: Welfare effects under the risk-based IGS in a competitive market.



This figure demonstrates the welfare effects of different guarantee fund premium loadings (γ) on the insurer's net shareholder value (SHV^{ins}), the guarantee fund's net shareholder value (SHV^{GF}) and the policyholders' welfare CE_0.

4.3.3 Comparison between flat-rate IGS and risk-based IGS

Finally, we compare policyholders' welfare under the risk-based and the flat-rate IGS in a competitive market. In order to ensure the comparability of the two different IGSs, the flat rate is adjusted for each guarantee fund premium loading under the risk-based IGS to be equivalent in the sense that it leads to the same amount of guarantee fund premium. In other words, the guarantee fund premium charged to the insurer is the same under the two IGSs.[22]

Our results (in Figure 7) show that policyholders are better-off overall under the risk-based IGS compared to the flat-rate IGS. This is due to the risk-shifting-mitigation ability of the risk-based IGS. For small markups on the IGS premium ($\gamma \leq 1$), the risk-based premium and the flat-rate premium do not differ in their influence on the policyholders' welfare, because the mitigating effect does not occur, so it is optimal for the insurer to invest 100% in risky assets under both schemes. For higher loadings ($\gamma > 1$), the risk-based IGS improves policyholders' welfare through risk mitigation, although the primary insurance premium rises with an increasing γ (due to the compensation of the insurer's shareholders). With regard to the impacts of these two schemes on "total welfare", the risk-based IGS dominates the flat-rate IGS in the sense of generating higher "Pareto-improvement" potentials (for $\gamma \leq 1$). For higher loadings ($\gamma > 1$), the risk-based IGS increases the stakeholders' welfare further through risk mitigation.

The main difference between the flat-rate IGS and the risk-based IGS is how they improve stakeholders' welfare. Under the flat-rate IGS, the improvement of stakeholders' welfare only depends on increasing the capacity of the guarantee fund, which is realized by obtaining more guarantee fund premiums from the insurer. However, the risk-based IGS functions through the risk mitigation. In Figure 7, for higher loadings ($\gamma > 1$), the risk-based IGS requires lower guarantee fund premiums due to the indeed lower risk of the insurer. Correspondingly, the equivalent flat rates β are also lower which causes declining "total welfare" under the flat-rate IGS.

In addition, we also determine the policyholders' welfare level in the case without IGS ($CE_0 = -32.26$) and in the case without purchasing insurance ($CE_0 = -30.58$). Both cases are detrimental to policyholders compared to the situation with insurance and the existence of the guarantee fund. When there is no guarantee fund, the insurer's initial equity capital endowment is the maximum compensation policyholders can obtain if severe losses occur. The presence of an IGS brings its equity capital into play, which serves as a further loss-absorption fund. The results also indicate that policyholders' welfare is the

[22] Table 4 shows different guarantee fund premium loadings (γ) presented in Figure 7 and their equivalent flat rates (β^e) .

lowest compared to all other cases when they purchase insurance without IGSs. In this situation, policyholders face both random losses and the insurer's maximal risk-taking.

Figure 7: Comparison of the policyholders' welfare and the total welfare under the risk-based IGS and under the flat-rate IGS.

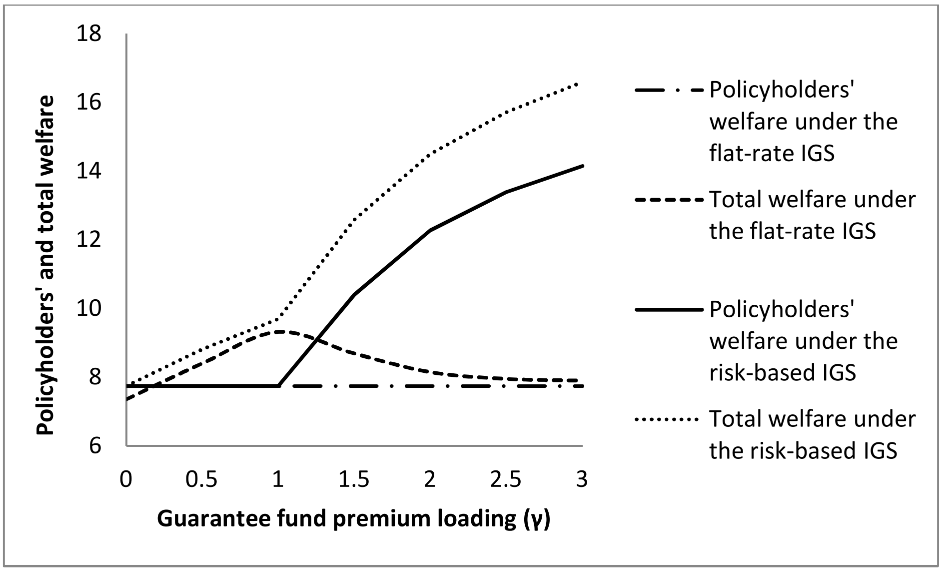


Table 4: Equivalent flat rates under the flat-rate IGS to the guarantee fund premium loadings under the risk-based IGS.

