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Evaluation of Benefits and Costs of Insurance Regulation – A Conceptual Model for Solvency II

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Abstract

Ensuring future payments to policyholders is of essential importance in the insurance business model. In order to provide a high safety level, the insurance industry faces particularly severe regulations by state authorities via varying means. These come with substantial benefits and costs for all affected stakeholder groups. However, it is in itself not clear if the benefits outweigh the costs. In this paper, we focus on the introduction of the Solvency II framework as a new regulatory measure and adopt a policyholder's point of view in our economic model. In the context of Solvency II, we compare the policyholder's willingness to pay for the higher safety level (i.e., a valuation of benefits of Solvency II) with the estimated costs mentioned in the literature for the new regulatory standard. Three different models are used to assess the policyholders' willingness to pay. These are (i) a behavioural approach, (ii) an option pricing model, as well as (iii) a utility-based model. Our analyses raise doubts about whether the estimated costs of the Solvency II framework are lower than the costs policyholders are willing to pay for an increased safety level due to Solvency II.

Key words Insurance Regulation · Solvency II · Behavioural Insurance · Costs and Benefits

1 Introduction

The insurance industry faces stringent regulations by state authorities. After a phase of deregulation in the mid-1990s, the entrepreneurial freedom of insurance companies became subject to new extensive regulatory requirements. In Europe, these included for example, a broader setup of guaranty funds (European Commission, 2010), new solvency requirements (European Commission, 2009) and extended directives on insurance mediation (German Department of Justice, 2007). The compliance with these regulations imposes severe costs and requires significant efforts to be made by insurance companies. An important, new regulatory tool, Solvency II, is planned to come into force in 2014, and will have a major impact on the entire industry. One of the major goals of the risk-adequate capital requirements of

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Solvency II is to decrease the ruin probability of insurance companies and consequently to ameliorate consumer protection. Given the magnitude of the change that insurers will face, the assessment of the benefits and costs of the Solvency II framework is of great interest. The impact of Solvency II on different aspects of insurance is discussed by many authors, among them, for example, van Bragt et al. (2010), Liebwein (2006), Doff (2008) and Van Laere and Baesens (2010). However, very few attempts have been made so far to estimate and compare the direct costs and benefits from the Solvency II framework. Ernst & Young (2011) addresses in cooperation with the Financial Services Authority (FSA) the issue of costs and benefits from Solvency II. Within their study which takes only a look at the UK, the focus is put on the impact on insurance companies. Policyholder implications are of minor concern in their considerations. The aim of this paper is to give conceptional thoughts on how such a comparison could be derived while focusing at the same time on the impact of Solvency II on policyholders. In fact regulators primarily focus on the perspective of the policyholders. Other positive effects which may arise from solvency requirements (e.g., financial stability, support for other industries) are not discussed in this paper.

Ensuring solvency and thus customer safety is one of the major goals of insurance regulation. Although it is generally assumed that regulations may be able to fulfil this goal, a review of the literature shows little assessment of the related benefits and costs. In order to find a way to show how benefits and costs could be compared in this context, we model two states, including and excluding the regulatory measure, and contrast the respective outcomes from the perspective of a policyholder. As a first step, we introduce a conceptual framework in order to assess the benefits the introduction of the Solvency II framework has on the safety level (in terms of ruin probability) of an insurer. Therefore our framework simulates the insurer's assets and liabilities by using stochastic processes. We examine the ruin probability of the insurer by means of Monte Carlo simulations under the assumption that a company is bankrupt if the value of its liabilities exceeds the value of its assets. Subsequently, we assess the policyholder's willingness to pay for the higher safety level due to the Solvency II framework using three different models. First, we apply an option pricing model by introducing a one-period contingent claims model (see, e.g., Doherty and Garven, 1986). Since insolvency risk is explicitly taken into account in the claims structure, we use the value of a default put option as a measure of the safety level of the insurance company (see, for example, Phillips et al., 1998). Secondly, a behavioural approach is applied: we adapt the model by Zimmer et al. (2009) and use the authors' empirical survey results to assess policyholders' willingness to pay for a decrease in the ruin probability of their insurer. Hence, the model compares the maximum premium that a consumer is willing to pay to insurers under various specific ruin probabilities. The third model is a normative utility-based model. By comparing a policyholder's wealth position in two different states – the presence of the Solvency II framework in one and its absence from the other – we again draw conclusions on the policyholder's willingness to pay. Finally, we compare the estimated associated costs of Solvency II with the theoretically derived policyholder's maximum willingness to pay for the higher safety level due to the new regulatory scheme (the benefits of the Solvency II framework). At first glance, our results indicate that the costs resulting from the introduction of the Solvency II framework outweigh the policyholders' willingness to pay and thus the pertaining benefits. In conclusion, our conceptual model presents a sound methodology which, in its practical application, needs for input an assessment of the market players (e.g., current safety levels), of the policyholders' effective willingness to pay for improved safety, and finally, of the costs associated to the regulatory measure. As pointed out before, our model focuses on the policyholder perspective and neglects impact from regulation on other stakeholders. Policyholder protection is the foremost goal of insurance regulation, as underlined, for example, by the International Association of Insurance Supervisors (IASA). In their *Insurance Core Principles*, the policyholder protection is named as the aim of supervision and regulation (IASA, 2011, p. 3).

The remainder of this paper is organized in the following way. Section 2 gives a literature overview of the topic of regulation. Thereby, the legitimization of regulation is discussed, its goals and tools, as well as its impact on the relevant stakeholders. Section 3 describes the methodology applied to assess the benefits and costs of regulation. Section 4 provides a comparative analysis of different models in order to assess the benefits and costs of the Solvency II framework from a policyholder's perspective. First, we measure the improvement in the policyholder's position in terms of the insurer's ruin probability by the introduction of Solvency II in Section 4.1. Secondly, we assess the policyholder's willingness to pay for the higher safety level offered by three different frameworks: (i) a model based on behavioural theory (Section 4.2.1), (ii) an option pricing model (Section 4.2.2) and (iii) a utility-based model (Section 4.2.3). The estimated costs of the Solvency II framework are discussed in Section 4.3. Section 4.4 summarizes and compares the resulting estimates as well as the derived approximation of costs associated with the Solvency II framework. Main conclusions are presented in Section 5.

2 Regulatory Considerations and Literature Overview

Ensuring future payments to the policyholders is essential in the insurance sector. The following reasons can be offered regarding why safety is of optimum importance for the insurance industry: (A) In insurance companies, customers are debt capital providers for the insurer. The solvency of the insurer influences the product quality directly. (B) Because of asymmetric information between the policyholder and the insurance company, the customer is generally not able to view the future safety level of the company and may be unable to adjust his willingness to pay according to the insurer's true safety level. This aspect seems to be of great relevance in the case of life insurance contracts with long duration where payments to the policyholders are promised in the distant future. (C) Another important matter arises in the indemnification of third persons: In casualty and liability insurance, the insurer covers losses of third parties in the case of accidents. However, the third party has no contract with the insurance company and faces disadvantages if policyholders decide to purchase cheap insurance from an unsafe provider. Given these aspects, one can assume that trust in the industry is increased via close supervision by the regulator (Llewellyn, 2005).

To date, when it comes to the legitimization of regulation, literature can be classified into three main categories. In the following section we briefly summarize these schools of thought. For a more detailed description of the theories we refer in particular to Posner (1974); Klein (1995); Nektarios (2010); Klein (2012); Kelly et al. (2012). The *Public Interest Theory* argues that intervention of the regulator is necessary to address the inefficiencies resulting from information discrepancies between policyholders and insurers and the resulting agency problems (Munch and Smallwood, 1981). The policyholders must be protected from high risk actions performed by the insurer – which can lead to the latter's insolvency – by the implementation and enforcement of solvency laws. The increase in social welfare outweighs the costs due to regulation and the limitations of the latter. The *Economic Theory* argues that self-interested insurance regulators will not always act in the best possible way to maximize efficiency. On the contrary, they may favour a regulatory environment that maximizes political support. Consequently, the regulator's goals relate more to their personal or political interests rather than what might be most beneficial for the consumer (see, for example, Stigler, 1971, and Peltzman, 1976). A third approach can be described as the *Ideological Theory.* Meier (1991) argues that the view of regulation depends on the size of the insurer. He includes additional variables in his regulation model such as the court, regulators' norms, resources, etc. The regulation is influenced by different groups who have specific interests, e.g., industry, consumers, politics, and the regulator.

