Essays on Insurance Regulation, Life Insurance Securitization, and Growth in Life Insurance

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The President:

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Für meine Eltern

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CONTENTS

SUMMARY

This dissertation is comprised of four parts, each of which represents an individual research paper. The first paper analyses the costs and benefits of regulation and is entitled "Evaluation of Benefits and Costs of Insurance Regulation – A Conceptual Model for Solvency II". Firstly, starting with the impact of the Solvency II framework on the safety level (in terms of ruin probability) of an insurer, a conceptual model is introduced in order to assess the benefits of the introduction. Subsequently, an assessment of the policyholder's willingness to pay for the higher safety level due to the Solvency II framework is done using three different models: (i) an option pricing model, (ii) an empiric behavior model, and (iii) a normative utility-based model. Comparing the estimated associated costs of Solvency II with the theoretically derived benefits, the results indicate at first glance that the costs outweigh the policyholders' willingness to pay and thus the pertaining benefits.

The second and the third research paper address issues of life insurance securitizations. Being the second part, the paper "The Impact of Life Insurance Securitization on the Issuer’s Default Risk" presents empirical results for the influence of life securitization transactions by public listed companies between 1999 and 2011 on the issuer's default risk. With the help of the Black-Scholes-Merton option pricing model, daily default probabilities for listed life insurers are calculated and the average values before a securitization transaction and after a successful deal are compared. The results show that securitization transactions are a suitable tool to lower the default probability of a life insurance company, i.e. to transfer risk from their underwriting books to third parties. Analyzing the drivers of the reduction's magnitude, the analysis shows that especially issuer specific characteristics play an important role, whereas country or market specific drivers can be neglected.

The paper "The Pricing of Hedging Longevity Risk with the Help of Annuity Securitizations: An Application to the German Market" is the third part of this dissertation and shows how insurers can use securitization transactions to address the longevity risk in their pension portfolios. A model is developed in order to hedge annuity portfolios against increases in life expectancy. Based on the percentile tranching method, where individual tranches are aligned to Standard & Poor's rating classes, an inverse survivor bond is priced. The bond offers fix coupon payments to investors while the principal payments remain at risk and depend on the survival rate within the underlying portfolio. In a last step, this securitization structure is applied to a sample portfolio from a large German life insurance company in order to calculate the securitization prices for the individual tranches.

Finally, the last part of the dissertation consists of the paper "Sales Efficiency in Life Insurance: On Growth and Profitability in the German Market", which is an empirical analysis of the drivers for sales success in the German life insurance. Since growth can be achieved while maintaining profitability in German life insurance, different multi-linear regression models are applied in order to determine what drives sales – and thus growth – in Germany for the period from 1998 to 2011. A distinction is made between sales success on the business unit level of life insurance and on the level of specific life products, i.e. the sales success drivers for pension insurance as well as term life insurance are additionally analyzed. Different significant drivers for sales success, which include the total return granted to policyholders, commissions paid to sales partners, the solvency of the insurer, the company (financial) rating, and the firm size are determined in the analysis.

ZUSAMMENFASSUNG

Die vorliegende Dissertation besteht aus vier einzelnen Teilen, von denen jeder ein eigenes Research Paper umfasst. Die erste Arbeit mit dem Titel "Evaluation of Benefits and Costs of Insurance Regulation – A Conceptual Model for Solvency II" entwickelt ein konzeptionelles Model um Kosten und Nutzen von Regulierung zu bewerten. Anhand des Beispiels von Solvency II und der einhergehenden Auswirkungen auf das Sicherheitsniveau (Ruinwahrscheinlichkeiten) von Versicherern, wird ein konzeptionelles Modell präsentiert, um den Nutzen der Einführung zu beziffern. Anschließend erfolgt eine Bewertung der Zahlungsbereitschaft seitens der Versicherungsnehmer für das gesteigerte Sicherheitsniveau aufgrund von Solvency II. Dies geschieht mit Hilfe dreier Modelle: (i) eines Optionspreismodels, (ii) eines empirischen Verhaltensmodells, (iii) sowie eines normativen Nutzenmodels. Ein Vergleich der geschätzten Kosten der Einführung von Solvency II mit dem daraus resultierenden, theoretisch abgeleiteten Nutzen zeigt, dass auf einen ersten Blick die Kosten die Zahlungsbereitschaft der Versicherungsnehmer – und somit den Nutzen – übersteigen.

Der zweite und dritte Teil der Dissertation beschäftigt sich mit der Verbriefung von Lebensversicherungen. Dabei umfasst der zweite Teil die Arbeit "The Impact of Life Insurance Securitization on the Issuer's Default Risk". Im Rahmen dieser Forschungsarbeit werden empirisch die Auswirkungen von Lebensversicherungsverbriefungen auf die Ruinwahrscheinlichkeit des Emittenten untersucht. Mit Hilfe von Transaktionen durch börsennotierte Lebensversicherer in den Jahren 1999 bis 2011 sowie des Black-Scholes-Merton-Optionspreismodels werden dabei tägliche Ruinwahrscheinlichkeiten errechnet. In einem zweiten Schritt erfolgt ein Vergleich dieser durchschnittlichen Werte vor einer Lebensversicherungsverbriefung und nach der Durchführung einer solchen Transaktion. Die Resultate belegen, dass Verbriefungen von Lebensversicherungen ein geeigneter Ansatz sind um die Ruinwahrscheinlichkeit zu senken, d.h. Risiken an den Kapitalmarkt oder Dritte zu transferieren. Eine Analyse der wesentlichen Treiber des Umfangs einer solchen Risikoreduktion zeigt, dass besonders Emittenten-spezifische Parameter einen hohen Einfluss haben, wohingegen Länder- oder Markt-spezifische Faktoren von untergeordneter Bedeutung sind.

Die dritte Forschungsarbeit trägt den Titel "The Pricing of Hedging Longevity Risk with the Help of Annuity Securitizations: An Application to the German Market" und präsentiert ein Model mit dessen Hilfe sich Lebensversicherer gegen Langlebigkeitsrisiken in ihren Rentenportfolien absichern (hedgen) können. Basierend auf der Methode des *Percentile-Tranchings*, bei der individuelle Tranchen entsprechend von S&P Ratings definiert werden, wird ein *Inverse Survivor Bond* gepreist. Dieser Bond bietet den Investoren fixe Couponzahlungen, wohingegen die Prinzipalzahlungen im Risiko stehen. Letztere sind abhängig von den Überlebensraten des zugrunde liegenden Portfolios. In einem letzten Schritt erfolgt die Anwendung des entwickelten Pricing-Models auf einen Teilbestandsabzug eines Rentenportfolios von einer großen deutschen Lebensversicherung.

Den letzte Teil der vorliegenden Dissertation bildet die Forschungsarbeit "Sales Efficiency in Life Insurance: On Growth and Profitability in the German Market". Sie stellt eine empirische Analyse der Erfolgstreiber für die Neugeschäftsgenerierung in der deutschen Lebensversicherung dar. Es wird gezeigt, dass profitables Wachstum in der deutschen Lebensversicherung in der Vergangenheit möglich

war, um anschließend mit der Hilfe verschiedener mutilinearer Regressionen anhand des Zeitraums 1998 bis 2011 zu untersuchen, welche Parameter dabei wesentlich das Wachstum beeinflussen. Die Analyse erfolgt dabei sowohl auf der Spartenebene der Lebensversicherung im Allgemeinen, als auch auf der einzelnen Produktebene anhand der Beispiele von Rentenversicherung und Risikolebensversicherung. Dabei können verschiedene signifikante Einflussfaktoren für den Neugeschäftserfolg nachgewiesen werden, darunter die laufende Verzinsung, Provisionen an Vertriebspartner, die Solvenz und das Rating des Versicherers, sowie die Firmengröße.

Part I

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

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.

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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 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 (IAIS). In their *Insurance Core Principles*, the policyholder protection is named as the aim of supervision and regulation (IAIS, 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 (IAIS) has defined the so called *Insurance Core Principles* which also provide guidance for insurance companies (IAIS, 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.

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 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

[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.

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.

	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.

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.

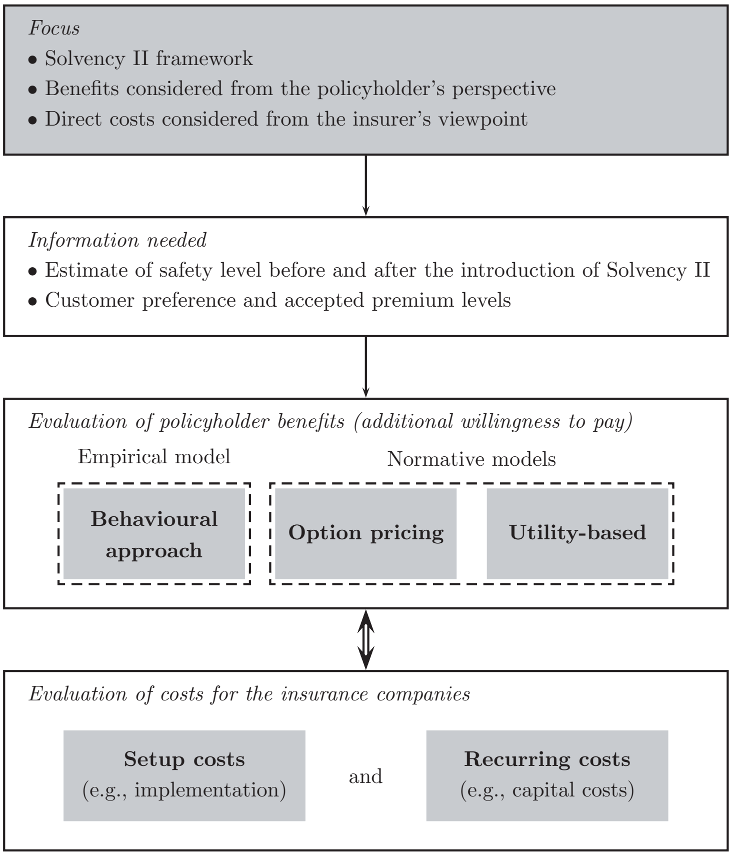


Figure 1: Overview of the approach to derive policyholder benefits and insurers' costs for the Solvency II framework.

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.

4 A Conceptual 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

$$C_0 = X_1 \cdot e^{-r_f} - X_0, \tag{1}$$

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

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

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

[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.

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.

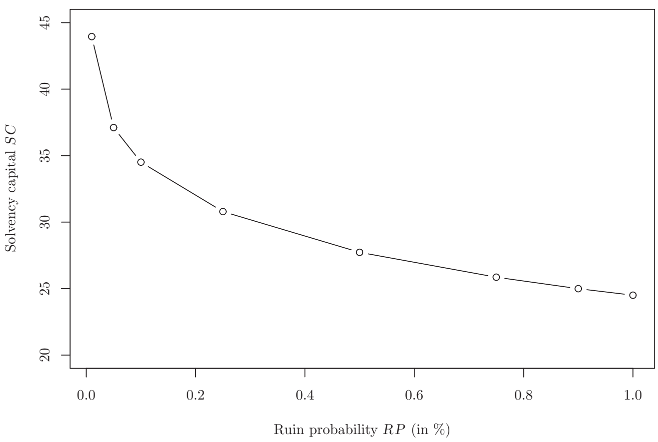


Figure 2: Illustration of the solvency capital SC required for different values of the ruin probability RP (in %).

States	$RP = \epsilon$	SC
(α)	**1.00%**	**24.50**
(β)	0.90%	24.99
	0.75%	25.86
	0.50%	**27.73**
	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]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 $\Delta^{(\alpha)\to(\beta)}RP = RP^{(\beta)} - RP^{(\alpha)} = -0.5\%$.

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

$PR_{\mathrm{up}} = 0.0107 \cdot \ln(RP) + 0.0873$ respectively. These two relations define a corridor (dotted lines) drawn on Figure 3.

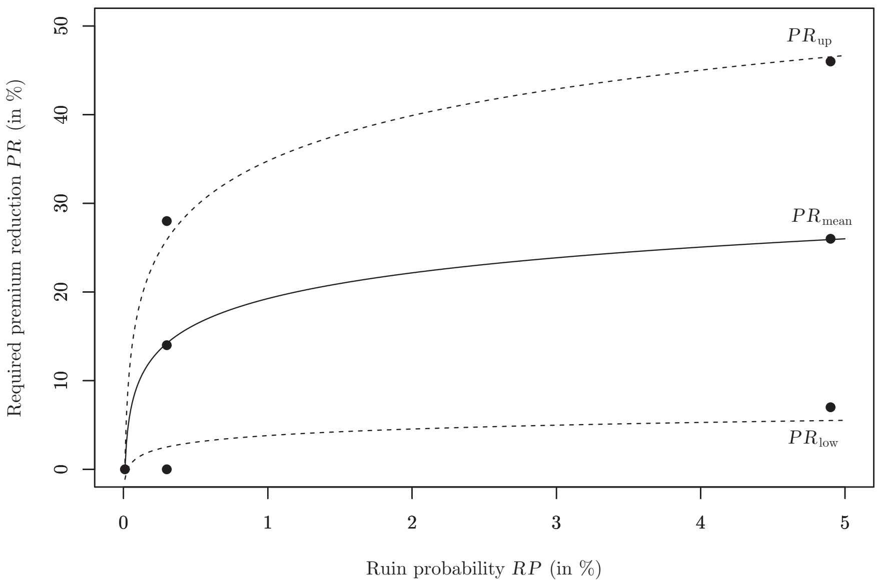


Figure 3: Illustration of the regression results on the mean willingness to pay (required premium reduction) for different ruin probabilities (solid line). The dotted lines define a bandwidth whose boundaries are determined by a regression on the mean values plus/minus one standard deviation. The dots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

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., we have $\Pi_0^L = e^{-\mathrm{r_f}} E^{\mathbb{Q}} [L_1] = 100.0$ 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

$\Pi_0^{E,(\alpha)}$ and $\Pi_0^{E,(\beta)}$) 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 $\Delta\Pi_0^{E,(\alpha)\to(\beta)} = \Pi_0^{E,(\beta)} - \Pi_0^{E,(\alpha)}$. These values are reported in column 6 of Table 5, together with the relative additional willingness to pay $\Delta\Pi_0^{E,(\alpha)\to(\beta)}/\Pi_0^{E,(\alpha)}$ (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.

Scenario	Premium reduction		Premium		$\Delta\Pi_0^{E,(\alpha)\to(\beta)}$	$\frac{\Delta\Pi_0^{E,(\alpha)\to(\beta)}}{\Pi_0^{E,(\alpha)}}$
	State (α)	State (β)	$\Pi_0^{E,(\alpha)}$	$\Pi_0^{E,(\beta)}$		
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 $\Pi_0^{E,(\alpha)}$ and $\Pi_0^{E,(\beta)}$) 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).