Premium loading (γ)	Equivalent flat rate (β^e)	Guarantee fund premium
0	7.46%	3.36
0.5	9.83%	4.43
1	11.81%	5.31
1.5	10.46%	4.71
2	9.27%	4.17
2.5	8.83%	3.97
3	8.72%	3.92

5 Conclusion

We construct a simple framework consisting of an insurer and its stakeholders and an insurance guarantee fund that is run as a stock company. In this setting, we have investigated to what extent a risk-based IGS is able to mitigate the risk-shifting problem of the primary insurance company. A key result is that the insurer's risk-shifting problem cannot be avoided through the risk-based IGS without an appropriate premium loading being imposed. Policyholders benefit from the more conservative investment policy of the insurer induced by the premium loading. In this case, the positive effects of the risk-shifting mitigation outweigh the disadvantage of an increased primary insurance premium. Therefore, due to the benefits of a higher level of the insurer's safety, policyholders' welfare improves compared to the cases under a flat-rate IGS, without any IGS and without purchasing insurance.

Compared to a competitive insurance market, a higher mark-up on the guarantee fund premium is required in a non-competitive insurance market to induce a lowering investment risk. This is due to the fact that the advantages from risk shifting are greater in this case than in a competitive insurance market, and therefore a more severe "punishment" by the guarantee fund is needed.

In the European Union, the planned solvency regulation system "Solvency II" aims to ensure more transparency concerning the insolvency risk on the insurance market. This could lead to a competitive insurance market that correctly reflects insurers' default situations. Therefore, the required supervisory reporting and public disclosure would, in the light of our results, contribute to the risk-mitigating function of a risk-based IGS. The IGS, although it is detrimental at first glance to enhancing market discipline, could therefore be useful for achieving a lower risk level of the insurer. More importantly, if we establish an IGS with the possibility of side-payments from guarantee fund owners to policyholders, the welfare of both stakeholders can increase under such an IGS.

An interesting extension of our approach would be to include further insurance companies. In this case, we would have to face cross-subsidization effects between the insurers via the IGS, and a prisoners' dilemma effect would interfere with incentives for risk-shifting mitigation. Wealth transfer among policyholder groups from different insurers may also exist, in which case IGSs may only be beneficial to a certain type of policyholders.

References

Bernier, G., & Mahfoudhi, R. M. (2010). On the economics of postassessments in insurance guarantee funds: A stakeholders' perspective. *Journal of Risk and Insurance*, *77*(4), 857-892.

Björk, T. (2009). *Arbitrage theory in continuous time* (3rd): Oxford University Press.

Buser, S., Chen, A., & Kane, E. (1981). Federal deposit insurance, regulatory policy, and optimal bank capital. *Journal of Finance*, *36*, 51–60.

Cohen, A., & Einav, L. (2007). Estimating risk preferences from deductible choice. *American Economic Review, 97*(3), 745–788.

Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS). (2010). *Quantitative impact study 5 (QIS5): Calibration paper*. CEIOPS-SEC-40-10. Retrieved from http://ec.europa.eu/internal_market/insurance/docs/solvency/qis5/ceiops-calibration-paper_en.pdf

Cummins, J. D. (1988). Risk-based premiums for insurance guarantee funds. *The Journal of Finance*, *43*(4), 823–839.

Cummins, D. J., & Danzon, P. M. (1997). Price, financial quality, and capital flows in insurance markets. *Journal of Financial Intermediation*, *6*, 3–38.

Cummins, J. D., & Sommer, D. W. (1996). Capital and risk in property-liability insurance markets. *Journal of Banking and Finance*, *20*, 1069–1092.

Downs, D. H., & Sommer, D. W. (1999). Monitoring, ownership, and risk-taking: The impact of guarantee funds. *Journal of Risk and Insurance*, *66*(3), 477–497.

Duan, J.-C., & Yu, M.-T. (2005). Fair insurance guarantee premia in the presence of risk-based capital regulations, stochastic interest rate and catastrophe risk. *Journal of Banking and Finance*, *29*, 2435–2454.

Duncan, M. (1984). An appraisal of property and casualty post-assessment guarantee funds. *Journal of Insurance Regulation*, *2*, 289–303.

Eisenführ, F., Weber, M., & Langer, T. (2010). *Rational decision making*: Springer.

Epton, B. E., & Bixby, R. A. (1976). Insurance guarantee funds: A reassessment. *Insurance Law Journal*, (639), 199–224.

European Commission. (2010). *White paper on insurance guarantee schemes*. Retrieved from http://ec.europa.eu/internal_market/consultations/docs/2010/whitepaper-on-igs/whitepaper_en.pdf

Filipovic, D., Kremslehner, R., & Muermann, A. (2011). *Optimal investment and premium policies under risk shifting and solvency regulation* (NCCR FINRISK Working Paper Series No. 677). Retrieved from www.nccr-finrisk.uzh.ch/media/pdf/wp/WP677_A5.pdf

French, E. (2005). The effects of health, wealth, and wages on labour supply and retirement behaviour. *Review of Economic Studies*, *72*(2), 395–427.