Having pointed out the theoretical legitimization of regulation, we now lay out the more concrete goals that should be achieved by regulatory actions. The literature (see, e.g., Pottier, 2010; Klein, 1995; Mathur, 2001) differentiates between *solvency regulation* (such as capital requirements, limitations on investments, reserve requirements, and insolvency funds) and *market regulation* (such as licensing, policy or contract provisions, rates, and tariffs). The former aims to protect policyholders from the risk whereby the insurance counterparty is not able to fulfil its financial obligations. The latter aims to fairly and transparently facilitate market principles in relevant areas such as products and product prices. In line with Bäte et al. (2006), we adapt this picture and extend the notion of solvency regulation to *policyholder protection* and distinguish between *efficiency of markets* and *stability of markets* within market regulation. The three goals are briefly described in the following section. Firstly, policyholders face the problem of asymmetric information against the insurer. Consequently, adverse selection and problems of moral hazard might arise. The protection of policyholders from these dangers or at least the mitigation of negative outcomes and the management of resulting risks (e.g., guaranty funds to cushion effects from insolvency) is often considered in the literature to be the foremost goal of regulation. Such discussion can be found, for example, in Adams and Tower (1994); Cooke (2004); Joskow (1973); Akerlof (1970); Shavell (1979); Klein (1995). A second important regulation goal that is not specifically intended for the insurance industry or financial services industry is to ensure the efficiency of markets. The formation of cartels as well as the use of monopolistic or oligopolistic market power shall be prevented by several different measures such as merger control or rate regulation (see, for example, Harrington, 2009; Klein, 1995; or Mulherin, 2007). Finally, the stability of markets focuses on the avoidance of system-inherent risk that can be triggered by various causes. The *bank run* may be the most prominent example of systemic risk in the financial services industry. Even if an *insurer run* presents a lesser risk, insurance regulation aims to avoid negative events that are inherent in the market and may affect the entire industry, rather than just single players. Contagion effects within the insurance industry should be reduced (see, for example, Schiro, 2006; Cooke, 2004; Nektarios, 2010; Paroush, 1988).

In pursuing the above goals, the regulator possesses a large variety of different tools to exercise insurance regulation (see Mathur, 2001; Nektarios, 1987; Skipper and Kwon, 2007). Table 1 structures and categorizes the distinct tools, complements them, and provides an overview of the different regulation possibilities with particular focus on current issues in Europe.[1] We distinguish between four different areas which are affected by regulatory tools, namely operations, insurer's capital, sales, and the product itself. We complement each of these categories with different regulation possibilities. For example, the operations of an insurer are regulated via the contract design and the required transparency towards customers. Insurer's capital is affected by regulation through solvency requirements or guaranty funds. The sale of policies is regulated via directives on mediation. Finally, the product, for example, is influenced via regulation of tariffing attributes or a necessary product approval. It is worthwhile to mention in this context that the International Association of Insurance Supervisors (IASA) has defined the so called *Insurance Core Principles* which also provide guidance for insurance companies (IASA, 2011). Among others, issues of corporate governance, design of internal controls or prevention of money laundry are discussed in this non-binding but generally accepted industry standards.

Operations	**Capital**
• Contract design • Information and transparency • Dispute resolution • Filing of data • Outsourcing	• Solvency requirements • Guaranty funds • Investment and accounting directives • Profit distribution • Separation of business lines
Sales	**Product**
• Regulation of intermediaries • Mediation directives	• Tariffication attributes / rate regulation • Product approval • Compulsory insurance

Table 1: Overview of the main regulatory tools in four core areas affected by insurance regulation.

The description of the impact of the regulatory tools can be structured along three different stakeholder groups that are primarily affected by regulation. They are the insurance company itself with its equity holders, the policyholders (debt holders), and other third parties (e.g., the general public, tax payers). Table 2 shows the impact of regulation on the different stakeholders. In the sequel, we consider different examples. Regarding rate making, the regulator can forbid defining tariffs using price differentiation criteria, such as gender (Court of Justice of the European Union, 2011). Hence, a cross-subsidy takes place from the previously advantaged group to the previously less advantaged group (see, e.g., Finkelstein et al., 2009, or Akerlof, 1970). A second example is given by the direct costs of regulation for

[1] Skipper and Kwon (2007, Chap. 24) present in Figure 24.2 an overview of the areas of insurance regulation. Table 1 specifies in more detail four areas of regulation which are currently particularly relevant in European insurance regulation.

	Positive impact	Negative impact
Insurers / Equity holders	• Better financial performance • Insurer solvency • Competitive advantage • Reduction of competitors	• Additional expenses • Higher capital requirements • Constraints on entrepreneurship • Misleading financial reporting
Policyholders (debt holders)	• Policyholder protection • Higher transparency • Better information	• Decreasing product diversity • Higher prices / rates • Lower returns / yields
Third parties	• Stability of financial markets • Economic stability and support • Ensuring of competition	• Fewer investments • State's rescue costs • Less coverage

Table 2: Review of possible positive and negative impacts of insurance regulation on selected stakeholders.

the insurers. The regulator is usually financed by payments from the insurance companies. Additionally, insurers pursue lobbying activities to communicate their interests to the regulator. The lobbying accounts for additional costs too (Adams and Tower, 1994).

The issue of costs and benefits of regulation in the insurance industry is addressed in the literature in basically two different categories: (1) the *case study approach* which analyzes a specific regulatory event and its impact on firms, and (2) a *standard cost model* approach that leads to an econometric estimate of the regulation costs, focusing mainly on the implementation and running costs. Numerous studies exist that focus on the *costs of regulation*. Early research conducted by Franks et al. (1997) compared the direct regulatory costs of the financial services industry in the UK, France and the US. Costs are allocated within four sectors: (i) securities and derivatives trading and broking, (ii) investment management, (iii) life assurance and unit trust marketing, and (iv) personal financial advice. The comparison includes the regulatory costs in absolute amounts as well as in proportional figures, namely the regulatory cost per employee. In addition, the compliance costs are assessed. The authors use mainly budget figures from the annual reports of the single regulators because these figures are not always fully available. The authors therefore apply other techniques to value the costs of a regulation agency (e.g., average proportion of operating expenses or cost per head). Deloitte (2006) conducted another study wherein the objective was to assess the incremental costs imposed by the Financial Services and Markets Act 2000 (FSMA) in the UK. Incremental costs are "those costs incurred in complying with regulation that would not be incurred or would not have been incurred in absence of the FSA mandatory rules developed under FSMA" (Deloitte, 2006, p. 23). The data basis is derived from the last audited accounting statement. Exemplary further studies with the same objective come from Alfon and Andrews (1999) or the Real Assurance Risk Management (2006). Consulting firms also attempt to quantify the impact of regulation. The Boston Consulting Group (2010) as well as Morgan Stanley and Oliver Wyman (2010) have published reports on the implementation of Solvency II.

With regard to the *benefits of regulation*, the number of studies is significantly lower. Oxera (2006) points out that a measure of the benefit of regulation can be seen in the improvements of market outcome caused by that particular regulation. The authors describe in detail how to measure the benefit of regulation. Their framework is applicable to the introduction of a specific rule as well as the removal or replacement of existing rules. Both direct and indirect measures are described qualitatively. Advantages and disadvantages of the different methods (such as consumer surveys or market price analysis) are discussed. The study does not conduct a specific evaluation in this respect and a quantitative model providing access to the benefits of regulation is not in the focus of the report.