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 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:

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

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

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

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

The present value of the indemnity payment for the policyholder can thus be separated into two different terms: $\Pi_0^L = e^{-\mathrm{r_f}} E^{\mathbb{Q}}\left[L_1\right]$ 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 $\Pi_0^{\mathrm{DPO}} = e^{-\mathrm{r_f}} E^{\mathbb{Q}}[(L_1 - A_1)^+]$ 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 $\Delta\Pi_0^{\mathrm{O},(\alpha)\rightarrow(\beta)}$, can be described by:

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

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 (β), $\Pi_0^{(\beta),\mathrm{DPO}} = 0.032$. In such a case the theoretical additional premium amount that a policyholder is willing to pay equals $\Delta\Pi_0^{\mathrm{O},(\alpha)\rightarrow(\beta)} = 0.032$. 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 $\Delta\Pi_0^{U,(\alpha)\rightarrow(\beta)}$ 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

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

As a result of our calculations, we obtain for $a = 2$ in our reference case a value for $\Delta\Pi_0^{U,(\alpha)\rightarrow(\beta)}$ of 0.158. Table 6 shows the calculated results for the additional willingness to pay $\Delta\Pi_0^{U,(\alpha)\rightarrow(\beta)}$ 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 $\Delta\Pi_0^{U,(\alpha)\rightarrow(\beta)}$ 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).

State	*RP*	*SC*	Empirical model		Option pricing model		Utility-based model	
			Π_0^{E}	$\frac{\Delta\Pi_0^{E,(\alpha)\to(\beta)}}{\Pi_0^{E,(\alpha)}}$	Π_0^{O}	$\frac{\Delta\Pi_0^{O,(\alpha)\to(\beta)}}{\Pi_0^{O,(\alpha)}}$	$\Delta\Pi_0^{U,(\alpha)\to(\beta)}$	$\frac{\Delta\Pi_0^{U,(\alpha)\to(\beta)}}{\Pi_0^{L}}$
(α)	1.00%	24.50	80.75	–	99.936	–	–	–
(β)	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%**
	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%

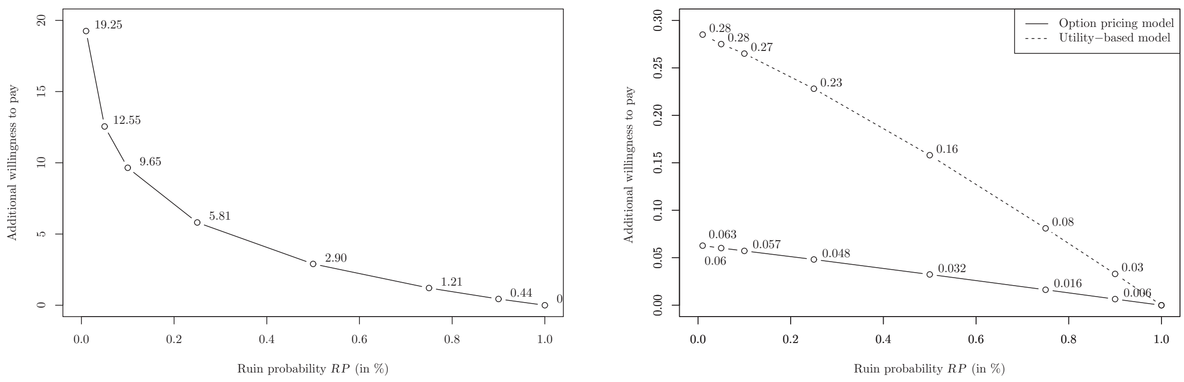
Table 7: Overview of the policyholder premiums obtained through the three models considered for different values of the safety level. Relative premium differences are expressed as a percentage of the premium in state (α). The values reported for the empirical model are based on the "mean" scenario; a 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).

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 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 require-



(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 $a = 2$.

ments (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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Part II

The Impact of Life Insurance Securitization on the Issuer's Default Risk

Abstract

Securitization transactions are a very powerful tool for financial institutions to optimize their risk position. Given the fact that the insurance securitization market has taken off in the P&C business due to the increasing usage of Cat Bonds, companies are still somewhat reluctant to use life insurance securitizations. This reluctance is in spite of the fact that these transactions should also ameliorate the insurer's risk position. In order to analyze the impact of the latter on the issuer's default probability, we perform an empirical analysis of life insurance securitizations by public listed insurers between 1999 and 2011. We will use the Black-Scholes-Merton option pricing model to assess the daily default probability of an insurance company and compare the levels of ruin probability before and after a life securitization. In line with the general view that securitization transactions transfer risk from the issuer's book to third parties, the empiric results show that life securitizations lower the ruin probability of the issuing insurer. It is especially issuer specific characteristics therefore, that determine the magnitude of the securitization impact.

Jonas Lorson (2012), The Impact of Life Insurance Securitization on the Issuer's Default Risk, *Working Papers on Risk Management and Insurance, IVW-HSG.*

1 Introduction

Despite the recent financial crisis, which was caused by an unreasoning securitization of mortgage loans, securitizing assets and cash flows is still a very powerful tool for financial service providers. The release of economic capital, the monetization of embedded profits, and the optimization of capital allocation are just a few benefits of these transactions. However, insurers are still very cautious when it comes to transferring risk from their underwriting books to the capital markets with the help of securitizations. Starting in the early nineties of the last century, Hurricane Andrew triggered the birth of this new financial product (Wemmer, 2008). Today, having strongly grown over the last years, insurance securitization primarily focuses on the P&C business via the emission of Cat bonds (see for example Doherty and Schlesinger, 2002, Cummins, 2008, or Cummins and Weiss, 2009). When it comes to the securitization of life insurance, the amount of deals and the related volume is much smaller. Nevertheless, several reasons can be observed as to how this type of transaction is also beneficial for life insurers. For instance, Rooney and Brennan (2006) or Cowley and Cummins (2005) specify that the main two benefits of the securitization are a reduction in capital costs, and an increase in the return on equity. Embedded profits in the balance sheet can be unlocked. Securitization offers an alternative possibility to financing, and helps to achieve liquidity goals. Last but not least, securitization increases the transparency of many on-balance-sheet assets and liabilities which are traditionally characterized by a certain degree of illiquidity, complexity, and informational opacity (Cowley and Cummins, 2005, p. 194).

Apart from the beneficial effects for the insurer itself, securitization of insurance portfolios also provides advantages for other players in the financial industry. It introduces a new asset class which is (largely) uncorrelated with any other asset class on the capital market (Cummins and Weiss, 2009, Lin and Cox, 2008, Deng et al., 2012, or Litzenberger et al., 1996). While bonds, stocks, and exchange rates show correlations, the value of a life portfolio is not influenced by the development of yield curves or the performance of stock indexes. Instead, the crucial factor of valuation is the life expectancy of the underlying policyholders – and this is not driven by developments in the capital markets. Consequently, the life insurance portfolio provides banks or hedge funds with a new investment possibility that will diversify the risk of their own portfolios.

In addition to the aforementioned advantages there is a further benefit that is derived from the securitization of life insurance products. By such transactions, risk of the insurer's books is transferred to the capital market, i.e. to third parties. Consequently, the overall risk position of the issuing insurer should be ameliorated. This should be reflected in the reduction of the insurer's ruin probability (see, for example, Cummins and Trainar, 2009 or De Mey, 2007).

The aim of this paper is to examine the effects of life securitizations on the issuer's risk position in terms of ruin probability. Therefore, an analysis of daily default likelihoods for securitizing life insurers before and after a securitization deal is performed. As a measurement, the Default Likelihood Indicator (DLI) from Vassalou and Xing (2004) is adapted. The analysis compares the average DLI before and after a life securitization for listed insurance companies. The effectiveness of assessing the probability of a financial service company defaulting with the help of the Black-Scholes-Merton (BSM) option pricing model – as the basis of the DLI – has been analyzed by Hillegeist et al. (2004). The authors compare the BSM-model with two widely used accounting methods, namely the Z-Score by Altman (1968) and the O-Score by Ohlson (1980). Hillegeist et al. come to the conclusion that a measurement of the default probability with the BSM-model provides significantly more insights into the company's position towards a default than the Z- and O-Score.

Comparable studies, such the one in in this paper, have been made by several researchers. Hagendorff et al. (2011) examine with the help of the Black-Scholes-Merton option pricing model, the impact of catastrophe bonds on the default risk of the issuer. The authors find that the issuing of catastrophe bonds leads to a reduction in the default risk of the issuing company. A further study by Akhigbe et al. (2007) uses the same approach to assess the impact of Fed policy actions on the default of commercial banks. The paper manages to detect evidence to support a connection between the level of Fed's interest rates and the default likelihood of commercial banks. Vallascas and Hagendorff (2011) analyze the impact of bank mergers on the default risk of the bidder with the help of the BSM-model. According to their results, European bank mergers are on average risk-neutral.

The contribution of this paper to the literature is threefold: Firstly, we present an overview on all life insurance securitization deals between 1999 and 2011 by listed companies. Secondly, the paper contributes to the literature by analyzing the risk implications of the securitizing of life insurance products. By transferrring the approach of Hagendorff et al. (2011) from cat bonds to life securitizations, we show empirically that these transactions are a suitable tool for transferring risks from the issuing company's underwriting book to third parties, i.e. to decrease the issuer's ruin probability. Thirdly, the analysis presented in this paper relates the fact that issuer specific characteristics play an important role in deciphering the magnitude of the impact from a securitization transaction.

The remainder of this paper is rooted in the structure of Hagendorff et al. (2011) and is organized as follows. Section 2 describes in detail the applied methodology of the Black-Scholes-Merton option pricing model and provides in Section 2.2 an overview of the data used for the analysis. Section 3 shows the overall impact of life securitization on the issuer's ruin probability while neglecting issuer specific characteristics. Section 4 provides the figures for the multivariate case, where an OLS regression is performed on the previous calculated changes in the daily default probability before and after a life securitization deal in order to detect the essential drivers of the securitization impact on the issuer's ruin probability. Finally, Section 5 summarizes the results and concludes the paper.

2 Methodology

The BSM-model that is used to assess the impact of life securitization deals on the default risk of the issuer is described in Section 2.1. Section 2.2 provides an overview of the data used for the analysis. Further details on the analyzed historic life securitization deals are provided in Appendix 6.

2.1 The Calculus

The approach of Hagendorff et al. (2011) is followed in order to determine the default likelihood or ruin probability of an insurance company on a daily basis. The authors base their measurement of default likelihood on the original model by Merton (1974) and the Black-Scholes-model (Black and Scholes, 1973). By doing so, they use the default likelihood indicator (DLI) introduced by Vassalou and Xing (2004). It is described in Hagendorff et al. (2011) as

$$DLI_t = N\left(-\frac{ln\left(V_{A,t}/L_t\right) + \left(\mu_A - \frac{1}{2}\sigma_{A,t}^2\right)T}{\sigma_{A,t}\sqrt{T}}\right), \tag{1}$$

with $V_{A,t}$ being the *market value* of assets on day t, L_t being the *book value* of total outstanding liabilities at the end of the respective fiscal year, μ_A being the drift of the assets, $\sigma_{A,t}$ being the annualized standard deviation of the asset returns on day t, T being the time to maturity, which is usually set at 1, and N representing the cumulative density function of the normal distribution with mean zero and standard deviation one (see also Akhigbe et al., 2007, p. 150). We follow Hagendorff et al. (2011) and calculate the daily default likelihood moving to the equivalent martingale measure $\mathbb{Q}$, which yields a change of the asset drift μ_A to the risk free rate of interest r_f, and which transforms Equation (1) to

$$DLI_t = N\left(-\frac{ln\left(V_{A,t}/L_t\right) + \left(r_f - \frac{1}{2}\sigma_{A,t}^2\right)T}{\sigma_{A,t}\sqrt{T}}\right). \tag{2}$$

Since $V_{A,t}$ and $\sigma_{A,t}$ are unobservable, the Black-Scholes-Merton option pricing method is used to derive their values (see, for example, Vallascas and Hagendorff, 2011, p. 905). According to Merton (1974), the equity can be viewed as a call option on the firm's assets. If the value of the firm's assets falls below the value of liabilities in $t = 1$, i.e. $A_1 < L_1$, the company can no longer meet its financial obligations and becomes bankrupt; the equity holders then receive nothing. Consequently, the equity can be viewed as a

European call option on the assets of the firm with a strike price of the firm's liabilities and an expiration date at time T when the liabilities matures. The value of the equity can then be described with the help of the Black-Scholes call-option formula while following the notation of Hagendorff et al. (2011) by

$$V_{E,t} = V_{A,t} N\left(d_{1,t}\right) - L_t e^{-r_f T} N\left(d_{2,t}\right) \ , \tag{3}$$

with $V_{E,t}$ being the market value of equity at the end of day t, N being the cumulative normal distribution with with mean zero and standard deviation one, and r_f being the risk-free rate. $d_{1,t}$ and $d_{2,t}$ are defined by

$$d_{1,t} = \frac{ln\left(V_{A,t}/L_t\right) + \left(r_f + \frac{1}{2}\sigma_{A,t}^2\right)T}{\sigma_{A,t}\sqrt{T}} \tag{4}$$

and

$$d_{2,t} = d_{1,t} - \sigma_{A,t}\sqrt{T} = \frac{ln\left(V_{A,t}/L_t\right) + \left(r_f - \frac{1}{2}\sigma_{A,t}^2\right)T}{\sigma_{A,t}\sqrt{T}} \ . \tag{5}$$

The standard deviation of the firm's equity $\sigma_{E,t}$ is often times referred to as the optimal hedge equation (see, for example, Akhigbe et al., 2007, p. 150) and is denoted by

$$\sigma_{E,t} = \sigma_{A,t}\frac{V_{A,t}}{V_{E,t}} N\left(d_{1,t}\right) \ . \tag{6}$$

Equations (3) and (6) are two non-linear equations with two unknowns, i.e. $V_{A,t}$ and $\sigma_{A,t}$. The process to find the value for $V_{A,t}$ and $\sigma_{A,t}$ is iterative and is described, for example, in Hillegeist et al. (2004). The two mentioned equations are simultaneously solved with $V_{E,t}$ equaling the market value of equity at the end of the fiscal year and $\sigma_{E,t}$ representing the volatility of daily equity returns over the last year multiplied by the square root of the number of trading days in the last year (i.e. 261 days) in order to annualize the result. As shown in Hagendorff et al. (2011, p. 8) and Vassalou and Xing (2004, p. 835), in order to derive $V_{A,t}$ and $\sigma_{A,t}$, an estimate of the volatility of equity $\sigma_{E,t}$ is used as an initial value for $\sigma_{A,t}$. With the help of the Black-Scholes formula, $V_{A,t}$ is computed by $V_{E,t}$ (as the market value of equity at time t) plus the book value of liabilities, i.e. $V_{A,t} = V_{E,t} + L_t$. The iterative Newton-Raphson search process for the pair of values that solve both equations is continued until it converges with a tolerance level of 1E-5 which usually happens within a few iterations (see also Hillegeist et al., 2004, p. 10). The value of r_f is represented by the yield of a two year government bond for the respective country of the issuing company.

Having derived the respective values for $V_{A,t}$ and $\sigma_{A,t}$, we can now calculate daily default probabilities with the help of Equation (2). This measure is applied to all public listed insurance companies that underwent life insurance securitization deals during the examination period of 1999 to 2011. In addition, the calculus was performed for all public listed life insurance and reinsurance companies in the countries of the issuing firms. This is necessary in order to adjust the *DLI* for industry specific impacts. This adjustment process will be briefly described below.