Green, R. C. (1984). Investment incentives, debt, and warrants. *Journal of Financial Economics*, *13*, 115–136.

Han, L.-M., Lai, G. C., & Witt, R. C. (1997). A financial-economic evaluation of insurance guarantee fund system: An agency cost perspective. *Journal of Banking and Finance*, *21*, 1107–1129.

Hank, A. H. (1976). Post-assessment guarantee funds: Are they the ultimate solution to the insolvency problem? *Insurance Law Journal*, 482–490.

Harrington, S. E., & Nelson, J. M. (1986). A regression-based methodology for solvency surveillance in the property-liability insurance industry. *Journal of Risk and Insurance*, *53*, 583–605.

Bohn, J. G., & Hall, B. J. (1999). *The moral hazard of insuring the insurers.* (Froot, K. A., Ed.): University of Chicago Press.

Jensen, M. J., & Meckling, W. R. (1976). Theory of the firm: Managerial behavior, agency cost, and ownership structure. *Journal of Financial Economics*, *3*, 305–360.

Krogh, H. C. (1972). Insurer post-insolvency guarantee funds. *Journal of Risk and Insurance*, *39*(3), 431–450.

Krogh, H. C., & Levin, M. S. (1986). Recent trends: State insurance guarantee funds and insurance company insurance assessment operations. *Journal of Risk and Insurance*, *53*(2), 335–355.

Lee, S.-J., Mayers, D., & Smith, C. W., Jr. (1997). Guarantee funds and risk-taking: Evidence from the insurance industry. *Journal of Financial Economics*, *44*, 3–24.

Lee, S.-J., & Smith, M. L. (1999). Property-casualty insurance guarantee funds and insurer vulnerability to misfortune. *Journal of Banking and Finance*, *23*, 1437–1456.

Ligon, J. A., & Thistle, P. D. (2007). The organizational structure of insurance companies: The role of heterogeneous risks and guarantee funds. *Journal of Risk and Insurance*, *74*(4), 851–861.

MacMinn, R. D. (1993). On the risk shifting problem and convertible bonds. *Advances in Quantitative Analysis of Finance and Accounting*, *2*, 181–200.

Mayers, D., & Smith, C. W., Jr. (1981). Contractual provisions, organizational structure, and conflict control in insurance markets. *The Journal of Business*, *54*(3), 407–434.

Merton, R. C. (1997). A model of contract guarantees for credit-sensitive, opaque financial intermediaries. *European Finance Review*, *1*, 1–13.

Monkiewicz, M. (2012). Insurance protection funds in the European Union - Quo vadis? *Risk Management and Insurance Review*, *15*(1), 89–106.

NCIGF. (2011). *The property and casuality guaranty funds*. Build to work. Retrieved from http://www.ncigf.org/media/files/NCI_GF_Brochure_SinglePages.pdf

Olson, D. G. (1986). Property and casualty guarantee funds before 1970: Lesson for the 1980s. *Journal of Insurance Regulation*, *4*, 132–145.

Oxera (2007). *Insurance guarantee schemes in the EU: Comparative analysis of existing schemes, analysis of problems and evaluation of options*. Final report prepared for European Commission DG Internal Market and Services. Retrieved from http://ec.europa.eu/internal_market/insurance/docs/guarantee_schemes_en.pdf

Phillips, R. D., Cummins, D. J., & Allen, F. (1998). Financial pricing of insurance in the multiple-line insurance company. *Journal of Risk and Insurance*, *65*, 597–636.

Rymaszewski, P., Schmeiser, H., & Wagner, J. (2010). Insurance guaranty funds - what good is it? *Zeitschrift für die gesamte Versicherungswissenschaft, Sonderheft zur Jahrestagung*, *100*(5), 719–731.

Rymaszewski, P., Schmeiser, H., & Wagner, J. (2012). Under what conditions is an insurance guaranty fund beneficial for policyholders? *Journal of Risk and Insurance*, *79*(3), 785–815.

Schich, S. (2009). Insurance companies and financial crisis. *OECD Journal: Financial Market Trends*, *2009*(2).

Schmeiser, H., & Wagner, J. (2012). The impact of introducing insurane guaranty schemes on pricing and capital structures. *Journal of Risk and Insurance*, *forthcoming*.

Schmeiser, H., Wagner, J., & Zemp, A. (2011). *A proposal for a capital market-based guarantee scheme for the financial industry* (Working Papers on Risk Management and Insurance No. 85). Institute of Insurance Economics, Universitaet St. Gallen.

Shim, J. (2010). Capital-based regulation, portfolio risk and capital determination: Empirical evidence from the US property-liability insurance. *Journal of Banking and Finance*, *34*, 2450–2461.

Smyth, S. J. (2006). *Essays on optimal taxation and the life cycle* (Dissertation). Harvard University, Cambridge, Massachusetts. Retrieved from http://www.econ.yale.edu/faculty1/tsyvinski/students/smyth.pdf

Sommer, D. W. (1996). The impact of firm risk on property-liability insurance prices. *Journal of Risk and Insurance*, *63*, 501–514.