3 Methodological Approach and Application to the Solvency II Framework

In the previous section, a general overview of regulatory concepts and the related literature has been provided. Even though the evaluation of costs of regulation is in principle well studied, we have not seen too many attempts to jointly measure the benefits and costs of regulation in order to find out, if a particular regulatory concept is beneficial for customers or not. We see three major reasons for this:

- In order to assess the regulatory impact, one must be able to compare the outcome in the state of regulatory presence with the state of a (partial) lack of regulation. Unfortunately, only an empirical analysis of one of the two states is possible. Either the regulator has introduced a new regulation tool and one can (in principle) measure the resulting consumer effects or there is no regulatory action and we can measure this state. In order to overcome this problem, one must make assumptions about the non-present status and compare the latter with the measured existing status (or vice versa).
- The second problem arises when trying to compare these two states. A comparison requires the definition of a common metric for the benefits and costs in both scenarios. The performance indicators must be chosen in a way that allows an assessment in both states which in many cases is not an easy task.
- Finally – and closely linked to the second point – the perspective from which the regulatory action is analyzed is essential. A holistic model that contains all three stakeholder groups presented above (see Table 2) is very difficult to derive. This is why a focus on one single stakeholder is in general necessary to obtain firm results.

Taking these general difficulties into account, we propose in what follows a standardized concept that should be applicable to many regulatory schemes. By doing so, we focus on one single stakeholder group and one single regulatory measure. We define two states (α) and (β) that stand for the condition without and with the new regulatory scheme. We compare the single outcomes with the help of common performance indicators and solely focus on the Solvency II regulatory concept.

The Solvency II framework is planned to come into force in 2014 and is based on three pillars. The first pillar represents the quantitative component of the new regulatory scheme. It will harmonize the capital requirements for insurance companies across the European Union. The second pillar sets new requirements for the governance of insurance companies, redefines risk management, and focuses on effective supervision of insurance companies. The last pillar refers to disclosure and transparency requirements.

The aim of the new regulatory framework is to harmonize EU wide insurance regulation and improve consumer protection (European Commission, 2009). The latter focuses primarily on the insolvency risk of insurance companies. In order to minimize the insolvency risk, it can be expected that the introduction of the Solvency II framework will lead to an increase in the risk bearing capital of insurance companies (see, for example, The Boston Consulting Group, 2010, Guy Carpenter, 2011b, or Morgan Stanley and Oliver Wyman, 2010). To determine the necessary solvency capital requirements, the new EU directive uses the *Value at Risk* concept (European Commission, 2009, Section 4, Article 101) on a confidence level of 99.5%.

The implications of the Solvency II framework on insurers are manifold. In the following section, a brief overview of the impact of Solvency II on the three main stakeholder groups from Table 2 is presented. As pointed out above, the new solvency requirements will most probably lead to higher capital requirements and could increase premiums through higher absolute capital costs. In addition, asset returns may decrease on average since companies increase their proportion of low risky investments in order to meet the new solvency requirements. For the last stakeholder group presented in Section 2, the third parties, Solvency II aims to increase the stability of financial markets, thus ensuring the economic stability of markets by safe insurance companies. Furthermore, the European Commission and its member states hope to see a very low probability for struggling insurers to be given financial support.

An overview of the conceptional approach taken and applied through exemplary calculations is given in Figure 1.

First the perspectives taken for the evaluation of the benefits (policyholder's viewpoint) and of the costs (insurer's viewpoint) are stated. Next, the information needed or to be estimated corresponding to the states without and with the regulatory measure (states α and β) is noted. Thirdly, the benefits and the costs are reflected. For the evaluation of the benefits empirical and normative models are proposed. For the evaluation of the costs, one-time and recurring costs are considered. In Section 4 we apply the approach and provide initial estimates for the various elements.

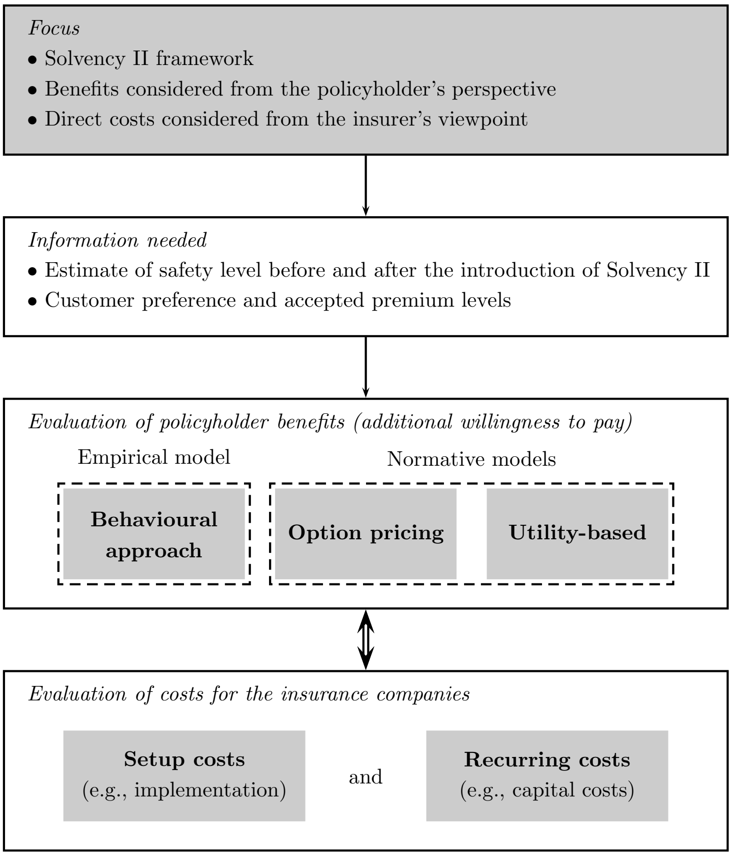


Figure 1: Overview of the approach to derive policyholder benefits and insurers' costs for the Solvency II framework.

4 A Conceptional Approach to derive Costs and Benefits of Solvency II

4.1 Calculation of Ruin Probabilities in the Context of Solvency II

In order to define the impact of the Solvency II framework on the safety level of a company, we compare two different states, namely the state (α) without the introduction of the framework and the state (β) with the introduction of Solvency II. The company's ruin probability (RP) is also compared, and in doing so, so is the safety level that can be achieved by the new regulatory measure.

In our model, a company that has assets of A and liabilities of L is introduced. A one-period model is used to quantify the states. We assume that an insurer is bankrupt if the value of its assets A is less than the value of its liabilities L. The framework is based on geometric Brownian motions for the stochastic processes of assets and liabilities of the insurer. As required in the Solvency II directive (see Section 3), the *Value at Risk* concept is applied in order to derive the required solvency capital for given safety levels. A discussion of the robustness and the model impact on the results, in the case where, e.g., the geometric Brownian motion allows for jumps, can be found for example in the work by Schmeiser et al. (2012).

Introducing $X_t = A_t - L_t$ with $t = 0, 1$, the change in available capital within one year C_0 at time $t = 0$ is defined by

$$C_0 = X_1 \cdot e^{-r_{\mathrm{f}}} - X_0, \tag{1}$$

where the discounting is provided with the risk-free interest rate r_{f}. Thus, the necessary solvency capital SC is defined through

$$SC = -\mathrm{VaR}_{\epsilon}\left(C_0\right). \tag{2}$$

where $(1 - \epsilon)$ indicates the confidence level and C_0 is defined in Equation (1).

The assets A_t and liabilities L_t follow a geometric Brownian motion under the objective measure $\mathbb{P}$. The time independent returns are μ_{r_A} and μ_{r_L} and the corresponding volatilities are expressed by σ_{r_A} and σ_{r_L}. The process of the company's assets and liabilities can be described by the stochastic differential equations:

$$dA_t = \mu_{r_A} A_t dt + \sigma_{r_A} A_t dW^{\mathbb{P}}_{A,t}, \quad \text{and,} \quad dL_t = \mu_{r_L} L_t dt + \sigma_{r_L} L_t dW^{\mathbb{P}}_{L,t}, \tag{3}$$

where the correlated standard $\mathbb{P}$-Brownian motions are expressed in the terms $W^{\mathbb{P}}_A$ and $W^{\mathbb{P}}_L$. The correlation coefficient $\rho_{A,L}$ is defined by $dW^{P}_{A,t} dW^{\mathbb{P}}_{L,t} = \rho_{A,L} dt$. The stochastic differential Equations (3) can be solved for time $t = 1$ by (Björk, 2004):

$$A_1 = A_0 \cdot \exp\left[\left(\mu_{r_A} - \sigma^2_{r_A}/2\right) + \sigma_{r_A}\left(W^{\mathbb{P}}_{A,1} - W^{\mathbb{P}}_{A,0}\right)\right], \qquad \text{and,} \tag{4}$$

$$L_1 = L_0 \cdot \exp\left[\left(\mu_{r_L} - \sigma^2_{r_L}/2\right) + \sigma_{r_L}\left(W^{\mathbb{P}}_{L,1} - W^{\mathbb{P}}_{L,0}\right)\right]. \tag{5}$$

In order to calculate the different safety levels in the two states (α) and (β), we utilize Monte Carlo simulations running 1 000 000 realizations. Table 3 summarizes the parameter settings for the reference case in state (α). In the following section we outline the derivation of the given reference parameterization.