Similarly to Hagendorff et al. (2011), this paper also follows Vallascas and Hagendorff (2011) and aims to eliminate the effects of general industry specific, as well as, time specific trends in the analysis of default probabilities. In order to do so, a country wide daily default likelihood index is calculated. Every analyzed life insurance securitization deal is adjusted by this index. The index is calculated as the weighted DLI of all life insurance and reinsurance companies which are publicly listed in the country of the issuing firm and have not performed any life securitization deals. The weighting is done on the basis of the company's liabilities at accounting year end. By doing so, an industry-adjusted change in the default likelihood, i.e. ΔDLI_{Adj}, of life securitizing firms can be calculated by (adopted from Hagendorff et al., 2011, p. 10 and Vallascas and Hagendorff, 2011, p. 905):

$$\begin{aligned} \Delta DLI_{Adj} &= \varnothing DLI_{Before} - \varnothing DLI_{After} - \left(\varnothing DLI_{index,Before} - \varnothing DLI_{index,After}\right) \\ &= \Delta DLI_{issuer} - \Delta DLI_{index}\,. \end{aligned} \tag{7}$$

In order to understand the concrete risk impacts of the life securitization, we analyze the average daily DLI values for a time period of 30 trading days ending 2 days before the deal date, and a 30 trading days period starting 2 days after the deal date. A similar approach was followed by Akhigbe et al. (2007) and Hagendorff et al. (2011). These authors used a sixty day trading period window around the announcement day of the forthcoming deal. However, media research on life insurance securitizations has shown that for almost all deals, no prior press announcement was made. Therefore, our analysis is based on 30 trading days around the deal date. Let η be the date of the analyzed securitization deal. Consequently, the observed time periods are described by $[\eta - 31; \eta - 2]$ for the time before the deal, and $[\eta + 2; \eta + 31]$ for the time after the deal. Thus, the exact calculation is performed based on Equation (7) and can be expressed by:

$$\Delta DLI_{Adj} = \varnothing DLI_{[\eta-31;\eta-2]} - \varnothing DLI_{[\eta+2;\eta+31]} - \left(\varnothing DLI_{index[\eta-31;\eta-2]} - \varnothing DLI_{index[\eta+2;\eta+31]}\right) \tag{8}$$

A positive value of ΔDLI_{Adj} represents a reduction in the daily default risk of the issuer and can be interpreted to mean that risk from the insurer's books has been successfully transferred to the capital markets.

2.2 The Data

Analogous to catastrophe bonds that are classified by different categories, such as earthquake or hurricane, life insurance securitizations are also classified by different product types. Four major types of these transactions exist in the field of life insurance and are briefly described below (based on Cowley and Cummins, 2005, Cipra, 2010, Cummins and Weiss, 2009, or Rooney and Brennan, 2006. For a more detailed description, please refer to mentioned the authors):

- *Embedded-Value Securitizations*: The primary goal of these transaction is the monetization of future profits of the in-force book (they are also therefore called "Value-in-Force (VIF) Securitizations"). Additional capital is raised that can be invested into new business lines or investments. This type of transaction also supports a demutualization (De Mey, 2007).

- *Mortality Securitizations*: This transaction aims at relieving the risk of extreme mortalities from the insurer's books. The peak mortality risks are shifted to investors analogous to a catastrophe bond structure. It allows the insurer to hedge its portfolio against peaks in the mortality which could be caused by pandemics, earthquakes or tsunamis for instance.

- *Regulation XXX or aXXX Securitizations*: This transaction is most relevant for American insurance companies since it results from regulation changes in the U.S. The regulations, beginning in the year 2000, posses significantly higher reserve requirements for life insurance companies since they change the valuation of policies which contain guaranteed premiums. By Regulation XXX and aXXX securitization deals, the insurer is able to issue debt securities on its capital reserve requirements, and, thus, to use this financial instrument to supply the necessary amount of capital required. This category of securitization is not based on the underlying assets of the insurer, but on receivables in terms of premiums by policyholders due in the future.

- *Swaps*: A swap is typically used by a pension fund. With the help of such a contract, the fund can hedge its exposure against fluctuations in future mortality rates. The counter party is typically an investment bank which then transfers the swap to institutional investors. If customers of the pension fund live longer than expected, the fund receives payments from the investment bank. However, if the customers die earlier than expected, the fund has to pay the bank.

Swaps are intentionally left out of the analysis. This is because swap issuing companies (especially pension funds) are not publicly traded and therefore, the relevant information to analyze these transactions is unavailable.

Table 7 (see Appendix) gives an overview of life securitization deals from 1999 to 2011. To the best of our knowledge, this list is comprehensive and includes all public available life securitization transactions in the observed time period (Swap-deals are not shown in the list due to the aforementioned reasons). The data has been derived from press research in Factiva and comparable news portals, from Swiss Re publications, as well as from declarations on Artemis[1] and Trading Risk[2], two online portals for risk trading. Deals that are disclosed in € have been transferred to $ with the respective monthly average exchange rate derived from www.oanda.com. Table 1 summarizes these deals and clusters them per insurer and type. In total, 24 insurance companies created a deal volume of $ 29.6 billion.

Insurer (Values in $ mn.)	Embedded Value	Mortality	Regulation XXX/aXXX	Total
Aegon	1 574		2 090	3 664
American Skandia	568			568
Aurigen Reinsurance	118			118
Aviva	356		325	681
AXA		442		442
Banner Life			1 196	1 196
Barclays Life	665			665
FLAC Holdings (Forethought)	284			284
Friends of Provident Life	732			732
Genworth			3 505	3 505
Hannover Re	1 162			1 162
ING			825	825
MetLife	2 500		350	2 850
Mony	300			300
MunichRe		100		100
Mutual of Omaha			150	150
New Ireland Assurance	573			573
Protective Life			1 970	1 970
Prudential Financial	1 750			1 750
RGA			850	850
SBLI			175	175
Scottish Re		155	3 406	3 561
SwissRe	665	1 897		2 562
Unum	930			930
Grand Total	12 176	2 594	14 842	29 612

Table 1: Summary of deals per insurer and category from 1999-2011. Values shown are in $ million.

Figure 1 gives an overview of the historic life securitization deals per year and category. More details are provided in Table 8 in the appendix. The figure illustrates that the initial amounts were quite small and strongly grew over the years 2005 to 2007. However, in the year 2008, the volume dropped significantly. When considering the analyzed samples, several deals need to be excluded. Six insurance

[1] www.artemis.bm
[2] www.trading-risk.com

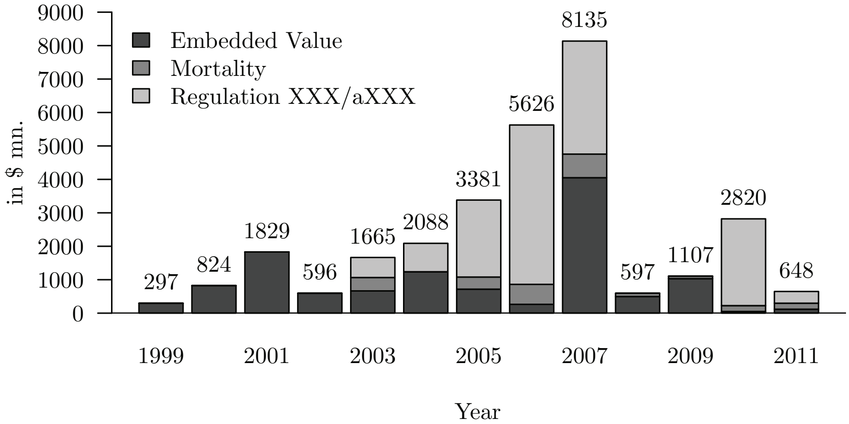

Figure 1: Historic life securitization transactions from 1999 to 2011. Figures are in $ million and categorized by Regulation XXX/aXXX securitization, mortality securitizations, and embedded value securitizations. The data on the issues has been obtained from SwissRe, Artemis, Trading Risk, as well as Factiva press research.

companies are not listed and thus need to be excluded from the analysis (Aurigen Reinsurance, Barclays Life, FLAC Holdings, Mutual of Omaha, New Ireland Assurance, and SBLI). National Provident Institution, Prudential Financial, and Friends of Provident Life were not listed at the time of the respective securitization deal and are consequently also excluded. Six deals of Genworth are similarly affected; the company's IPO date allows no intended time interval analysis on these deals and are therefore excluded as well. In addition, for five securitization deals of public listed companies, no specific deal date could be found; therefore an analysis on the above described time intervals ($[\eta - 31; \eta - 2]$ and $[\eta + 2; \eta + 31]$) could not be performed. These transactions are also excluded from the analysis. In total, 20 deals with a shared volume of $6.7 billion are not taken into account. The final sample consists of 11 primary insurers and 5 reinsurers which are geographically distributed as shown in Table 2.

Type	France	Germany	Netherlands	Switzerland	UK	US	Grand Total
Primary	1		2		3	5	11
Re		2		1	1	1	5
Grand Total	1	2	2	1	4	7	16

Table 2: Distribution of analyzed life securitization deals per insurer type and country.

The number of life securitization transactions is almost three times higher for primary insurers than for reinsurers. These figures also show that mainly US and UK based insurance companies use the life securitization tool. Continental European insurers seem to be more reluctant on the issuing of life insurance linked securities. Even very large companies such as Allianz or Generali did not undertake even one single transaction. Table 3 summarizes the *analyzed* life securitization deals in the three categories of embedded value, mortality, and Regulation XXX/aXXX transactions and distinguishes between the issuer types.

Type	Embedded Value	Mortality	Regulation XXX/aXXX	Grand Total
Primary	6 103 (13)	442 (1)	8 961 (19)	16 743 (33)
Re	950 (6)	2 152 (8)	4 256 (4)	7 358 (18)
Grand Total	7 052 (19)	2 594 (9)	13 217 (23)	22 863 (51)

Table 3: Distribution of analyzed life securitization deals per insurer type and deal type. Values shown in $ million. Figure in brackets represents the number of deals.

The highest volume has been securitized via Regulation XXX or aXXX deals, starting in the early years of the new millennium. Only a small part of the transactions ($ 2.6 billion via 9 deals) of extreme mortality risks has been transferred to the capital markets so far. The final sample covers a total of 51 transactions with a value of $ 22.8 billion.

In order to be able to calculate the DLI, the relevant data has been derived from different sources: all equity and interest related data has been sourced from Bloomberg (daily stock prices, historic interest rates per country), and all accounting related data was extracted from ThomsonONE- and Orbis-Databasis (historic figures for assets and liabilities).

3 Overall Impact of Life Securitization on the Issuer's Ruin Probability

As analyzed by Hagendorff et al. (2011), we assess the overall impact of life securitization transactions on the issuer's ruin probability and perform several robustness tests on the results. Section 3.1 presents the numerical outcomes of the calculations concerning the differences in the average of daily default probabilities over a 30 trading day time interval of $[\eta - 31; \eta - 2]$ before a life securitization deal, and $[\eta + 2; \eta + 31]$ after the deal (η being the deal date). Afterwards, Section 3.2 provides several robustness tests on the results in order to check whether the findings also hold true in different settings.

3.1 Numerical Outcomes

In this section, we analyze the overall effects of life securitization on the ruin probability of the issuer. If life securitization deals are successful in transferring risk to third parties, the average industry adjusted default likelihood index DLI_{Adj} should be lower after the transaction, i.e. $\Delta DLI_{Adj} = DLI_{Before} - DLI_{After} > 0$. Table 4 shows the results of the overall analysis. Results for the pre-issue period $[\eta - 31; \eta - 2]$ and the post issue period $[\eta + 2; \eta + 31]$ are shown, and the difference – i.e. the impact of the securitization – is calculated. In addition, values for the mean as well as the median of the analysis are presented.

	N	mean(%) (t-Statistics)	median(%) (Wilcoxon-Test)	ΔDLI$_{Adj} > 0$ N	ΔDLI$_{Adj} > 0$ %
$Pre - Issue\ DLI_{Adj,[\eta-31;\eta-2]}$	51	1.49231%*	-0.00063%		
$Post - Issue\ DLI_{Adj,[\eta+2;\eta+31]}$	51	1.24548%*	-0.00108%		
ΔDLI_{Adj}	51	0.24683%**	0.00046%**	35	68.7

Table 4: Impact of life securitization on the issuer's industry adjusted default likelihood.
Notes: The two-tailed t-statistics (for the average) as well as the non-parametric Wilcoxon-Test (for the median) are also provided. *,**, and *** represent the respective significance levels of the 10%, 5%, and 1% levels.

The adjustment of industry effects has been included by a weighted average of listed insurance companies in the respective country[3]. The weighting is based on the value of the company's liabilities in the respective accounting year.

The intended effect of lowering the insurer's ruin probability with the help of life securitization can be empirically proven in this analysis. Almost 70% of the issuing firms experience a reduction in their daily default probability after the issuing of a life security (see Table 4). On average, as per sample, a life insurance securitization lowers the ruin probability of the issuing company by 0.25%. This result is significant at the 5.0% level of the t-Test. The median reduction of ruin probability for a securitization deal is 0.00046%. The significance of this result has been tested with the help of the Wilcoxon-Test for ranked values and is also significant at the 5% level. The tests are performed against the null hypothesis that the changes in the average or median of ruin probabilities from life securitization issuing companies are zero.

Note that the shown average reduction of 0.25% seems quite high. However, one has to bear in mind that the calculus does not incorporate the hidden reserves of the issuing insurer. Taking these into account, the pre-issue and post-issue ruin probability will be lower as well as the effect of the securitization.

[3]For Germany, France and the Netherlands, the industry values are calculated on the basis of the weighted average of the three countries since France and the Netherlands have less than 3 listed insurance companies which can yield to a distorted industry picture. For coherence, Germany has also been adjusted by these Euro-zone weighting.

However, the positive trend that can be observed by life securitization on the issuer's ruin probability will still prevail.

3.2 Robustness Tests

In order to check the obtained results for robustness, we perform several robustness tests (analogous to Hagendorff et al., 2011). Firstly, we evaluate if the results presented above have been driven by issues which resulted in large changes in the daily default likelihood. In order to evaluate on a very conservative basis, we eliminate outliers which have resulted in changes in the daily default likelihood of more than 0.5%. This approach results in the exclusion of 6 deals. Running the analysis again with the reduced sample, positive differences in the daily default likelihood before and after the issuing of life securitizations can be observed again. The results are significant at the 5% level of the t-Test for the average as well as for the median using the Wilcoxon-Test.

Secondly, we check for the impact of the deal size. In doing so, all securitization deals with a volume of less than $ 100 million are eliminated from the sample. This approach results in the exclusion of 10 deals. The results of the second robustness test are in line with the previous one. A positive value of $\Delta \text{DLI}_{\text{Adj}}$ continues, both for the average and the median, however the significance level slightly decreases to the 10% level for the average and remains constant at the 5% level for the median in comparison to the base case scenario in Section 3.1.

Thirdly, the impact of the relative deal size is tested. Calculating the proportion of the respective deal in comparison with the total liabilities of the issuer, we use these values to calculate a weighted average of the $\Delta \text{DLI}_{\text{Adj}}$. The positive effect of life securitization on the issuers default risk also persists in this robustness test. The observed effect is significant at the 5% level for the average (t-Test).

The last robustness test concerns the observed time period. As mentioned earlier, Hagendorff et al. (2011) as well as Akhigbe et al. (2007) use a window of 60 trading days to observe effects in the default likelihood. The results remain qualitatively constant when running the current analysis on a 60 day trading window. The observed effect is significant at the 10% level for the average (t-Test) but shows no significance for the median (Wilcoxon-Test). The results of the performed robustness test are summarized in Table 5.