Parameter	Variable	Value
Ruin probability	$RP^{(\alpha)}$	1.0%
Initial Assets	$A_0^{(\alpha)}$	124.5
Asset Drift Brownian Motion	μ_{r_A}	5.0%
Volatility of Assets	σ_{r_A}	8.9%
Initial Liabilities	L_0	100.0
Liability Drift	μ_{r_L}	3.0%
Volatility of Liabilities	σ_{r_L}	5.0%
Correlation A/L	$\rho_{A,L}$	0.0
Risk-free rate of return	r_{f}	2.0%

Table 3: Parameterization of the reference case in state (α).

The average asset return is derived from a weighted return on bonds, stocks and real estate. For this, the annualized average daily return over a 10-year period (January 2000 to December 2010) is used for the DAX 30, MSCI World Index, MSCI Emerging Markets Index as well as EuroStoxx 50 for stocks, the MSCI Real Estate World Index for real estate, and the Deutsche Rentenindex (German Government Bonds) as well as the Standard & Poor's and BG Cantor U.S. Treasury Bond index for bonds. The following weighting for the asset portfolio of the different classes is selected: 70% investment in bonds, 20% investment in real estate, and 10% investment in stocks. The corresponding calculated mean return equals 4.6% (asset drift for Brownian motion of $\mu_{r_A} = 5.0\%$) and the volatility is $\sigma_{r_A} = 8.9\%$. It is assumed that the different asset classes are uncorrelated. For the liabilities, we assume μ_{r_L} to be 3.0%, a value we adapt from Zielke (2009, p. 11) who states average guarantees for life insurance companies at 3.5%. In the remainder of this analysis we do not consider correlations between the assets and liabilities processes and thus the correlation coefficient $\rho_{A,L}$ is set to zero. Initially, the ruin probability in our reference case (α) is set to 1.0%, i.e.,

$$RP^{(\alpha)} = P\left(A_1^{(\alpha)} < L_1\right) = 1.0\%. \tag{6}$$

This corresponds to a $(1-\epsilon) = 99.0\%$ confidence level. In order to provide such a hypothetical safety level, an initial solvency capital $SC^{(\alpha)} = 24.50$ is needed. The liabilities and the initial solvency capital total 124.50 and correspond to the value of the initial assets (balance equation in t = 0).[2][3]

As presented in Section 3, the Solvency II framework applies the *Value at Risk* measure based on a confidence level of $(1-\epsilon) = 99.5\%$, i.e., a ruin probability of $RP^{(\beta)} = \epsilon = 0.5\%$ (state β) is provided. In our numerical example, this Solvency II requirement leads to $SC^{(\beta)} = 27.73$. Hence, in our context, the introduction of Solvency II corresponds with an increase in solvency capital of 3.23[4] while the transition from state (α) to state (β) accounts for a reduction of the ruin probability of 0.5%[5].

Table 4 gives an overview of the numerical results for different values of the parameter ϵ which set different solvency targets for state (β). State (α) relates to the reference case where the ruin probability is $RP^{(\alpha)} = 1.0\%$. State (β), referring to the state with the stronger solvency requirement, is illustrated through different targets for the ruin probability with $RP^{(\beta)}$ varying between 0.01% and 0.90%. In Table 4 the initial situation (state α) and the target state corresponding to Solvency II are printed in bold. The corresponding values are illustrated graphically in Figure 2.

[2] When taking a closer look at the German market, a similar result can be empirically derived by comparing the total value of assets and underwriting provisions for the life, health, as well as property and casualty insurance. Firstly, adjusting the asset figures for hidden reserves (since hidden reserves are more volatile than the book values of assets, an adjustment on the three-year average of hidden reserves in Germany is preferable (BaFin, 2010, p. 25)), and secondly, deriving a weighted ratio over the three mentioned business lines on the basis of their premium amounts, the calculation yields an asset-liability-ratio of 1.24 for the German market in 2010.

[3] In the following we derive results where we start with a reference setting (α) bearing a ruin probability of 1.0%. The methodology holds for different starting states. The resulting premiums for different states are summarized in Table 7 from which relative differences between different states can be derived.

[4] The difference in solvency capital from state (α) to state (β) is expressed by $\Delta^{(\alpha)\to(\beta)}SC = SC^{(\beta)} - SC^{(\alpha)} = 3.23$.

[5] The difference in ruin probability from state (α) to state (β) is expressed by $\Delta^{(\alpha)\to(\beta)}RP = RP^{(\beta)} - RP^{(\alpha)} = -0.5\%$.

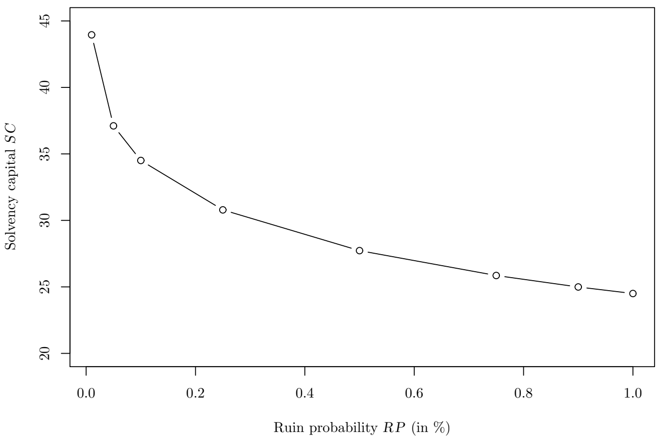


Figure 2: Illustration of the solvency capital SC required for different values of the ruin probability RP (in %).

States	$RP = \epsilon$	SC
(α)	**1.00%**	**24.50**
	0.90%	24.99
	0.75%	25.86
	0.50%	**27.73**
(β)	0.25%	30.79
	0.10%	34.51
	0.05%	37.11
	0.01%	43.95

Table 4: Overview of the required solvency capital SC corresponding to different values of the ruin probability RP.

4.2 Policyholder's Willingness to Pay for Different Safety Levels

The previous paragraph indicates by means of a numerical example what impact the introduction of the Solvency II framework has on the safety level and the ruin probability of an insurance company. Such an impact should be the major benefit of the new regulatory requirement. To measure such a potential benefit, we model the additional willingness to pay from the side of the policyholders. In the following sections, three distinct models are presented that quantify the additional amount of premiums policyholders are willing to pay in order to benefit from a decreased insurer ruin probability.

4.2.1 An Empirical Approximation for the Policyholder's Willingness to Pay

A straightforward way to assess the policyholder's willingness to pay for higher security levels is by an empirical approach. Previous empirical analysis on the customer's willingness to pay in the context of insurance include, among others, the works by Wakker et al. (1997) and Zimmer et al. (2009). The following paragraph briefly describes the design of the study by Zimmer et al. (2009) whose results we will use in what follows. The authors have analyzed 719 responses from people about their willingness to pay for household insurance contracts. This subject is chosen because it is quite likely that the participants possess or possessed household insurance or at least know about it. In addition, there is a good chance that the participants had already faced one or more claims in the context of household insurance. The participants are asked to state their willingness to pay for two specific types of household insurance in comparison to a reference premium offered by a third insurer. The reference insurer is assumed to possess a ruin probability of 0% whereas the two other insurance companies are described as having ruin probabilities of 0.3% and 4.9%. The underlying basics of the contracts (e.g., insured object, insured sum, scope of indemnity, etc.) are the same for all offerings; the only distinction is the ruin probability.