All robustness tests confirm the initial results from Section 3.1 that issuing life securitization is a suitable tool for insurers to transfer risk to third parties and lower their ruin probability in turn.

Test Type			N	t-Statistic	Wilcoxon-Test
Robustness Test 1	Outlayers	Results Confirmed	45	Yes	Yes
		Significance Level		**	**
Robustness Test 2	Absolute Deal Size	Results Confirmed	41	Yes	Yes
		Significance Level		*	**
Robustness Test 3	Relative Deal Size	Results Confirmed	51	Yes	Yes
		Significance Level		**	n.a.†
Robustness Test 4	Time Periods	Results Confirmed	51	Yes	Yes
		Significance Level		*	

Table 5: Robustness tests on the impact of life securitization on the issuer's default probability.

Notes: The two-tailed t-statistics (for the average) as well as the non-parametric Wilcoxon-Test (for the median) are also provided. *,**, and *** represent the respective significance levels of the 10%, 5%, and 1% levels.
The results are confirmed if the average (respectively the median) is greater than zero and the life securitization has a lowering effect on the issuer's ruin probability, i.e. $\text{DLI}_{\text{Before}} - \text{DLI}_{\text{After}} > 0$.
† The calculation of a weighted median is not possible.

4 Drivers of Securitization Impact on the Issuer's Ruin Probability

This section examines the influence of several different variables on the results of the change in daily default likelihoods presented above. Following Hagendorff et al. (2011), Section 4.1 introduces a multivariate regression model that is used to quantify the impact of different characteristics on ΔDLI_{Adj}. Section 4.2 then presents the numerical results of the regression.

4.1 The Regression Model

The multivariate model described in this section analyses the impact of different parameters on the change in the default likelihood of life securitizing insurance companies. In order to do so, we perform an OLS regression on the observed change in the industry adjusted default likelihood of an issuing insurer with the following multi linear equation (adopted from Hagendorff et al., 2011):

$$\Delta DLI_{Adj} = \alpha + \beta \times Issuer_i + \gamma \times Transaction_i + \delta \times Market_i + \epsilon \,, \tag{9}$$

where

- ΔDLI_{Adj} represents the industry adjusted change in the issuer's default probability that has been calculated for each life securitization deal in Section 3.1,

- α being a constant value,
- $Issuer_i$ stands for specific characteristics of the issuing insurer,
- $Transaction_i$ representing characteristics of the single transaction,
- $Market_i$ being a vector of specific market characteristics for the country of the issuing insurer, and
- ϵ being the normal distributed errors.

The values that are used in the regression for accounting figures are derived from ThomsonONE and Orbis. GDP data (which is applied in the market vector) has been retrieved from Eurostat. Country specific interest rates are taken from Bloomberg and represent the return of a 2 year government bond. All used data refers to year end figures prior to the date of the securitization deal (analogous to the analysis of Hagendorff et al., 2011). In the following sections, the applied variables in the regression are described in more detail. In order to ensure comparability, variables equal to those applied by Hagendorff et al. (2011) are tested where appropriate.

4.1.1 Issuer Characteristics

The first variable of the included issuer characteristics is the size of the issuing company ($SIZE$). Therefore, the ln-scaled values of the issuer's total assets at the year ending previous to the securitization deal are put in the regression. In order to ensure comparability, all values have been transferred to USD. Despite the common assumption that risk can be better diversified the larger the underlying portfolio, we expect that the size of the insurer will have a positive impact on the effect or risk reduction via securitization. We base our expectation on the special characteristics of the life portfolio. Individual mortality risk can be diversifed to full extended by increasing the number of risks within the portfolio, i.e. no systematic risk remains. However, shifts in the overall life expectancy of all individuals can not be mitigated by portfolio size increasing (see, for example, De Waegenaere et al., 2010). As a result, higher life expectancies can become even more dangerous for larger insurers cpmpared to smaller ones due to the portfolio size. Therefore, we expect that the beneficial influence of life securitization on the issuer's risk position (in terms of ruin probability) will increase with the underlying size of the company.

Calculating the leverage of the issuing firm by dividing the total liabilities of the company by its total assets, the variable $LEVERAGE$ is also included in the regression analysis. The positive effects on the decrease in default probability should increase with the leverage of the company. Insurance companies with high leverage ratios might have lower available excess cash flows to react to operating or investment losses for example. Securitization deals improve a company's liquidity situation (Hagendorff et al., 2011, p. 17).

The issuer's profitability is also taken into account. RoA represents the return on assets defined as the pre-tax profit divided by the total assets of the company[4]. de Haan and Kakes (2010) argue that the default risk of more profitable insurers is lower since they possess greater funds to cover for potential losses. Therefore, the return on equity should have a negative impact on the change in the issuer's default probability, i.e. more profitable insurance companies should experience a lower reduction of their default probability thanks to life securitization deals. However, these figures should be interpreted with caution in life insurance. Discrepancies between the measurement of assets and liabilities (market vs. book values) as well as effects from the accounting of acquisition expenses may distort the profitability picture of RoA-view (Swiss Re, 2012).

The variable $PREVIOUS$ represents the number of previous life insurance securitization deals before the current analyzed deal, i.e. for instance, the value for the first deal of a company equals zero. As pointed out by Hagendorff et al. (2011), it can be expected that the more often an insurer has performed a life securitization deal, the higher the reduction in his default probability after an additional deal; arguments for this hypothesis can be found on both the issuing and the buyer side. The capital market, i.e. the buyer, already has experience with the quality of the securitized assets by a specific company and can value the new deal more appropriately. The issuer himself can profit from a know-how advantage structuring and performing the securitization deal as well as from a potential reputation benefit, which is the result of previous successful deals.

In addition, two variables out of Hagendorff et al. (2011) are included in the model which account for the risk of the insurer's portfolio in order to ensure comparability of the studies. Generally, the loss ratio, defined as the sum of claim expenses divided by the premium income (Cox and Schwebach, 1992), represents an appropriate measure for the portfolio risk of an insurer. Therefore, $LOSSRATIO$ is included in the regression as well as the underwriting success $UWSUCCESS$ which is defined as the standard deviation of the loss ratio over a period of four years before the securitization date. Both variables should have a positive impact on the change of default probability, i.e. the higher the loss ratio and the underwriting risk – or the riskier the underlying portfolio – the greater the reduction of the daily default probability after the securitization deal. In the P&C business, the loss ratio appropriately reflects the profitability of the business, however in the life segment this might not be the best measure of profitability due to, for instance, timely discrepancies between premiums earned and claims paid. Nevertheless, we follow the approach of Hagendorff et al. (2011) and include these two variables in the

[4]The results remain the same if the operating profit is used instead of the pre-tax profit.

regression since many of the analyzed companies are not pure life players but also have a P&C business.

The dummy variable $TYPE$ stands for the type of the issuing firm. Two values are coded within the analyzed deals: primary insurance company or reinsurer. We expect that reinsurers can realize a higher reduction of their daily default probability in comparison to primary insurers since they have more experience with securitization transactions in general than primary insurers (Cummins and Trainar, 2009). They should be able to structure the securitization more effectively, and thus reduce their risk better than a primary insurer.

$HIGHEXP$ is the second dummy variable in the regression. The variable equals "Yes" if the issuer's default probability before the issuing of the respective life securitization deal is in the highest quartile of daily default likelihoods and "No" otherwise. Similar to Hagendorff et al. (2011) did, we expect that the reduction in default probability will be higher for firms with a high pre-issue default probability than for those with a lower pre-issue default probability.

4.1.2 Transaction Characteristics

The variable $ISSUESIZE$ measures the relative value of the issued life securitization transaction in proportion to the equity of the issuing company. The ratio is based on the market value of equity of the year end previous to the issuing date. It can be expected that a higher proportion of transferred risk, i.e. a higher relative value of the deal, results in a higher decrease in default probability since more risk will have been transferred to third parties.

4.1.3 Market Characteristics

Firstly, we follow Hagendorff et al. (2011) and control for the influence of the economic development on the risk transfer capability of life securitization deals. Therefore, the change of the gross domestic product for the respective country of the issuing firm is included in the analysis as the variable GDP.

In addition, we analyze the effect of the interest level of the issuer's country by including $INTEREST$ in the regression via the yield of a two year government bond for the respective country of the issuing firm. The rationale behind this lies in the fact that life insurance companies are very sensitive to interest fluctuation. Both the market valuation of their liabilities as well as certain embedded options in the contract react to changing interest levels (see, for example, Bernard et al., 2005, or Zaglauer and Bauer, 2008). The lower the prevailing interest level, the harder it also gets for life insurers to achieve sufficient capital returns since they mainly invest in government bonds. In some countries (for example, Germany, France, or Switzerland), there is also a certain minimum guarantee return rate for life insurance contracts. Therefore, it can be assumed that in an environment of low interest returns, the securitization of life insurance products has a more important impact on the issuer's default likelihood in comparison to high interest markets or environments.

4.2 Numerical Regression Results

The results of the OLS regressions for the base case scenario are summarized in Table 6.

Variable	β_i	Std. Error	p-value	Sign.
INTERCEPT	-0.0278	0.0256	0.2875	
SIZE	0.0013	0.0006	0.0340	**
LEVERAGE	0.0081	0.0269	0.7666	
RoA	-0.0325	0.0937	0.7313	
PREVIOUS	0.0002	0.0002	0.3665	
LOSSRATIO	0.0024	0.0014	0.0856	*
UWSUCCESS	-0.0080	0.0035	0.0307	**
TYPE (Reinsurer)	0.0028	0.0016	0.0863	*
HIGHEXP (Yes)	0.0308	0.0022	1.6E-14	***
ISSUESIZE	0.0058	0.0401	0.8864	
GDP	-0.0003	0.0003	0.3002	
INTEREST	0.0870	0.0570	0.1375	
Adjusted R^2	0.8843			
Observations	45			

Table 6: Regression results on the effect of life securitization on the issuer's default risk in the base case. Notes: *,**, and *** represent the respective significance levels of the 10%, 5%, and 1% levels. The deals from MONY and American Skandia need to be excluded from the regression analysis due to a lack of data.

The insurer specific characteristics $Issuer_i$ in the regression on the change of default probability ΔDLI_{Adj} have certain variables with significant impact on the development of the company's default situation. The size of the company has a significant influence at the 5% level on the development of the change in default probability. The larger the corporation, the higher the benefit of securitization is in terms of reducing the ruin probability. The initial hypothesis from Section 4.1.1 is confirmed. A contrary effect can be observed when considering the underwriting success (defined as the standard deviation of the loss ratio over a period of four years before the securitization date) of the issuer. The more volatile the insurer's performance has been in the past, the less influence he has over the securitization of life insurances. This observed effect is contradictory to the aforementioned expectation. The two dummy variables used in the regression, $TYPE$ and $HIGHEXP$, also show significant influence (at the 10% level and at the 1% level) for the base case scenario and confirm the hypotheses. The regression yields that reinsurers benefit more from securitization deals than primary insurers. The variables have been tested for multicollinearity with the help of variance inflation factors (VIF). All variables show VIF values under the commonly accepted treshold of 10; thus, multicollinearity can be neglected.

The transaction characteristic $Transaction_i$ has no explanatory power in our model, i.e. that the size of the transaction does not hold any significant relationship with the transaction's success with decreasing the default probability of the issuing company.

The last category of variables, $Market_i$, represents the market variables and tends to have no significant influence on the impact of life securitizations on the default probability of insurers as well.

When it comes to the performed robustness tests, the regressions on the single test samples support the qualitative results that life insurance securitizations are a suitable tool for reducing the ruin probability of the issuing company.

5 Conclusion

This paper examines the impact of life insurance securitizations on the issuer's default probability. In order to assess this ruin probability, the Black-Scholes-Merton option pricing model is applied to life securitizations of public listed companies between 1999 and 2011. This model enables the calculation of a value for the ruin probability of a company on a daily basis by interpreting the company's value of equity (which can be easily observed at the stock exchange) as a call option on the asset value. The analysis shows that life securitization deals are a suitable tool for transferring risk from the insurer's book to third parties. The ruin probability, measured by the daily DLI of Vassalou and Xing (2004), decreases, on average, after a life insurance securitization.

Our findings contribute to the discussion on the risk implications of insurance securitization. Empirical prove has been provided that both reinsurers as well as primary insurers are able to ameliorate their risk position (measured by the daily default likelihood) with the help of life insurance securitization. In addition, it has been shown that especially issuer-specific characteristics have influence on the magnitude of risk reduction by securitization.

The limitations of the study lie in the fact that the presented method can only be applied to public listed companies since the market value of equity is an essential input parameter for the calculation of daily default likelihoods. However, life securitization deals are also closed by non-listed insurers. The impact of these transactions for private companies cannot be analyzed with the applied methodology. In addition, the number of life securitization deals is still quite small; a larger data sample might strengthen the results in the future.

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6 Appendix

The following table contains, to the best of our knowledge, all life securitization deals from 1999 to 2011. As mentioned above, the data has been derived from press research in Factiva and comparable news portals, from Swiss Re publications, as well as from declarations on Artemis[5] and Trading Risk[6], two online portals for risk trading. Deals that are disclosed in € have been transferred to $ with the respective monthly average exchange rate derived from Oanda[7].

Deal Closed	Issuer	Category	Volume ($ mn.)
December-11	Aurigen Reinsurance	Embedded Value	117,65
August-11	SwissRe	Mortality	180,00
March-11	MetLife	Regulation XXX/aXXX	350,00
December-10	SwissRe	Embedded Value	50,00
December-10	Protective Life	Regulation XXX	790,00
October-10	SwissRe	Mortality	175,00
June-10	Aviva	Regulation XXX	325,00
May-10	Mutual of Omaha	Regulation XXX	150,00
April-10	Protective Life	Regulation XXX	505,00
January-10	ING	Regulation XXX	825,00
October-09	SwissRe	Mortality	75,00
October-09	Aegon	Embedded Value	900,00
January-09	Hannover Re	Embedded Value	131,60
July-08	Aegon	Embedded Value	497,07
February-08	MunichRe	Mortality	100,00
December-07	SBLI	Regulation XXX	175,00
December-07	MetLife	Embedded Value	2.500,00
October-07	Unum	Embedded Value	800,00
October-07	New Ireland Assurance	Embedded Value	573,00
July-07	Protective Life	Regulation aXXX	575,00
May-07	Aegon	Regulation XXX	550,00
April-07	Genworth	Regulation XXX	540,00
January-07	Aegon	Regulation XXX/aXXX	1.540,00
January-07	Aegon	Embedded Value	176,65
January-07	SwissRe	Mortality	705,00
December-06	FLAC Holdings	Embedded Value	134,00
November-06	AXA	Mortality	442,00
November-06	Unum	Embedded Value	130,00
October-06	Genworth	Regulation aXXX	315,00
September-06	Genworth	Regulation XXX	300,00
September-06	Banner Life	Regulation XXX	450,00

[5]www.artemis.bm
[6]www.trading-risk.com
[7]www.oanda.com

Deal Closed	Issuer	Category	Volume ($ mn.)
June-06	RGA	Regulation XXX	850,00
May-06	Scottish Re	Mortality	155,00
May-06	Scottish Re	Regulation XXX	2.100,00
January-06	Genworth	Regulation XXX	750,00
December-05	Hannover Re	Embedded Value	102,00
December-05	SwissRe	Embedded Value	370,00
December-05	Scottish Re	Regulation XXX	456,00
October-05	Genworth	Regulation XXX	300,00
August-05	Protective Life	Regulation XXX	100,00
June-05	Genworth	Regulation XXX	200,00
April-05	SwissRe	Mortality	362,00
February-05	Scottish Re	Regulation XXX	850,00
January-05	Genworth	Regulation XXX	100,00
January-05	Banner Life	Regulation XXX	98,00
January-05	Genworth	Regulation XXX	100,00
January-05	SwissRe	Embedded Value	245,00
January-05	Banner Life	Regulation XXX	49,00
January-05	Banner Life	Regulation XXX	49,00
December-04	Friends of Provident Life	Embedded Value	732,30
December-04	Genworth	Regulation XXX	300,00
October-04	Aviva	Embedded Value	356,00
November-04	Banner Life	Regulation XXX	550,00
July-04	FLAC Holdings (Forethought)	Embedded Value	150,00
December-03	SwissRe	Mortality	400,00
December-03	Genworth	Regulation XXX	300,00
October-03	Barclays Life	Embedded Value	664,50
July-03	Genworth	Regulation XXX	300,00
October-2002	Hannover Re	Embedded Value	296,10
April-02	Mony	Embedded Value	300,00
December-01	Prudential Financial	Embedded Value	1.750,00
January-01	American Skandia	Embedded Value	78,98
December-00	American Skandia	Embedded Value	77,69
December-00	American Skandia	Embedded Value	113,90
December-00	Hannover Re	Embedded Value	182,00
November-00	Hannover Re	Embedded Value	250,00
July-00	American Skandia	Embedded Value	75,10
March-00	American Skandia	Embedded Value	125,40
November-99	Hannover Re	Embedded Value	51,00
July-99	Hannover Re	Embedded Value	149,00
June-99	American Skandia	Embedded Value	97,30

Table 7: Historic life insurance securitization transactions from 1999 to 2011 per issuer and deal type (Embedded Value, Mortality, and Regulation XXX/aXXX). Values shown in $ million.

Table 8 shows the amount and number of life securitization deals per category and closure year.

Year	Embedded Value	Mortality	Regulation XXX/aXXX	Grand Total
2011	118 (1)	180 (1)	350 (1)	648 (3)
2010	50 (1)	175 (1)	2 595 (5)	2 820 (7)
2009	1 032 (2)	75 (1)		1 107 (3)
2008	497 (1)	100 (1)		597 (2)
2007	4 050 (4)	705 (1)	3 380 (5)	8 135 (10)
2006	264 (2)	597 (2)	4 765 (6)	5 626 (10)
2005	717 (3)	362 (1)	2 302 (10)	3 381 (14)
2004	1238 (3)		850 (2)	2 088 (5)
2003	665 (1)	400 (1)	600 (2)	1 665 (4)
2002	596 (2)			596 (2)
2001	1 829 (2)			1 829 (2)
2000	824 (6)			824 (6)
1999	297 (3)			297 (3)
Grand Total	12 176 (31)	2 594 (9)	14 842 (31)	29 612 (71)

Table 8: Distribution of analyzed life securitization deals per year and deal type (Embedded Value, Mortality, and Regulation XXX/aXXX).

Values shown in $ million. Figure in brackets represents the number of deals.

Part III

The Pricing of Hedging Longevity Risk with the Help of Annuity Securitizations: An Application to the German Market

Abstract

Prolongation of life expectancy implies a severe risk for annuity providers. Insurance companies can use securitization transactions to address this longevity risk in their portfolios. Securitization can serve as a substitute for classic reinsurance since it also transfers risk to third parties. We develop a model to hedge annuity portfolios against increases in life expectancy. By doing so, we forecast future mortality rates with the Lee-Carter-model and use the Wang-transformation to incorporate insurance risk. Based on the percentile tranching method, where individual tranches are aligned to Standard & Poor's ratings, we price an inverse survivor bond. This bond offers fix coupon payments to investors while the principal payments are at risk and depend on the survival rate within the underlying portfolio. Finally, we apply this securitization structure to calculate the securitization prices for a sample portfolio from a large life insurance company.

Jonas Lorson, Joël Wagner (2012), The Pricing of Hedging Longevity Risk with the Help of Annuity Securitizations: An Application to the German Market, *Working Papers on Risk Management and Insurance, IVW-HSG.*

1 Introduction

Across the globe, and in the industrial nations in particular, people have seen an unprecedented increase in their life expectancy over the last decades (see, for example, MacDonald et al., 1998). The benefits of this apply to the individual, but the dangers apply to annuity providers. Insurance companies often possess no effective tools to address the longevity risk inherent in their annuity portfolio. However, they can use the financial markets to mitigate the negative implications from an increase in life expectancy to their risk position by securitizing parts of their portfolio. The synthetic securitization acts as a hedge for the insurer's portfolio: the securitization deal transfers the risks of the portfolio to third parties and serves as a substitute for reinsurance.

In contrast to non-life segments, where securitization transactions such as CAT bonds are an established instrument now and account for high volumes, the life securitization market is still in its infancy (see, e.g., Deutsche Bank, 2010). The first mortality-linked securitization transaction was carried out by Swiss Re in 2003. The issue of the Vita Capital bond for a three-year time period reduced Swiss Re's exposure resulting from shifts in mortality. This bond had principal payments which were dependent on the development of a predefined mortality index (Blake et al., 2006). Another attempt at a longevity bond occurred in 2004. The European Investment Bank tried to issue, with the help of BNP Paribas, a bond with coupon payment depending on the survival of English and Welsh males aged 65 in the year 2002. The duration of the contract was intended to be 25 years and the total volume to be £ 540 mn. However, the transaction did not attract enough investors and was abandoned in 2005 (Chen and Cummins, 2010). After these initial attempts, the life securitization market gained momentum with increasing volumes and transactions until 2007. However, with the beginning of the financial crisis, the issuing of life securitizations dropped significantly and is still in a recovery phase today (for a detailed review, see Section 2).

The literature offers a variety of models for hedging longevity risk. Among them, Wang et al. (2011) apply the concept of reverse mortgages to hedge longevity risk for life insurance companies. Wang et al. (2010) use a model to determine the optimal annuity product mix to receive a natural hedge against longevity risk, while Luciano et al. (2012) make use of Delta-Gamma hedging. In the paper by Gatzert and Wesker (2012), the authors consider a "natural" hedge between life insurance and annuities in order to reduce net portfolio exposure to systemic mortality risk. Another approach is the annuity securitization: Kim and Choi (2011) present a method for securitizing longevity risk with the help of percentile tranching using a coupon-at-risk calculation (see also, for instance, Wills and Sherris, 2010, or Bae et al., 2009). The authors apply the concept of an inverse survivor bond to a fictional portfolio of Australian annuity contracts. Their focus lies on the yield that investors can achieve with an investment in such a bond. Our approach is closest to that of Kim and Choi (2011). We make use of a percentile tranching method directly linking chosen percentiles to Standard & Poor's (S&P) rating classes for insurance-linked securities. By doing so, investors receive a clear picture of the quality of the securitization tranche they are investing in. In addition, the issuer has the possibility to approach specific investor types in terms of risk-attitude directly with its securitization offer. Typically, the coupon payments are put at risk within an inverse survivor bond. The insurer receives on the issuing date cash flow from investors which can be considered a loan. This loan is then repaid to the creditors with an annual principal amount over the entire maturity of the bond. The principal payments are of equal size for each period; however, their full repayment remains subject to the actual survival rates within the underlying portfolio. In addition, the investors receive at each time period the respective coupon rate, which is tranche specific. Within this securitization structure, the insurer receives the loan from the investors and can use this money to generate capital returns. At the end of the transaction, the full loan has been paid back to the investors and the coupon payments depend on the portfolio's survival rates. In the current low interest capital market environment, it is doubtful if this structure is still advantageous for the insurer since the ability to generate sufficient capital returns with the borrowed money to cover potential additional payments from longevity increases might be limited. Thus, and in order to ensure that enough capital is available, our model is based on the payment of fixed coupon rates and variable repayments of the principal (principal-at-risk approach).

In this paper, we extend on methods insurer's can use to hedge their annuity portfolio against longevity risk with the help of annuity securitization. To do so, we take the perspective of the issuing insurance company and calculate the costs of hedging in a four step process. First, we calculate future mortality rates using the classic Lee-Carter-model (Lee and Carter, 1992). In a second step, we adapt the forecasted mortality rates with the help of the transformation by Wang (2000) in order to incorporate the price of risk in the insurance contract. We then apply the transformed death rates to the annuitants of our sample portfolio. Third, we slice the forecasted annuity portfolio into different tranches with the help of the percentile tranching method (analogous to Kim and Choi, 2011). Thereby, we use attachment and detachment points for the individual tranches corresponding to S&P ratings for insurance-linked securities. In a last step, we price the different tranches of our annuity securitization with the help of classical bond pricing. The principal payments that investors receive are a random variable and depend on the survival distribution of the underlying portfolio. If the number of actual survivors is higher than expected, the amount of principal payment is reduced according to the determined tranche levels. To illustrate the implication of this bond structure, we finally conduct several sensitivity tests before we apply our pricing model to the retail sample annuity portfolio from a leading German life insurer. The contribution to the academic literature is threefold. On the theoretical side, building on the work of Kim and Choi (2011), we adapt their pricing model to the current market situation. Putting the principal at risk instead of the coupon payments, the insurer is supplied with sufficient capital in order to cover additional costs due to longevity. On the empirical side, we specify the method for the German market. Inserting specific country data into the model, we analyze price sensitivities of the presented securitization model. Finally, in a case study, we apply the procedure to the annuity portfolio of a large German life insurer and calculate the price of hedging longevity risk.

The remainder of this paper is organized as follows. In Section 2, the theoretical background of securitization in general, and life insurance securitization in particular, is discussed as well as the related literature review. The concept of inverse survivor bonds is explained in detail. Section 3 presents the mathematical calculus of an annuity securitization, from the definition of future mortality rates with the help of the Lee-Carter-model up to the pricing of single securitization tranches. Section 4 presents numerical outcomes and shows the dynamics and sensitivities of our model. Afterwards, Section 5 applies the model to a real-world annuity portfolio from a large life insurance company. Section 6 summarizes the presented results and concludes.

2 Literature review and securitization market overview

With the recent financial crisis in mind – and its being caused by unsound structuring of mortgage loans – securitization is still of major interest for financial service providers in general and insurance companies in particular. In contrast to the banking sector where securitization, via asset-backed securities or collateralized debt obligations for instance, hit huge levels before the financial crisis, life insurance companies are still very cautious about these transactions despite potential benefits (see, for example, De Mey, 2007, or Beltratti and Corvino, 2008, for a review). In general, securitization can be defined as the "repackaging and trading of cash flows that traditionally would have been held on-balance-sheet" (Cummins and Weiss, 2009, p. 515). The purpose of this trading lies in the diversification of risk.

There are manifold explanations why securitization transactions are beneficial for life insurers. According to Cowley and Cummins (2005), a reduction of costs of capital as well as an increase in the return on equity are the main advantages. Through securitization, unlocking embedded profits in the balance sheet becomes possible for the issuer. In addition, this financial instrument can serve as an alternative possibility to financing. Furthermore, the transparency of many on-balance-sheet assets and liabilities – traditionally characterized by a certain degree of illiquidity, complexity, and informational opacity – is improved by securitization (Cowley and Cummins, 2005, p. 194). Other players in the financial market can also benefit from these transactions. Life securitization introduces a new asset class with almost no correlation to other investments (see also Lin and Cox, 2008). The true driver of life portfolios lies in the life expectancy of the policyholders – and this is not affected by the development of yield curves or stock market returns. Consequently, institutional investors should be able to reduce their overall portfolio risk by adding life securitization to their investments (see, for example, Litzenberger et al., 1996, and Deng et al., 2012). From a regulatory perspective, it is expected that securitization will be treated under Solvency II analogous to reinsurance when it comes to the determination of standard capital requirements (Cummins and Trainar, 2009, p. 489). At the same time, it enables third parties to invest in insurance products without possessing an insurance license by acting as investors to the securitization.

Historic life securitization transactions

Figure 1 shows an aggregation of the issued life securitizations from 1999 to 2011. The deals are clustered into three different categories: regulation XXX/aXXX securitization deals,[1] mortality securitizations and embedded value securitizations. Historically, the maximum total amount of life securitization was achieved in 2007 with a volume of $ 8.1 bn. The amount of transaction volumes then drops significantly with the start of the financial crisis in 2008 to $ 0.6 bn. In comparison with the assets on the balance sheets of life insurers, the volume of these transactions is totally negligible even in years with extensive

[1] Issuing of debt securities on insurer's capital reserve requirements for term life products. More details on the different categories can be found in, e.g., Kampa (2010) or Cowley and Cummins (2005).

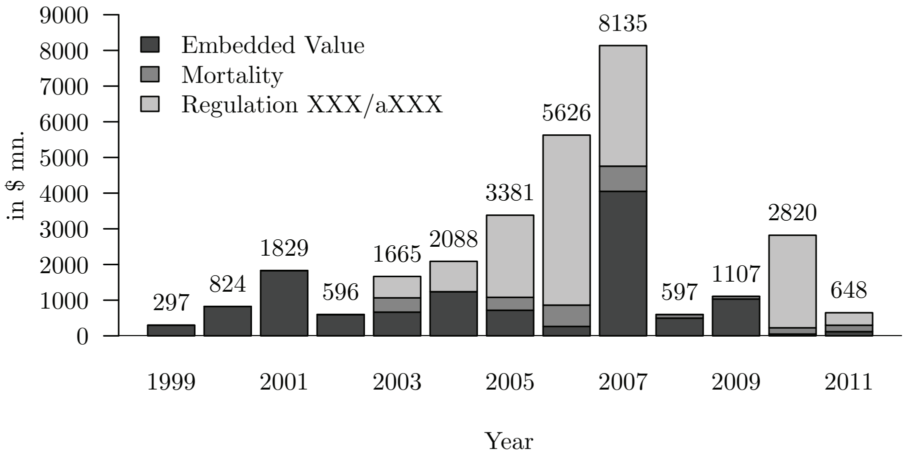

Figure 1: Historic life securitization transactions from 1999 to 2011. Figures are in million US dollars and categorized by regulation XXX/aXXX securitization, mortality securitizations, and embedded value securitizations. The data on the issues is compiled from Swiss Re (2006), Artemis (`http://www.artemis.bm`), Trading Risk (`http://www.trading-risk.com`), and Factiva press research (`www.dowjones.com/factiva`). See also Lorson (2012).

usage of this instrument. On average, the securitized deal had a size of $ 417 mn while the median of the transaction volumes is $ 300 mn. The top three issuing companies in terms of total volume are Aegon ($ 3.7 bn), Scottish Re ($ 3.6 bn), and Genworth ($ 3.5 bn). In total, insurance companies undertook 71 life securitization transactions from 1999 to 2011, of which 31 were embedded value, 31 regulation XXX/aXXX transactions and 9 mortality transactions. In that period, primary insurers securitized life products in 48 deals with a value of $ 21.6 bn and reinsurance companies transferred a volume of $ 8.4 bn with the help of 23 transactions. Further information on observed life securitization deals can be found in, e.g., Lorson (2012).