The chosen ruin probabilities represent empirically observed default rates for insurance companies that are rated extremely strong (ruin probability of 0%), good (ruin probability of 0.3%) and weak (ruin probability of 4.9%). The study discovers that participants who are willing to buy from an insurer that has a positive ruin probability require a reduction with respect to the default risk free premium. In order to buy from the company with a ruin probability of 0.3%, it is observed that a premium reduction of 14% is necessary. When it comes to the insurer that has a ruin probability of 4.9%, the premium reduction needs to be 26% compared to the default-free insurer's offering.

We adapt this data for use as an empirical model (see Zimmer et al., 2009, Table 5.1, Experiment 1). Since in practice, a default risk free insurer does not exist, our adjustment made to the data concerns the reference insurer with a zero ruin probability. In order to account for insurance companies for which ruin is very unlikely due to their financial strength and underwriting politics, we adjusted the data point of the default-free insurer to an insurer with a ruin probability of 0.01%, which corresponds to a 10 000 year event. The assumption that, for this very safe insurer, a policyholder is not expecting any premium reduction is left unchanged. With the help of these three data points for the ruin probabilities of 0.01%, 0.3% and 4.9%, we perform a regression of logarithmic type on empirical values of the mean willingness to pay in order to derive the premium reduction PR as a function of the ruin probability RP. This type of regression gives a good fit for small values of ruin probabilities. The regression using the mean values yields the following equation:

$$PR_{\text{mean}} = 0.0419 \cdot \ln(RP) + 0.3855. \tag{7}$$

The corresponding regression curve is shown in the graph of Figure 3 (solid line). Since non-linear regression with three data points is critical and in order to cope with the uncertainty underlying the survey points, a bandwidth is introduced around the regression on the mean values. For this we consider the reported values of the standard deviation on the willingness to pay (Zimmer et al., 2009, Table 5.1) and derive the corresponding lower and upper boundaries for the premium reduction. The resulting equations for the lower (index "low") and the upper ("up") boundaries are $PR_{\text{low}} = 0.0739 \cdot \ln(RP) + 0.6881$ and $PR_{\text{up}} = 0.0107 \cdot \ln(RP) + 0.0873$ respectively. These two relations define a corridor (dotted lines) drawn on Figure 3.

With the help of the regression in Equation (7), we calculate the required premium reduction for the ruin probabilities considered in Section 4.1 (see Table 4). First, we apply our model for the two states (α) and (β) with ruin probabilities of 1.0% and 0.5%. Applying the (adjusted) results from Zimmer et al. (2009) for these ruin probabilities, we obtain a required premium reduction in the first state of $PR^{(\alpha)} = 19.3\%$ and in the second state of $PR^{(\beta)} = 16.4\%$. One can conclude from these figures that the premium reduction required by the policyholders decreases when the achieved safety level increases. This effect will continue until a state with a default free safety level is achieved where the policyholder requires no premium reduction at all. The above figures represent a required premium reduction by policyholders in comparison to the default risk free premium. For the latter we assume the fair premium Π_0^L to be calculated on the basis of the present value of the policyholder claims. This is calculated through the discounted expected value (under the equivalent martingale measure $\mathbb{Q}$) of the liabilities in time $t = 1$, i.e.,

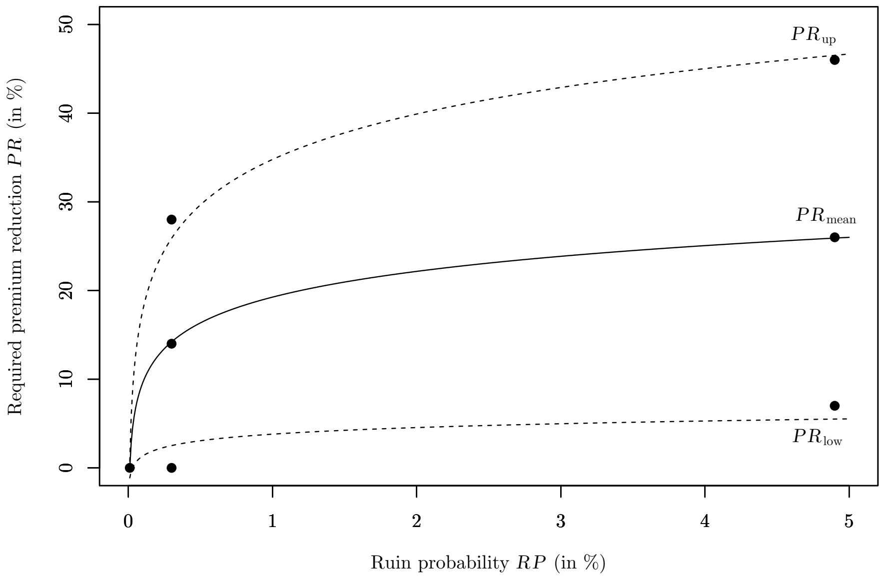


Figure 3: Illustration of the regression results on the mean willingness to pay (required premium reduction) for different ruin probabilities (solid line). The dotted lines define a bandwidth whose boundaries are determined by a regression on the mean values plus/minus one standard deviation. The dots on the graph correspond to the empirical results adopted from Zimmer et al. (2009, Table 5.1).

we have $\Pi_0^L = e^{-r_f} E^{\mathbb{Q}}[L_1] = 100.0$ in the reference setting (see Table 3). Hence we apply the estimated premium reductions on the fair premium of 100.0. The resulting customer willingness to pay (premiums $\Pi_0^{\mathrm{E},(\alpha)}$ and $\Pi_0^{\mathrm{E},(\beta)}$) in each state is reported in Table 5. We report these values considering each of the scenarios introduced above: mean willingness to pay ("mean") and the upper and lower boundaries ("up", "low"). In each scenario the additional premium that customers are willing to pay when the safety level moves from state (α) to state (β) is expressed through $\Delta\Pi_0^{\mathrm{E},(\alpha)\to(\beta)} = \Pi_0^{\mathrm{E},(\beta)} - \Pi_0^{\mathrm{E},(\alpha)}$. These values are reported in column 6 of Table 5, together with the relative additional willingness to pay $\Delta\Pi_0^{\mathrm{E},(\alpha)\to(\beta)}/\Pi_0^{\mathrm{E},(\alpha)}$ (column 7).

Thus from an empirical point of view (see Table 5), a policyholder is willing to pay a 3.60% higher premium for the better safety level due to the introduction of the Solvency II framework in our modelled state (β) ("mean" scenario). When comparing the outcomes from the different scenarios reported in Table 5, it is noted that the potential additional willingness to pay extends from 0.77% to 7.85% with the mentioned mean of 3.60%. A summary of the presented figures as well as additional results for different ruin probabilities in the state (β) in the mean scenario are presented in Table 7.

Finally, we need to point out that the presented results have to be interpreted with caution and should be seen as an illustration only. Typically, we expect policyholders not to worry about specific probabilities

Scenario	Premium reduction		Premium		$\Delta\Pi_0^{\mathrm{E},(\alpha)\to(\beta)}$	$\frac{\Delta\Pi_0^{\mathrm{E},(\alpha)\to(\beta)}}{\Pi_0^{\mathrm{E},(\alpha)}}$
	State (α)	State (β)	$\Pi_0^{\mathrm{E},(\alpha)}$	$\Pi_0^{\mathrm{E},(\beta)}$		
PR_{up}	3.8%	3.1%	96.20	96.94	0.74	0.77%
PR_{mean}	19.3%	16.4%	80.75	83.65	2.90	3.60%
PR_{low}	34.8%	29.7%	65.22	70.34	5.12	7.85%

Table 5: Results of the empirical derivation of the willingness to pay (premiums $\Pi_0^{\mathrm{E},(\alpha)}$ and $\Pi_0^{\mathrm{E},(\beta)}$) for two different states (safety levels of $RP^{(\alpha)} = 1.0\%$ and $RP^{(\beta)} = 0.5\%$). The reported results include the additional customers' willingness to pay when comparing the two considered states. Results are given for the "mean" scenario based on the mean empirical results from Zimmer et al. (2009, Table 5.1) and based on two boundary scenarios "up"/"low" (see also Figure 3).

that they are not reimbursed for their claims in market situations in which defaults of insurance companies are very rare. Consequently, two questions arise: Firstly, how well informed are people really about situations of insurer ruin and, secondly, how efficient can they value such a numeric ruin probability (many people do not apply numeric probabilities at all, see, e.g., Hogarth and Kunreuther, 1995)? Bearing these questions in mind, the required premium reductions may be exaggerated to some degree. In addition, one has to also bear in mind that the empirical study has been provided for household insurance only. The willingness to pay in respect to different safety levels of the insurer may widely differ for different insurance lines and policyholder groups.