An explanation for the relatively low transaction volumes in comparison to the balance sheet assets of life insurers can be found in D'Arcy and France (1992). The concerns for the usage of insurance futures based on catastrophy loss indices stated by the author in 1992 still hold true today for the securitization of life insurance portfolios: concerns about the counterparty risk, uncertainties about the treatment of contracts by the regulator, and lack of insurer know-how or expertise. Before we can argue about the three concerns, an important difference between "normal" securitizations and the securitization of life insurance portfolios has to be pointed out. "Normal" securitizations often represent asset securitization such as mortgages or credit card receivables (see also Cowley and Cummins, 2005). The borrower receives an initial amount of money or funding and then begins to make payments (both interest and principal) over time to repay the loan. Consequently, the originator faces the credit risk of the borrower but no risk exposure exists vice versa. By any securitization deal, the economic situation and the risk of the borrower is not affected. However, when it comes to life insurance securitization, the situation is different: life securitization is a securitization of liabilities and implies a different logic. In this case, one counterparty of the original contract (the policyholder) makes payments over a long period of time and receives a payment from the other counterparty (the insurer) in the future at the end of the contract. The policyholder is consequently facing the credit risk of the counterparty and its economic position is severely affected by the counterparty, especially by the originator's default risk (see Cowley and Cummins, 2005). Insurers who are willing to pursue a life portfolio securitization have to select the buyer of their portfolio very carefully in order to avoid an increase of the counterparty risk for the policyholder. Even if the selection is done carefully and the economic situation of the policyholder will not be deteriorated, it is doubtful whether the regulator will allow such a transaction and how the regulatory environment looks like (see for example Cummins and Weiss, 2009).

Classification of securitization deals

When it comes to classifying securitization deals, Cummins and Weiss (2009) divide the securitization primarily into two different categories: the asset-backed securities such as securities backed by corporate bonds or mortgages, and the non-asset-backed products with examples like futures and options. The first are usually backed by the underlying asset that is securitized, the latter are normally guaranteed by the counterparty of the transaction and/or by an exchange. Both types of securitizations have in common that they can be traded in an organized exchange environment as well as over-the-counter. Through securitization, investors that do not possess an insurance license have access to insurance cash flows (Cox and Schwebach, 1992). This further facilitates the diversification of risk in the entire financial market.

An insurer deciding to undergo a life insurance securitization has, at least theoretically, two possibilities to proceed. The first one is a true sale of the assets which should be securitized, and the second one is a synthetic securitization. In the case of a "true" securitization the insurer would securitize its portfolio (or parts of it) by selling the contracts to investors in different tranches. In contrast to the banking sector where true sale transactions occur daily, this type of securitization does not take place in the insurance industry. The main reason for this is legal issues. As mentioned before, in life insurance the economic position of the policyholder is severely affected by the counterparty since the fulfillment of the service promise lies in the future. It is very doubtful if a regulatory authority would allow such transactions in which the counterparty obligation fades from a supervised insurance company to third party investors. In addition, such a deal would result in a giant time horizon of commitment for the investors. Contract durations of more than 60 years are not uncommon (for instance in the case of classic pension products). Only few investors might be interested in engaging in such long transactions. Furthermore, a potential investor would face several operational problems in a true sale life securitization: he must provide the necessary systems for the premium collection, for instance, or take care of the asset management. Consequently, to the best of our knowledge, there has been no true sale life securitization so far. The second option, "synthetic" securitization (or "synthetic" sale) is the common method for annuity securitization.

Within this approach, accounting for the contracts and carrying of risks remains with the insurance company. In most cases, a special purpose vehicle is established to serve as an intermediary for cash flows between the issuer and the investors. The transaction is simply a securitization of cash flows.

Models for life securitization and pricing

Several models for life securitization approaches can be found in the literature. Blake and Burrows (2001) proposes the issuing of survivor bonds whereby the coupon payment which investors receive depend on the mortality rates of a specified population and are thus a random variable (see also Dowd, 2003, and Blake, 2003). This construct of survivor bonds is also applied by Denuit et al. (2007). Other possibilities to hedge longevity risk are survivor options or swaps and futures, which are discussed, for example, by Cox and Lin (2007). Survivor swaps comprise the exchange of cash flows between two parties with a fixed cash flow in the present and an uncertain future cash flow depending on the mortality of a specified group (see, for example, Dowd et al., 2006). Cox et al. (2006) consider the first mortality securitization by Swiss Re in 2003 and use multivariate exponential tilting to price this transaction. Lin and Cox (2005) develop a model for analyzing mortality-based securities, in particular mortality bonds and swaps, and price these contracts (by applying the one factor Wang transformation). Cox et al. (2010) integrate permanent longevity jump processes as well as a temporary jump process in mortality to the Lee-Carter-model and use the derived forecasted mortality rates to price a longevity option with indifference pricing. Lin and Cox (2008) use a two-factor Wang transformation to develop an asset pricing model for securities based on mortality. Bauer et al. (2010) review existing pricing methods for longevity-linked securities and present a longevity derivative that provides an option-type payoff. Also Dowd et al. (2006) use the idea of survivor swaps to exchange future cash flows between the insurer and third parties based on a reference survivor index. Wills and Sherris (2010) securitize a longevity bond with the help of Australian mortality data. They calculate different tranches by percentage cumulative loss and price these tranches. Biffis and Blake (2010) address in their study the effects of asymmetric information on longevity securitizations and how they should be tranched under partial information. For further references on longevity securitization research, we refer to the review by Blake et al. (2011).

Inverse survivor bonds

An inverse survivor bond is a special case of survivor bonds that insurance companies can use to hedge their annuity portfolio against mortality changes. The structure of these bonds is illustrated in Figure 2.

At the center of the bond structure stands a special purpose vehicle (SPV). This legal entity brings together the issuer (the insurance company) and the investors who want to engage in the annuity portfolio. The insurer – while paying out the annuities to its annuitants – transfers the premiums received from the annuity sales to the SPV. Following the investors participation in the bond, the SPV provides contingent payments to the insurance company (securing thus the annuity payments). On the investor side, the SPV issues a survivor bond which pays regular coupon payments. Often, the principal is paid as a lump sum at the maturity of the bond, while the coupon payment is paid annually and is subject to the survival rate of the underlying portfolio, and thus at risk. The investor faces the risk that partial future coupon

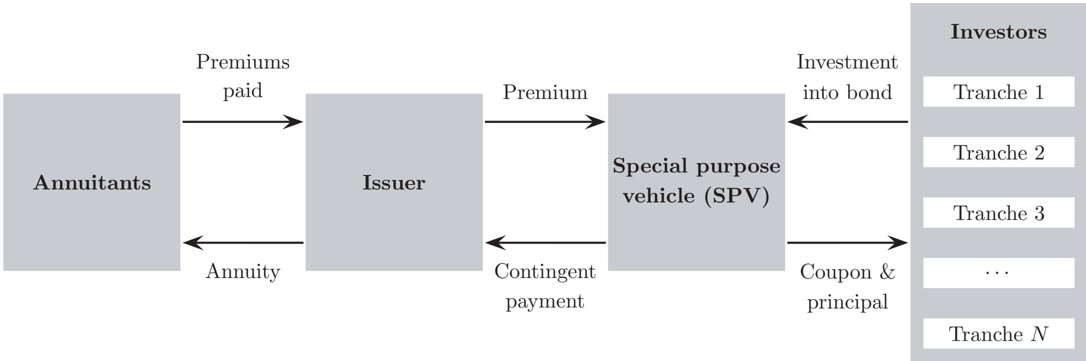

Figure 2: Structure of an Inverse Survivor Bond (adapted from Wills and Sherris, 2010, and Kim and Choi, 2011).

rates or even all future coupon rates are lost if less annuitants than ex ante expected die within the portfolio. In our consideration, as mentioned before, the principal payment will be at risk whereas the coupon payments are secured.

In order to attract more investors and to offer a tailored risk profile, the survivor bond is sliced into different tranches. Lane and Beckwith (2007) argue that tranching becomes more popular when related to insurance-linked securities. Such bonds usually possess less than ten tranches, which can differ significantly in their risk profile. The investors in the first tranche are provided with the least coverage. They are the first to lose their coupon or principal payments if the number of actual survivors in the portfolio is higher than expected. If the first tranche is exceeded, the loss moves to the second tranche, and so on. Due to the different risk characteristics, each tranche has a different price within the survivor bond. In order to signal to investors the quality of the securitized portfolio, the first loss position (the first tranche) is often kept by the issuer (see, for example, Gale and Hellwig, 1985, or Riddiough, 1997). When maintaining the first loss position, the issuer has an incentive to closely monitor the correct and timely premium collection and to price the portfolio conscientiously.

3 Calculation of the securitization of an annuity portfolio

This section describes the calculus used to synthetically securitize a life annuity portfolio. We adapt the model from Kim and Choi (2011) for an inverse survivor bond with the core difference that we set the principal payment at risk and not coupon payment. Figure 3 illustrates our approach.

Based on historic life tables, Section 3.1 describes the application of the Lee-Carter-model in order to forecast future mortality rates. Afterwards in Section 3.2, we adjust the derived survival probabilities for the uncertainty in the mortality tables as well as the uncertainty of the annuitant's lifetime. Therefore, we use the Wang-transformation (Wang, 2000) to derive the adjusted survival probability distribution for all ages x of annuitants and future years $t = 1, \dots, T$, where T denotes the duration of the securitization

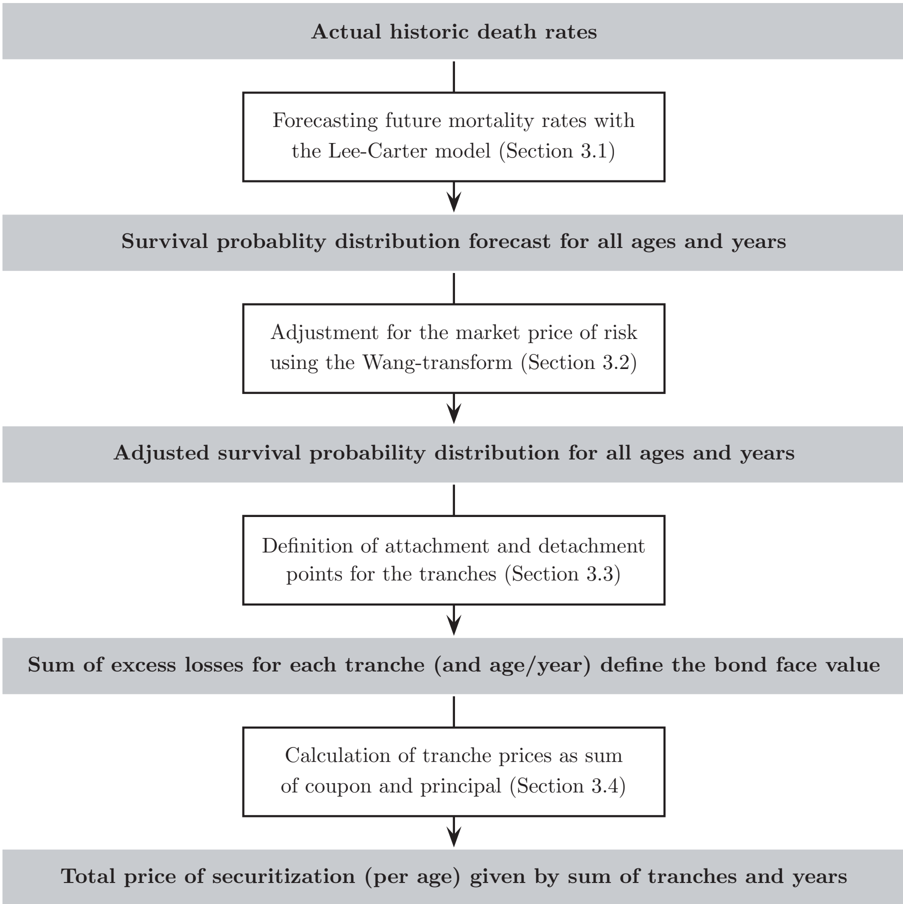

Figure 3: Approach for calculating the price of an annuity securitization.

contract. In Section 3.3 the different attachment and detachment points for each observed tranche are introduced. We define N tranches with the help of percentiles based on cumulative survival probabilities. Based on these tranche limits, we derive the value of each individual tranche j, $j = 1, \dots, N$, for each time t (until T) and the face value FV of the entire inverse survivor bond. Using this face value we price the individual tranches in Section 3.4 by calculating prices for the coupon payments as well as for the principal payments for all contract years t. We assume that coupons and principals are paid once a year at the end of the period. Finally, we derive the total price of securitization for a given annuitant aged x by summing all tranches and contract years.

3.1 Forecasting future mortality rates with the Lee-Carter model

A range of stochastic models for forecasting mortality rates have been developed in the last decade. The earliest model was developed by Lee and Carter (Lee and Carter, 1992) and several researchers built on and extended their work.[2] The Lee-Carter-model is is still the most popular model and widely used in the literature for valuating life portfolios and as a basis for insurance securitization (see, for example, Denuit et al., 2007, or Kim and Choi, 2011).

The Lee-Carter-model is a discrete time series model that uses historic mortality rates to project the future trend of mortality. It is based on the assumption that future mortality will continue to change at the same rates as it did in the past. In the model, the fitted death rates $m(x,t)$ for ages x at times t (see Lee and Carter, 1992, p. 660) follow the log-linear expression:

$$\ln m(x,t) = \alpha_x + \beta_x \kappa_t + \epsilon_{x,t}. \tag{1}$$

The death rates $m(x,t)$ are described by two age-specific constants, α_x and β_x, and a time-varying factor κ_t that represents an index of the level of mortality. The error-term $\epsilon_{x,t}$ captures the age-specific effects that are not contained in the model. The fitted parameter α_x describes the average age over time (independently of the time index). The coefficient β_x is the age-specific component describing how death rates vary to changes in the index κ_t. We consider in our model ages from $x = 0$ (less than one year) up to $x = 100$ years for the fitting. Our analyses include a separate assessment of male and female death rates, as well as of the whole population without gender-differentiation. By doing so, we choose the widely adopted method[3] of Lee and Miller (2001) who adjust the original Lee-Carter-model in three ways. First, concerning the fitting horizon, the latter half of the last century is chosen with the goal of reducing structural shifts. In addition, the mortality index k_t is adjusted to the life expectancy e_0 instead of total deaths. Finally, the "jump-off" error is eliminated through forecasting using observed instead of fitted rates.

Applying the Lee-Carter-model requires a two step process. First, the model parameters in Equation (1) are estimated based on the observed mortality rates, and, second, the projections for the future are performed. Following Lee and Carter (1992), a singular value decomposition is performed on the matrix $\ln m(x,t) - \alpha_x$ with resulting estimates of β_x and κ_t. Subsequently, an iteration process re-estimates the values for κ_t until the modeled number of deaths equals the actual amount of deaths. In order to forecast future mortality rates, Lee and Carter assume that α_x and β_x remain constant over time. To forecast the values of the mortality index κ_t, a standard univariate time series model with a random walk with drifts is used. Under these assumptions and parameterization, Equation (1) evaluates future death rates per age group, which forms the basis for all following calculations. In the following we will refer to the cumulated survival rates for a time-span of t years for individuals aged x at the time of securitization. Thus we transform the obtained mortality rates $m(x,t)$ into survival rates $1 - m(x,t)$, and derive the (simulated) t-year survival probabilities for x years aged individuals (at the time of securitization), which

[2] The most prominent models are those of Renshaw and Haberman (2006), De Jong and Tickle (2006), Delwarde et al. (2007), Czado et al. (2005), or Cairns et al. (2006).