4.2.2 The Option Pricing Model

The results from the previous section indicate a broad range for the customer willingness to pay. Due to the rather small data set and specific focus (household insurance products) we reflect our findings using a normative model. In the option pricing model, we introduce a one-period contingent claims model, initially developed by Doherty and Garven (1986). The model incorporates insolvency risk via the default put option of the insurance company (see, e.g., Phillips et al., 1998). In the used arbitrage-free setting, a fair premium (corresponding to the present value of the indemnity payment to the policyholder) is paid by the policyholder (see also Sherris, 2006). We denote this premium by Π_0. In a one-period context, the indemnity payment I_1 in time $t = 1$ can be defined as

$$I_1 = \min(L_1, A_1) = L_1 - (L_1 - A_1)^+, \tag{8}$$

where the notation $(\cdot)^+$ stands for $\max(\cdot, 0)$. At the end of the observed period the policyholder receives the value of the claim L_1 if the insurer is still solvent, i.e., the liabilities L_1 do not exceed the assets A_1. In the case of insolvency, $A_1 < L_1$, the policyholder receives only the market value of the insurer's assets A_1. Hence, the risk of insolvency is denoted by $(L_1 - A_1)^+$.

As mentioned in Section 4.1, the assets and liabilities are modelled following a geometric Brownian motion. Moving to the equivalent martingale measure $\mathbb{Q}$, the drift of the asset and liability processes change from μ_{r_A} and μ_{r_L} to the risk-free interest rate r_f, i.e., the Equations (5) are adapted as follows:

$$A_1 = A_0 \cdot \exp\left[\left(r_f - \sigma_{r_A}^2/2\right) + \sigma_{r_A}\left(W_{A,1}^{\mathbb{Q}} - W_{A,0}^{\mathbb{Q}}\right)\right], \qquad \text{and,} \tag{9}$$

$$L_1 = L_0 \cdot \exp\left[\left(r_f - \sigma_{r_L}^2/2\right) + \sigma_{r_L}\left(W_{L,1}^{\mathbb{Q}} - W_{L,0}^{\mathbb{Q}}\right)\right]. \tag{10}$$

Using these expressions, the present value of the policyholder's position can be calculated as follows:

$$\Pi_0^{\mathrm{O}} = e^{-r_f}\left(E^{\mathbb{Q}}\left[L_1\right] - E^{\mathbb{Q}}\left[(L_1 - A_1)^+\right]\right) = \Pi_0^L - \Pi_0^{\mathrm{DPO}}. \tag{11}$$

The present value of the indemnity payment for the policyholder can thus be separated into two different terms: $\Pi_0^L = e^{-r_f} E^{\mathbb{Q}}\left[L_1\right]$ stands for the present value of the liabilities L_0 and represents the fair premium in the case of no default-risk. The second term $\Pi_0^{\mathrm{DPO}} = e^{-r_f} E^{\mathbb{Q}}[(L_1 - A_1)^+]$ represents the *default put option* (DPO) that accounts for the insolvency risk in the contract and can be interpreted as the insolvency costs for the policyholder (see, e.g., Butsic, 1994, or Sommer, 1996). The additional premium amount policyholders are willing to pay for the higher safety level in the state (β), denoted by $\Delta\Pi_0^{\mathrm{O},(\alpha)\to(\beta)}$, can be described by:

$$\Delta\Pi_0^{\mathrm{O},(\alpha)\to(\beta)} = \Pi_0^{\mathrm{O},(\beta)} - \Pi_0^{\mathrm{O},(\alpha)} = e^{-r_f}\left(E^{\mathbb{Q}}\left[(L_1 - A_1^{(\alpha)})^+\right] - E^{\mathbb{Q}}\left[(L_1 - A_1^{(\beta)})^+\right]\right) = \Pi_0^{(\alpha),\mathrm{DPO}} - \Pi_0^{(\beta),\mathrm{DPO}}. \tag{12}$$

Let us consider again the Solvency II framework setting with $\epsilon = 0.5\%$. Referring to the parameterization of the reference setting (see Table 3) and the solvency capital derived in Table 4, we calculate $\Pi_0^{\mathrm{O},(\alpha)} = 99.936$ and $\Pi_0^{\mathrm{O},(\beta)} = 99.968$. Since the present value of the liabilities $L_0 = \Pi_0^L$ is the same for both scenarios with the value of 100.0, the respective values of the default put option are in state (α), $\Pi_0^{(\alpha),\mathrm{DPO}} = 0.064$, and in state ($\beta$), $\Pi_0^{(\beta),\mathrm{DPO}} = 0.032$. In such a case the theoretical additional premium amount that a policyholder is willing to pay equals $\Delta\Pi_0^{\mathrm{O},(\alpha)\to(\beta)} = 0.032$. To summarize our option pricing model, a policyholder is willing to pay an additional 0.03% of the premiums stipulated in a contract from safety state (α) while profiting from the better safety level after the introduction of the Solvency II framework (state β). A review of the above figures and additional results for different ruin probabilities in state (β) are presented in Table 7 in Section 4.3.

4.2.3 Utility-Based Model

The last model we use to assess the policyholder's willingness to pay for the higher safety level following the introduction of the Solvency II framework is a normative utility-based model. In this model, we assume a standard mean-variance preference for the policyholder, with the utility Φ expressed through

$$\Phi\left(W_t\right) = E\left[W_t\right] - \frac{a}{2}\sigma^2\left[W_t\right], \tag{13}$$

where W_1 represents the stochastic wealth position in $t = 1$, and W_0 the wealth position in $t = 0$ which is the policyholder's initial wealth. The term $E\left[W_1\right]$, respectively $\sigma^2\left[W_1\right]$, represents the expected value and the variance of the terminal wealth position of the policyholder W_1, a stands for the policyholder's risk aversion level. In what follows, we assume risk averse policyholders with $a > 0$ and consider $a = 2$ as the reference example. At time $t = 1$, the stochastic wealth position can be described by $W_1 = W_0 - \Pi_0 - L_1 + I_1$ where L_1 stands for the losses incurred and I_1 represents the insurer's indemnity payment given by Equation (8). Hence, the wealth position in time $t = 1$ is given by

$$W_1 = W_0 - \Pi_0^{\mathrm{U}} - L_1 + I_1. \tag{14}$$

Let our *ceteris paribus* assumptions (see Section 4.1) hold true in this model as well, the liabilities and initial wealth positions in the two states (α) and (β) remain equal. However, the policyholder's willingness to pay for state (β) is different to that in state (α) since the safety level in the state (β) is higher. Similarly to the previous approaches, we define

$$\Pi_0^{\mathrm{U},(\beta)} = \Pi_0^{\mathrm{U},(\alpha)} + \Delta\Pi_0^{\mathrm{U},(\alpha)\to(\beta)}. \tag{15}$$

The indemnity payment I_1 that the policyholder receives from the insurer, is comprised of the claim costs L_1 reduced by a factor for the risk that he may not receive the full claim costs due to the insurer's insolvency, namely $(L_1 - A_1)^+$. Incorporating these assumptions into the Equation (14) for both states (α) and (β), the formulae to calculate the wealth of the policyholder yield:

$$W_1^{(\alpha)} = W_0 - \Pi_0^{\mathrm{U},(\alpha)} - L_1 + \left(L_1 - (L_1 - A_1^{(\alpha)})^+\right) = W_0 - \Pi_0^{\mathrm{U},(\alpha)} - (L_1 - A_1^{(\alpha)})^+, \tag{16}$$

$$W_1^{(\beta)} = W_0 - \Pi_0^{\mathrm{U},(\alpha)} - \Delta\Pi_0^{\mathrm{U},(\alpha)\to(\beta)} - (L_1 - A_1^{(\beta)})^+ . \tag{17}$$

The policyholder's utility is evaluated using Equation (13). The utility in the two states is described by:

$$\Phi^{(\alpha)} \doteq \Phi\left(W_1^{(\alpha)}\right) = W_0 - \Pi_0^{\mathrm{U},(\alpha)} - E\left[(L_1 - A_1^{(\alpha)})^+\right] - \frac{a}{2}\sigma^2\left[(L_1 - A_1^{(\alpha)})^+\right], \tag{18}$$

$$\Phi^{(\beta)} \doteq \Phi\left(W_1^{(\beta)}\right) = W_0 - \Pi_0^{\mathrm{U},(\alpha)} - \Delta\Pi_0^{\mathrm{U},(\alpha)\to(\beta)} - E\left[(L_1 - A_1^{(\beta)})^+\right] - \frac{a}{2}\sigma^2\left[(L_1 - A_1^{(\beta)})^+\right]. \tag{19}$$

The difference $\Delta\Pi_0^{\mathrm{U},(\alpha)\to(\beta)}$ at time $t = 0$ is calibrated in such a way that $\Phi^{(\alpha)} = \Phi^{(\beta)}$ holds true, i.e., such that the utility position in both states is the same. This corresponds to assigning the additional value in utility generated to an increase of the safety level to an additional premium (additional willingness to pay). Hence, while rearranging Equations (18) and (19), we finally get

$$\Delta\Pi_0^{\mathrm{U},(\alpha)\to(\beta)} = E\left[(L_1 - A_1^{(\alpha)})^+\right] - E\left[(L_1 - A_1^{(\beta)})^+\right] + \frac{a}{2}\sigma^2\left[(L_1 - A_1^{(\alpha)})^+\right] - \frac{a}{2}\sigma^2\left[(L_1 - A_1^{(\beta)})^+\right] . \tag{20}$$

As a result of our calculations, we obtain for $a = 2$ in our reference case a value for $\Delta\Pi_0^{\mathrm{U},(\alpha)\to(\beta)}$ of 0.158. Table 6 shows the calculated results for the additional willingness to pay $\Delta\Pi_0^{\mathrm{U},(\alpha)\to(\beta)}$ in absolute terms for selected values of the risk attitude parameter a between 0.5 and 10 as well as different levels of the ruin probability. The figures illustrate that even very risk averse policyholders are only willing to pay a relatively small amount of additional premiums in order to improve their safety level. For example, considering the case of a risk aversion of $a = 10$ and the lowest target ruin probability of 0.01% considered (down from initially 1%) an additional willingness to pay of 1.275 corresponds to 1.275% of the present value of the liabilities $\Pi_0^L = 100.0$

$RP^{(\beta)}$	Risk aversion a				
	0.5	1	2	5	10
0.90%	0.011	0.018	0.033	0.076	0.147
0.75%	0.028	0.046	0.081	0.188	0.367
0.50%	0.054	0.089	**0.158**	0.366	0.713
0.25%	0.079	0.129	0.228	0.528	1.026
0.10%	0.092	0.149	0.265	0.611	1.187
0.05%	0.095	0.155	0.275	0.635	1.235
0.01%	0.099	0.161	0.285	0.656	1.275

Table 6: Additional willingness to pay $\Delta\Pi_0^{\mathrm{U},(\alpha)\to(\beta)}$ in absolute values for different safety levels ($RP^{(\beta)}$) and different levels of risk aversion a.

4.2.4 Summary of the Presented Models

Table 7 summarizes the results from the previous models. It shows the benefits from the Solvency II framework in terms of additional willingness to pay by policyholders illustrated by means of a numerical example. For the state (β), i.e., the state with the presence of the new regulatory framework, the results are provided for different values of the ruin probability. The graphs in Figure 4 illustrate the additional willingness to pay for different models as a function of the target ruin probability in state (β).

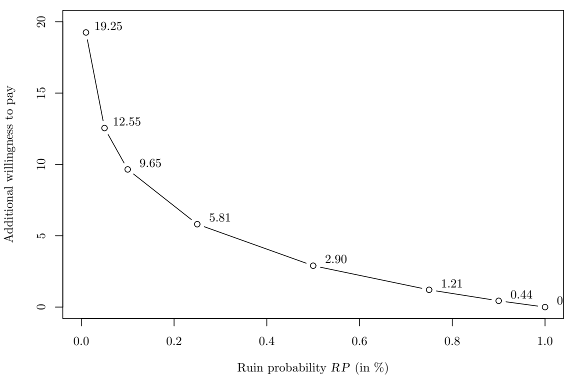
Note that when interpreting the results of Table 7, two major issues should be kept in mind. Firstly, the empiric model which yields the highest willingness to pay for by policyholders is based on a relatively small sample. In addition, the results can be influenced by biases in the perception of the interviewed survey participants. Secondly, the other two capital market oriented models do not account for – by definition – the irrationality within and inefficiencies of the capital markets and their participants. Furthermore the higher required reductions in the empirical model are in line with other literature on behavioral insurance theory. Besides Zimmer et al. (2009), also other studies found the effect that policyholder's require a significant premium reduction when default risk of the insurer comes into play (see, for example, Albrecht and Maurer, 2000, or Wakker et al., 1997). The results of the empirical and theoretical models yield different orders of magnitude which is illustrated in Figure 4. In detail, the concavity of the curves is different. While theoretical models result in a slightly concave relation of additional willingness to pay and ruin probability, the empirical model results in a convex function. The latter is strongly linked to the shape of the empirical data (see Figure 3).

4.3 Estimated Costs for the Solvency II Framework

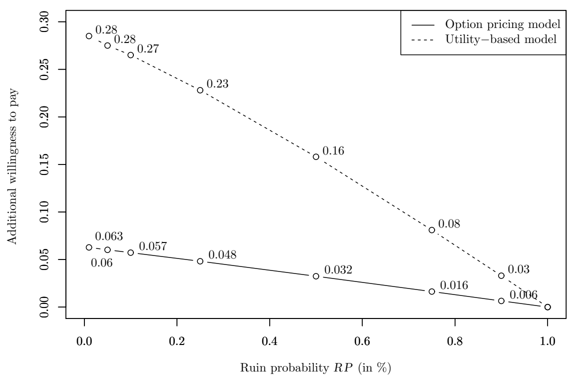
Having pointed out the benefits of the Solvency II framework in terms of additional willingness to pay above, we will now focus on the related costs to the new regulatory scheme. When it comes to assessing

State	RP	SC	Empirical model		Option pricing model		Utility-based model	
			Π_0^{E}	$\frac{\Delta\Pi_0^{\mathrm{E},(\alpha)\to(\beta)}}{\Pi_0^{\mathrm{E},(\alpha)}}$	Π_0^{O}	$\frac{\Delta\Pi_0^{\mathrm{O},(\alpha)\to(\beta)}}{\Pi_0^{\mathrm{O},(\alpha)}}$	$\Delta\Pi_0^{\mathrm{U},(\alpha)\to(\beta)}$	$\frac{\Delta\Pi_0^{\mathrm{U},(\alpha)\to(\beta)}}{\Pi_0^{L}}$
(α)	1.00%	24.50	80.75	–	99.936	–	–	–
	0.90%	24.99	81.19	0.55%	99.942	0.007%	0.033	0.033%
	0.75%	25.86	81.95	1.49%	99.952	0.016%	0.081	0.081%
	0.50%	**27.73**	**83.65**	**3.60%**	**99.968**	**0.032%**	**0.158**	**0.158%**
(β)	0.25%	30.79	86.55	7.19%	99.984	0.048%	0.228	0.228%
	0.10%	34.51	90.39	11.95%	99.993	0.057%	0.265	0.265%
	0.05%	37.11	93.30	15.55%	99.996	0.060%	0.275	0.275%
	0.01%	43.95	100.00	23.85%	99.999	0.063%	0.285	0.285%

Table 7: Overview of the policyholder premiums obtained through the three models considered for different values of the safety level. Relative premium differences are expressed as a percentage of the premium in state (α). The values reported for the empirical model are based on the "mean" scenario; a ruin probability of 0.01% yields the default risk free premium of 100.00 by our hypothesis (see Section 4.2.1). Values for the utility-based model refer to the case of a risk aversion level of $a = 2$ (see Section 4.2.3).



(a) Empirical model



(b) Option pricing and utility-based models

Figure 4: Additional willingness to pay $\Delta\Pi_0^{(\alpha)\to(\beta)}$ for different ruin probabilities in the models considered. The values reported for the empirical model are based on the "mean" scenario; values for the utility-based model refer to the case of a risk aversion level of $a = 2$.

the costs, the distinction between implementation costs and ongoing costs is necessary even if a clear differentiation is not always possible.