[3] See, for example, Hanewald et al., 2011, or Booth and Tickle, 2008.

we denote by $\widetilde{p}_{x,t}$. We use the notation $\widetilde{\cdot}$ to denote random variables.

3.2 Adjustment for the market price of risk

Having calculated the future survival probabilities (Section 3.1), we now address the insurance risk inherent in a contract. Following, e.g., Kim and Choi (2011), Denuit et al. (2007), Dowd et al. (2006), and Lin and Cox (2005), we apply the Wang-transformation to our forecasted mortality rates.[4] Wang (2000) has developed a method to price the insurance risk inherent in an insurance contract which combines the classical financial as well as insurance pricing theory. Thus, we will use observed annuity prices to estimate the market price of risk for annuity mortality and then use this distribution to price bonds (see Lin and Cox, 2005). By doing so, the previously obtained survival rates $\widetilde{p}_{x,t}$ are adapted for the uncertainty in the mortality tables as well as the uncertainty in the lifetime of the annuitant.

If Φ denotes the standard normal cumulative distribution function and Φ^{-1} its inverse, Wang (2000, p. 20) introduces the distortion operator described by

$$g_{\lambda}(u) = \Phi\left[\Phi^{-1}(u) + \lambda\right], \tag{2}$$

for all u with $0 < u < 1$. The real-valued parameter λ can be interpreted as the market price of risk. Thus a function with given cumulative distribution function, F with values of $-\infty < F < +\infty$ can be transformed into a distorted distribution function F^* with the help of the market price of risk λ by the following equation,

$$F^* = 1 - g_{\lambda}(1-F) = \Phi\left[\Phi^{-1}(1-F) + \lambda\right]. \tag{3}$$

In our framework, we apply the above formula and let F stand for the cumulative distribution function of the future survival probabilities $\widetilde{p}_{x,t}$ for ages x and years t. In the sequel we denote with $\widetilde{p}^{\lambda}_{x,t}$ the so-transformed survival probabilities.

3.3 Tranche definition and excess loss per tranche

The next step involves the definition of individual tranches to be securitized and the calculation of the excess loss for each tranche. We consider N different tranches in our inverse survivor bond. The attachment points $p^{\lambda(j-1)}_{x,t}$ and detachment points $p^{\lambda(j)}_{x,t}$ for tranche j, $j = 1, \ldots, N$, are defined as a percentile of the cumulative survival distribution based on the Wang-transformed values. Here our approach differs from Kim and Choi (2011, p. 15, Fig. 12). These authors define the attachment point of the first tranche $p^{\lambda(0)}_{x,t}$ at the median survival probability or 50%-tile. In order to derive results from financial markets practice, we link the attachment points to the tranches according to the S&P default table for insurance-linked securities.[5] S&P provides cumulative default probabilities for different rating classes and different maturities. In Table 9 (see Appendix 7.2) we report the S&P cumulative default probabilities for insurance-linked securitizations corresponding to the rating classes AAA to B– and maturities ranging

[4]Chen et al. (2010) prove that for long maturities, the Wang transformation is the preferable method for longevity risk pricing.

[5]See S&P default tables from 2008, `http://www.standardandpoors.com`.

from $T = 1$ to 30 years. In our application, the detachment point of the last tranche is defined as the 100%-tile of the survival distribution, i.e. $p_{x,t}^{\lambda(N)} = 1$ (100%-tile). The attachment and detachment points for the remaining tranches can be flexible and defined according to the intended tranche composition of the securitization. The percentile below the attachment point of the first tranche $p_x^{\lambda(0)}$ is the part retained by the issuer. It can be considered as a first loss position. In our further applications, we will, e.g., define the attachment $p_{x,t}^{\lambda(0)}$ equal to the percentile of the S&P B+ tranche, which corresponds to an approximately 30% cumulative default probability within 10 years. For further tranches we consider BBB–, A, and AAA in our reference case (see Table 4). The face value FV of the bond can also be readily calculated. It corresponds to the difference between the 100%-tile of the survival distribution and the attachment point of the first tranche ($p_{x,t}^{\lambda(0)}$).

To calculate the excess loss for each tranche, we assume that the insurer pays 1 (one) currency unit to each annuitant who survives each year. In the following, we suppose the attachment points $p_{x,t}^{\lambda(j-1)}$ and the detachment points $p_{x,t}^{\lambda(j)}$ for each tranche j, $j = 1, \ldots, N$ given. Let l_x represent the initial population of annuitants of age x at the beginning of the securitization ($t = 0$). Thus the actual number of survivors in each group (tranche) is a random variable driven by the numerically simulated distribution of survival rates $\widetilde{p}_{x,t}$, and $\tilde{l}_{x+t}^{\lambda} = l_x \cdot \widetilde{p}_{x,t}^{\lambda}$ describes the actual number of survivors at age $x + t$. Furthermore, and with the yearly annuity payment set to unity, it follows that $l_{x+t}^{(j)} = l_x \cdot p_{x,t}^{\lambda(j)}$ denotes the actual amount of losses linked to the attachment/detachment points (see also Kim and Choi, 2011, pp. 11 and 16). With the above notations, we are able to derive the calculation of the excess of loss. We illustrate our proceeding in Figure 4. Each dot in Figure 4 represents one realization of the simulation run for the life expectancy of an x years aged individual at a given time t after securitization. The dashed lines indicate the attachment and detachment points of the observed tranche j (at time t). If a survival realization lies within the borders of the loss that the considered tranche j has to bear – in line with the definition of the respective attachment and detachment points – the tranche is triggered by the grey shaded loss. Thus the excess loss for the jth tranche for individuals aged x at the time of securitization and t years after securitization, denoted by $\tilde{L}_{x+t}^{(j)}$, is a random variable and can be described by

$$\widetilde{L}_{x+t}^{(j)} = \left[\tilde{l}_{x+t}^{\lambda} - l_{x+t}^{(j-1)}\right]^{+} - \left[\tilde{l}_{x+t}^{\lambda} - l_{x+t}^{(j)}\right]^{+}, \tag{4}$$

where $[\cdot]^{+}$ stands for $\max(0, \cdot)$.

Having determined the excess loss for the tranche, the cash flows to the investors have to be calculated accordingly. A reduction by the excess loss can be applied to the coupon rate or the principal payment of the inverse survivor bond. While existing literature often discusses the case of a reduction of the coupon rate, both models can be found in practice. In our model, if a tranche is triggered by an amount of survivors that is higher than expected, the principal payment of this tranche is reduced proportionally. Therefore, a proportion factor of default is introduced for each tranche j and time t that is defined by

$$\widetilde{\Lambda}_{x+t}^{(j)} = \frac{\widetilde{L}_{x+t}^{(j)}}{l_{x+t}^{(j)} - l_{x+t}^{(j-1)}}, \tag{5}$$

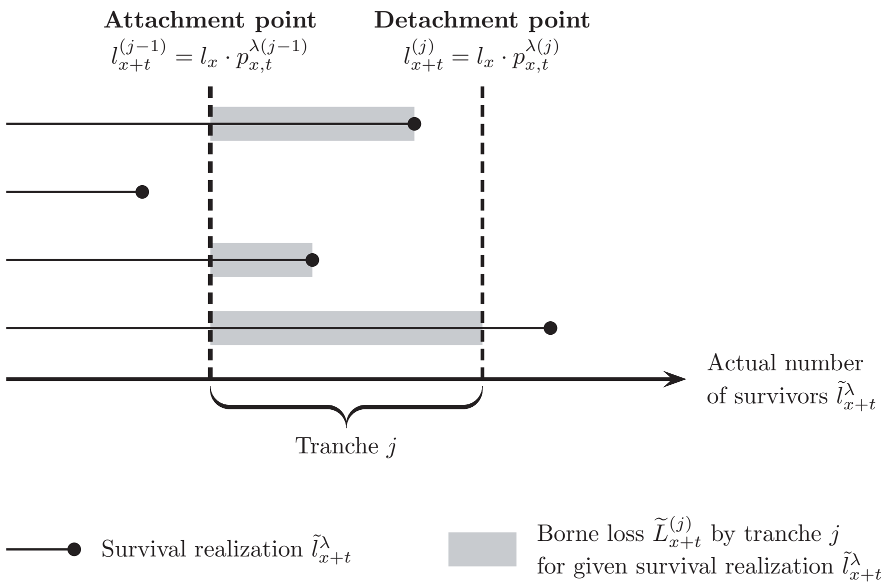

Figure 4: Illustration of the excess loss $\widetilde{L}_{x+t}^{(j)}$ calculation (see Equation 4) for tranche j at time t for annuitants aged $x+t$ (age x at the time of securitization).

where we have $0 \leq \widetilde{\Lambda}_{x+t}^{(j)} \leq 1$. This factor represents the loss percentage that is inherent in the jth tranche, given the amount of survivors for the observed realization. It corresponds to the ratio of the realized excess loss $\widetilde{L}_{x+t}^{(j)}$ in the tranche and the "width" of the tranche given by $l_{x+t}^{(j)} - l_{x+t}^{(j-1)}$.

3.4 Pricing of the inverse survivor bond

The mechanism used for pricing the single tranches and the annuity securitization is as follows. As with any other bond, the price of the inverse survivor bond consists of two parts, the coupon payment and the principal payment.

The bond is structured in a way that the back payment of the *nominal* face value FV is distributed over the duration of the contract T with T equally sized payments defined by FV/T. Since the principal payment is put at risk, it becomes a random variable which is expressed by

$$\widetilde{\mathcal{P}}_{x+t}^{(j)} = \left(1 - \widetilde{\Lambda}_{x+t}^{(j)}\right) \cdot \frac{FV}{T}, \tag{6}$$

for the tranches $j = 1, \ldots, N$ and the annuitants' ages $x+t$ $(t = 1, \ldots, T)$. The principal is inversely proportionate to the amount of losses or, framed differently, to the amount of survivors in our portfolio. The principal's value can vary between 0, in the case where the actual survival rate is greater than the detachment points of the jth tranche, and the full payment of FV/T, in the case where the actual survival rate is lower than the corresponding attachment point of the jth tranche, i.e., we have $0 \leq \widetilde{\mathcal{P}}_{x+t}^{(j)} \leq \frac{FV}{T}$.

The coupon payment is based on the outstanding principal and is paid annually. The applied annual interest rate $c^{(j)}$ for each tranche j is comprised of a reference yield y such as, for instance, LIBOR or EURIBOR, and a tranche-specific spread $s^{(j)}$, i.e., $c^{(j)} = y + s^{(j)}$. The basis for the calculation of the interest amount is defined by the outstanding amount of debt towards the investor given by $D_t = FV - (t-1) \cdot FV/T = (T-t+1) \cdot FV/T$. Thus the coupon payment is given by

$$\mathcal{C}_t^{(j)} = D_t \cdot c^{(j)} = (T-t+1) \cdot \frac{FV}{T} \cdot \left(y + s^{(j)}\right), \tag{7}$$

for all tranches $j = 1, \ldots, N$ in times $t = 1, \ldots, T$.

On the basis of the principal and coupon payments for each year and tranche along to the realized excess loss, the price of the inverse survivor bond can be derived with the help of the general bond equation. The bond price $P_x^{(j)}$ in time $t = 0$ for an x years aged individual (at the time of securitization) and for tranches $j = 1, \ldots, N$, corresponds to the present value of the sum of principal payments $P_x^{(j),\mathcal{P}}$ and the sum of all discounted coupon $P_x^{(j),\mathcal{C}}$ payments until contract maturity T. The present value calculus is done by using the discounted empirical expected payoffs. The price $P_x^{(j)}$ is given by

$$\begin{aligned}
P_x^{(j)} &= P_x^{(j),\mathcal{P}} + P_x^{(j),\mathcal{C}} \\
&= \sum_{t=1}^{T} E\left(\widetilde{\mathcal{P}}_{x+t}^{(j)} \cdot (1+r_{\mathrm{f}})^{-t}\right) + \sum_{t=1}^{T} \mathcal{C}_t^{(j)} \cdot (1+r_{\mathrm{f}})^{-t} \\
&= \sum_{t=1}^{T} \frac{1}{(1+r_{\mathrm{f}})^t} \cdot \left[E\left(\widetilde{\mathcal{P}}_{x+t}^{(j)}\right) + \mathcal{C}_t^{(j)}\right] \\
&= \frac{FV}{T} \cdot \sum_{t=1}^{T} \frac{1}{(1+r_{\mathrm{f}})^t} \cdot \left[E\left(1 - \widetilde{\Lambda}_{x+t}^{(j)}\right) + (T-t+1) \cdot \left(y + s^{(j)}\right)\right],
\end{aligned} \tag{8}$$

with r_{f} the risk-free interest and $E(\cdot)$ denoting the expected value operator.

4 Numerical implementation and results

The aim of this section is to apply the previously introduced model step-by-step to the German market and to link the definition of the tranches to S&P ratings. Thus we will be able to compare the prices for different portfolio structures (different definition of the tranches) and perform selected sensitivity analysis on the example of the results for a 65 year-old annuitant at the moment of securitization and unity (€ 1) annual pension claims.

4.1 Forecasting future mortality rates for Germany

In most industrial societies, the life expectancy of the population has risen continuously over the last decades. This also holds true for Germany. As the basis for our calculations, we use German historic mortality rates from the years 1960 to 2009. Thereby we combine the reported values of the Federal

Republic of Germany and the German Democratic Republic.[6] For our study we proceed as described in Section 3.1. For the analysis of the data on deaths and exposures as well as for the Lee-Carter forecasting of mortality rates we use the R package 'demography'.[7] Figure 5 shows the historic age-specific death rates in log-values. One can clearly observe that death rates across all ages continuously declined over the last decades. Assuming that this trend continues in the future, we use the Lee-Carter model to calculate future mortality rates for the population. First the model is fitted to the historic death rates. Figures 6 and 7 report the values of α_x, β_x, and the forecasted κ_t for the entire German population, i.e. without regard to gender (gender-indifferent case). Separate results for the male and female population are provided in Figures 14 to 17 in the Appendix 7.1.

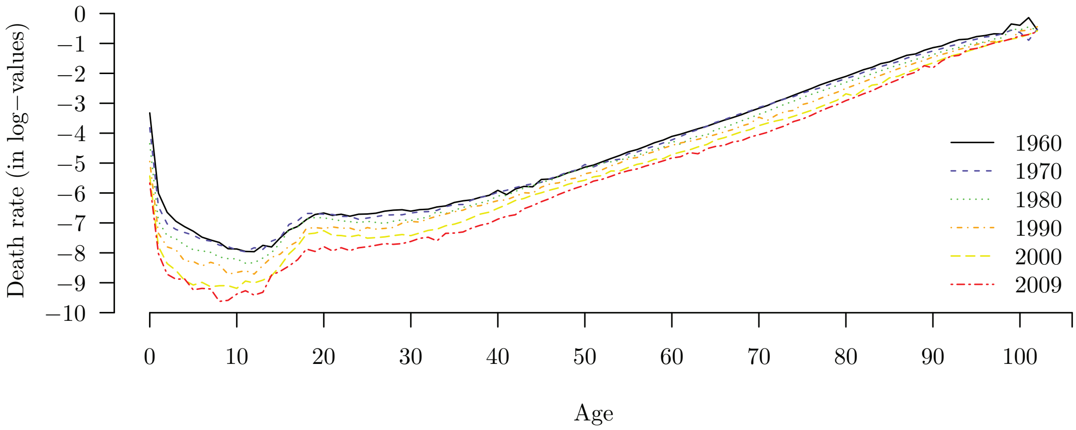

Figure 5: Illustration of German historic death rates (in log-values) for ages 0 to 102 from 1960 to 2009 using data from the Human Mortality Database available at `http://www.mortality.org`.