Implementation costs are estimated by several studies: The European Commission put the anticipated industry-wide implementation costs of the Solvency II framework in 2007 at approximately € 3 billion (CEA, 2007). However, PricewaterhouseCoopers (2010) expects that the implementation costs will be higher still. A new Financial Service Authority (FSA, UK) report from November 2011

(Financial Service Authority (FSA), 2011) estimates costs of £ 1.9 billion for the UK alone. In addition, there are sporadic costs that accompany the introduction of the Solvency II framework. Insurers need their internal models to be signed off by the regulator; the related costs incurred by the regulator will be passed back to the insurers.

In addition, many insurers have to raise additional capital in order to meet the Solvency II requirements (see, for example, Guy Carpenter, 2011a, or The Boston Consulting Group, 2010). In 2010, CEA (2011) expected EU-wide insurer's investment portfolios to account for € 7 300 billion. If the industry needed even additional equity capital of 1% (according to our calculations, an increase of as much as 2.6% from 124.50 to 127.73 is considered) under Solvency II capital requirements, the insurers would have to raise € 73 billion in additional capital. Similar values can be derived from the discussion in Pfister (2012). In the current market situation, the costs for raising capital (risk-free investment) differ from 1.75% to 3.00%. Given the risk of the capital investment, we assume (conservatively) a higher rate of 5.00%; and the raising of this amount of capital would cost € 3.65 billion per year.

Another example affects the recruiting of skilled employees. It is possible that a *war for talents* may start to attract actuarial staff. This will primarily affect smaller insurers with small risk management departments which cannot cope with the new additional requirements.

When it comes to the further ongoing costs of the Solvency II framework, the literature provides to the best of our knowledge, no estimates. Nevertheless, the following example shall give at least an indication for one aspect of the ongoing costs. It is clear that higher solvency requirements by the new framework may also have an impact on the investment allocation of the insurer. Companies would pursue a more conservative investment strategy and seek safer and less volatile investments in order to minimize their risk (see Section 3). If one assumes that only 10% of the insurer's assets, i.e. € 730 billion, will be put in safer investments, such as government bonds and if these investments yield only a 1% lower return due to their less risky nature, the industry will face a return loss of € 7.3 billion per year. However, the latter change in the asset allocation changes the risk situation of the insurer. This could iteratively enable a reduction of the needed equity capital.

Even if these estimates are very rough, one can expect a yearly recurring cost of a one to two digit billion euro amount that can be allocated to the implementation and ongoing costs of the Solvency II framework. A more detailed analysis of the incurred costs could be the focus of further research.

4.4 Comparison of Costs and Benefits of the Solvency II Framework

After having calculated different values for the benefits (in terms of the willingness to pay) in the context of the new regulatory framework, these figures are compared with the roughly estimated costs for the Solvency II framework. CEA (2011, the European Insurance and Reinsurance Federation) reported € 1 107 billion in 2010 for insurance gross written premiums (GWP) in the European Union. If we apply the policyholder's willingness to pay in the individual approaches to these European Union GWP figures, we can derive the benefits of the Solvency II framework in Euros. These values should not be exceeded from a policyholder's point of view due the increased safety level. Table 8 gives an overview of the calculated benefits for each scenario.

Model	Additional willingness to pay	Estimate of the benefits
Empirical model	0.77% – 7.85%	€ 8.52 – 86.90 bn
Option pricing model	0.032%	€ 0.35 bn
Utility-based model	0.158%	€ 1.74 bn

Table 8: Benefits from the Solvency II framework according to different models. The estimates are based on an increase of the safety from a state with a ruin probability of 1.0% to a state with a ruin probability of 0.5%. The additional willingness to pay is expressed as a % of premiums in the empirical and option pricing model, as a % of the present value of the liabilities in the utility-based model corresponding to an estimate of relative premium increase (see also Table 7). Underlying are the European Union gross written premiums amounting to € 1 107 bn in 2010.

According to our models, the highest benefits from the Solvency II framework are derived from the empirical view point. Due to the limitations of this approach (see Section 4.2.1), we take the lower end of the benefit range into consideration which yields benefits of € 8.52 billion. The option pricing model leads to the lowest benefits of € 0.35 billion. Taking our cost estimates into account, it seems that the costs of the Solvency II framework may be much higher than the theoretical benefits from a policyholder's point of view.

However, even if we assume the safety level before the introduction of Solvency II were better than 1% (which is probably true) and take into account, that the resulting estimates on the customer benefit side as well as associated regulatory costs are still in a very broad range, we at the very least would like to propose a conceptional basis on how benefits and costs of regulation could be derived in principle. The amount of the benefits derived by the policyholders' additional willingness to pay for the improvement in the insurers' safety level could be interpreted as a budget for regulatory tools like Solvency II.

Since Solvency II is based on the same structure as the Basel II framework (see, for example, Gatzert and Wesker, 2012), a closer look on the implementation costs in the banking industry for the new regulatory requirements can serve as an additional hint on what insurers have to bear in order to comply with the new supervision requirements. In 2004, PricewaterhouseCoopers (2004) estimated the implementation costs for Basel II with a figure of € 20 – 30 bn after tax. Consequently, it is not surprising that Herring (2005) argues that it is unlikely that the benefits will outweigh the costs for the implementation of and compliance with Basel II. For the new regulatory banking standard Basel III, McKinsey & Co. (2011) estimates for a midsize European bank implementation costs between € 45 mn and € 70 mn (without capital funding).

For the case of Solvency II and the application of our concept, further critical and open points for a sound use of the methodology include the following:

- Precise assessment of the safety level before the introduction of Solvency II;
- evaluation of the effective final safety level reached after the introduction of Solvency II;
- choice and calibration of the model used to measure the benefits;
- inclusion of one-time and recurring costs associated with the regulatory measure;

- estimate what costs are covered by the additional willingness to pay and which types of costs are not.

5 Conclusion

This paper introduces a conceptual approach to compare the benefits and costs of the introduction of the Solvency II framework from the policyholder's point of view with the help of an economic model. The former is represented by the policyholder's willingness to pay for the higher safety level due to the new regulation. In order to assess the benefits, we applied three different models that take the insurer's insolvency risk into consideration. First, an empirical model by Zimmer et al. (2009) was adapted. The model was based on behavioural theory where the required premium reduction demanded by policyholders was compared for different default probabilities of the related insurer. Second, an option pricing model was used where we compared the value of the policyholder's default put option before and after the implementation of the Solvency II framework. The results of this were used to obtain a drawback of the maximum amount of premiums that the policyholder is willing to pay in addition for a higher safety level. The last model was a utility-based model where we compared the expected utility of policyholders before and after the introduction of the Solvency II framework. The model translated the difference in utility into an additional premium amount that the policyholder is willing to pay for the greater safety level in the Solvency II state. The three different models yield a range of different premium amounts with regard to the policyholder's valuation of the benefits from Solvency II.

Our findings contribute to the current discussion on Solvency II and the benefit of the new regulatory measure. We agree in fact that the presented isolated analysis of costs and benefits of Solvency II is not sufficient to assess the overall usefulness of the new regulatory scheme. However, the analysis carried out exemplifies a first take on how costs and benefits of Solvency II could be compared. Further research could be undertaken to detail the assessment of the safety level before and after the introduction of Solvency II; the choice and calibration of the model used to measure the benefits; the inclusion of one-time and recurring costs associated with the regulatory measure; and what costs are covered by the additional willingness to pay, and which types of costs are not. In addition, the concept derives the regulatory budget through the policyholders' additional willingness to pay only. However, other benefits from regulation in the insurance sector such as an improvement in the stability of related industries or general corporate integration effects are not taken into account and may influence the results considerably.

Finally the results of the improvement of the safety level due to the implementation of Solvency II can also be back-tested after its introduction. Taking the entire European Union into account, a market with several hundreds of insurers can be monitored for company defaults. The annual total number of defaults can be compared before and after the introduction of Solvency II in order to underline the hypothesis that the new regulatory standard and its stricter capital requirements lead to a reduction in insurer defaults.

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