4.2 Adjustment for the market price of risk

After having determined the predictions on future mortality rates, the next step in securitizing annuity contracts incorporates the adjustment of these rates for insurance risk inherent in the contract with the help of the Wang-transformation as described in Section 3.2. Thus we first estimate the market price of risk λ for the German life insurance market. In order to do so, we use four different quotes of leading German life insurance companies (Allianz, AXA, Generali, and R&V) for an annuity product with an initial payment of € 100 000 and a duration of 10 years. The underlying annuitant is assumed to be a male and a female with the age at 65. For both male and female quotes, we derive the market value of

[6] The data is derived from the Human Mortality Database and available for download at `http://www.mortality.org`.
[7] See `http://cran.r-project.org/web/packages/demography/demography.pdf` for the documentation.

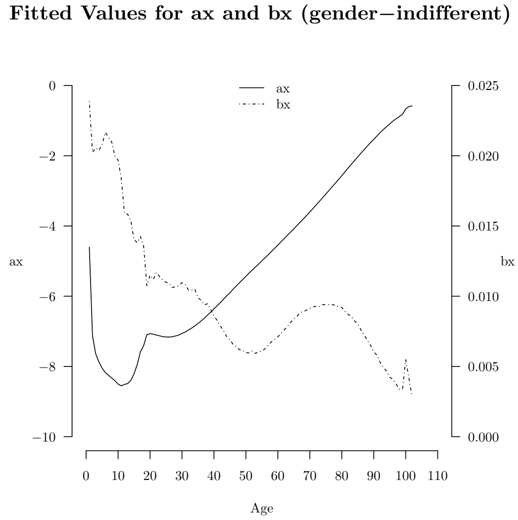

Figure 6: Fitted values for a_x and b_x for ages 0 to 101 for the German population.

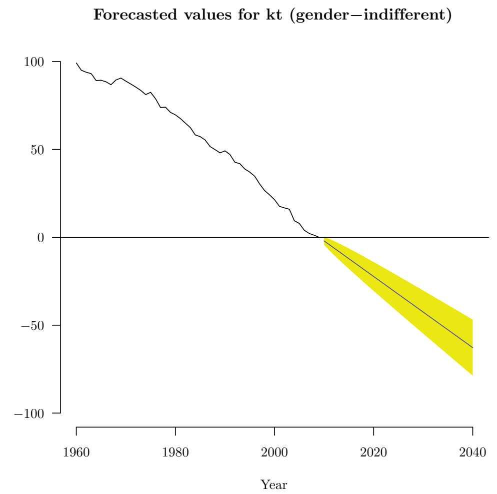

Figure 7: Forecasted values of k_t for the years 2010 to 2040 for the German population.

risk λ by numerically solving the following equation:[8]

$$\text{net single premium} = \text{annuity quote} \cdot \psi^{\lambda}_{65,10}. \tag{9}$$

The net single premium is the market price net of annuity expenses, i.e., the net single premium times $(1 - \text{cost loading})$. The cost loading is calculated individually for each company based on the disclosed acquisition and administration costs in the offer. The total cost loading is close to 6% in the analyzed offers. $\psi^{\lambda}_{65,10}$ represents the actuarial present value of a 10-year immediate annuity at age 65. The value is calculated using the risk-adjusted survival probability $p^{\lambda}_{65,10} = \left(1 - \Phi\left[\Phi^{-1}\left(q_{65,10}\right) - \lambda\right]\right)$, where $q_{65,10}$ stands for the 10-year mortality rate of a 65 year-old man or woman provided by the German Federal Statistical Office. Furthermore the discounting of the individual annuity quotes is done with an interest rate of 2.5% as an average of historic two-year government bond returns. The resulting values for the market price of risk λ differ slightly from insurer to insurer. The detailed results for the market price of risk for the different insurers are shown in Table 1.

Market price of risk λ	Allianz	AXA	Generali	R&V	Average
Male	0.3039	0.1957	0.0668	0.5243	0.2727
Female	0.1736	0.0207	0.0571	0.4906	0.1855
Average	–	–	–	–	0.2291

Table 1: Market price of risk λ for different life insurers in Germany.

[8] This proceeding follows, for example, Kim and Choi (2011), or Lin and Cox (2005).

Our findings for the German market are close to the values reported for other markets in the literature (see, for example, Kim and Choi, 2011) where often a value of 0.2 is used for λ. Since the average result of analysis is near to the values observed by other authors and in order to ensure comparability with existing literature, we will use the parameter value $\lambda = 0.2$ for the Wang-transformation.

4.3 Tranche definition in a reference case

In general, an annuity securitization – as any other securitization transaction – can be performed with different tranche ratings and thus a different inherent quality of the single tranches. In our model, we use the rating definitions of S&P for insurance-linked securities. S&P provides cumulative default probabilities for different time horizons for each rating category. Exemplary values for insurance-linked securities with a maturity of ten years are plotted in Figure 8. A detailed list of these probabilities is provided in Table 9 in Appendix 7.2. We use these values to evaluate the attachment and detachment points for the different tranches of the securitization. According to S&P, there are 16 different ratings with investment grade, ranging from the lowest rating of B− to the top rating of AAA; we only consider these ratings and no ratings for speculative assets. In addition to the different cumulative default probabilities, each rating class possess also an individual yearly yield or return. We define in our model the yield of a rating tranche as a spread in basis points (bp), i.e. hundredth of %, over a reference rate y such as LIBOR or EURIBOR. Figure 9 presents the spreads that we apply for the respective ratings (for details, see Table 9). These spreads have been adapted to observed spreads both in the securitization market as well as in the literature (see, for example, Mählmann, 2012, or Cowley and Cummins, 2005, p. 221).

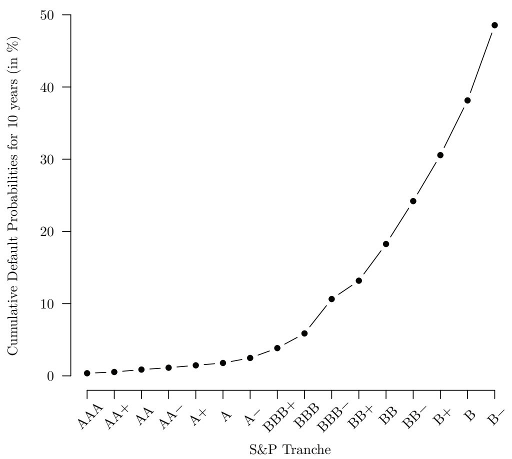

Figure 8: S&P cumulative default probabilities for insurance-linked securities for a 10-year maturity.

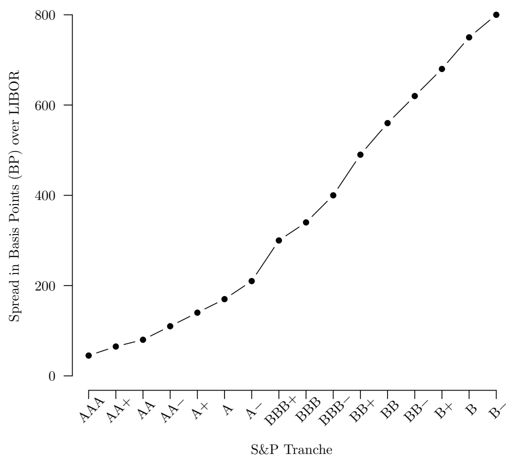

Figure 9: Applied spreads in basis points over reference yield LIBOR for different S&P tranches.

In order to specify the attachment points $p_{x,t}^{\lambda(j-1)}$ and detachment points $p_{x,t}^{\lambda(j)}$ of the tranches, we need to fix further parameters of the contract. Let us introduce a reference case through a portfolio with one annuitant aged 65 at the issuing of the securitization transaction. We set the market price of risk $\lambda = 0.2$ as derived in Section 4.2. Furthermore, for the reference case, we apply a securitization with $N = 4$ rated tranches, namely B+, BBB−, A, and AAA. This can be considered as a structure of tranches with "medium" quality. Following Table 9, the cumulative default probability of the B+ tranche, i.e. the first tranche that is accessible for investors, over a 10-year maturity is 30.565% with the corresponding survival probability of 69.435%.

It is reasonable to assume that the issuing insurer has built up reserves for its annuity portfolio over time which cover the 50%-tile of a potential survival distribution. This means that usually the reserves of annuitants dying earlier can be used to cover additional expenses by the insurers for annuitants who live longer than expected. This is close to the usual logic behind the risk pooling or pricing in insurance contracts, often refering to the expect value of claims or out-payments as measure. Given the proposed securitization structure, the insurer will still have to cover the annuity payments between the reserved 50%-tile and the percentile where the cumulative default probability of the first securitized tranche kicks in. Only from there on the risk is transferred to investors. In our example of a 10-year securitization with a B+ tranche as the most junior, this layer goes from the 50%-tile to the 69.435%-tile. This approach means that the first loss position – under the assumption of a reserve policy of the 50%-tile – is borne by the issuer. This approach is also in line with the literature postulating that the first loss piece is kept by the issuer in order to signal towards investors about the quality of the portfolio (see, for example, Riddiough, 1997, or Gale and Hellwig, 1985).

Table 2 shows the attachment points corresponding to the reference securitization. The numerical findings are based on the Wang-transformed survival rates derived from the Lee-Carter model and are compiled from 100 000 simulation runs.

T	$p_{65}^{\lambda(B+)}$	$p_{65}^{\lambda(BBB-)}$	$p_{65}^{\lambda(A)}$	$p_{65}^{\lambda(AAA)}$
1	0.9935	0.9937	0.9940	0.9942
2	0.9862	0.9866	0.9870	0.9873
3	0.9778	0.9784	0.9791	0.9796
4	0.9691	0.9699	0.9709	0.9715
5	0.9593	0.9604	0.9617	0.9624
6	0.9490	0.9503	0.9519	0.9529
7	0.9378	0.9396	0.9415	0.9428
8	0.9255	0.9276	0.9300	0.9316
9	0.9123	0.9148	0.9177	0.9196
10	0.8973	0.9003	0.9038	0.9061

Table 2: Illustration of the attachment points $p_{65}^{\lambda(j)}$ for four selected tranches B+, BBB−, A, and AAA, and maturities $T = 1, \ldots, 10$ (in years) in the reference case. The market price of risk is set to $\lambda = 0.2$.

4.4 Pricing of inverse survivor bond in a reference case

In order to derive prices for the bond, we need to define further parameters for the reference setting. For the following analysis, we assume the maturity of the inverse survivor bond to be $T = 10$ years. The considered annuitant in the reference case possesses an annual pension claim of € 1 per year and is aged $x = 65$ at the time of securitization. For our securitization, we define the face value FV of the bond equal to $T \cdot € 1 = € 10$ which is a *nominal* value. The discounted face value of the bond then equals a present value of € 8.53. Furthermore, the coupon payments of the bond are interpreted as spreads over the reference yield y. We set $y = 1\%$. The discounting is done with a risk-free interest rate $r_{\mathrm{f}} = 3\%$. The forceasting of future mortality with the help of the Lee-Carter-model is done on the basis of the whole population. Table 3 summarizes the parameter assumptions for the reference case.

Parameter	Variable	Value
Annuitants' age at issuing	x	65 years
Population/Gender	–	male & female
Maturity	T	10 years
Market price of risk	λ	0.2
Reference yield	y	1%
Risk-free interest	r_{f}	3%
Annual pension	–	€ 1

Table 3: Model parameterization in the reference case.

With these input parameters, we calculate the tranche prices $P_{65}^{(j)}$ for the securitization of the reference case. The results obtained are presented in Table 4. According to our model, the hedging of the annuity contract with an annual pension payment of € 1 for a 65 year old yields a bond price for the issuing insurer of € 10.057 (present value). This represents costs of 17.9% (1.527/8.53) based on the present value € 8.53 (present face value of the bond). The results show further that the principal amount of the securitization, which is initially distributed among the four tranches in an equal manner (see Section 3.3), differs significantly by the quality of the tranches. The most riskiest tranche – in our simulation the B+ rated tranche – suffers the highest losses and receives a principal payment of $P_{65}^{(B+),\mathcal{P}} = € 1.715$ instead of the present value of the tranche's face value 2.133 (8.53/4). The amount of coupon payments for each tranche shows exactly the opposite development than the principal. Since the spreads follow an exponential increase according to the riskiness of the tranches (see Figure 9), the B+ tranche receives the highest coupon payments, i.e. y + 680 bp, and can compensate the principal loss with the guaranteed yields. Thus the B+ tranche yields overall annually 2.3% over the risk free rate when comparing the total price $P_{65}^{(B+)} = 2.671$ to the invested € 2.133. The more senior tranche AAA suffers in the principal losses of 0.002, which is neglegible and is still renumerated with additional coupon payments yielding a total payment of 2.309 corresponding to an annual 0.8% return over the risk free rate.

Tranches j		B+	BBB−	A	AAA	Sum
Attachment point	$p_{65}^{\lambda(j)}$	69.435%	89.363%	98.218%	99.638%	
Principal payments	$P_{65}^{(j),\mathcal{P}}$	1.715	2.022	2.113	2.131	7.981
Coupon payments	$P_{65}^{(j),\mathcal{C}}$	0.955	0.612	0.331	0.178	2.076
Bond price (total)	$P_{65}^{(j)}$	2.671	2.634	2.444	2.309	10.057

Table 4: Tranche prices (in €) for the parameterization of the reference case (see Table 3).

4.5 Sensitivity analyses of the bond prices

Before we step to the valuation of the retail insurance portfolio in Section 5, we analyze the effects and sensitivities inherent to the synthetic securitization model. For this we will use fictional portfolios or contracts. In the following paragraphs we study the variations in the results, i.e., the principal and coupon payments as well as the total bond price, when changing selected contract parameters. Our first sensitivity analyses include variations in the bond maturity T and in the structure of the portfolio, i.e. the rating of the tranches and the number N of tranches. Further analysis include changes in the values of the reference yield y and of the risk-free interest r_{f} (or discount factor). Finally we also vary the underlying population considered and its historical mortality rates, i.e., we consider the total (male and female) population as well as males and females separately.

Bond maturity

First we address the differences in the bond prices for several time horizons T of the securitization transaction. For this we use the parameterization of the reference case specified in Table 3 and let T take the values 5, 10, 15, and 20 years. Table 5 presents the results of the sensitivity analysis. The results for the impact of different maturities are also illustrated through Figures 10(a)–(d).

When it comes to the maturity of the inverse survivor bond, several effects can be noticed. The longer the duration is, the more important become the coupon payments $P_{65}^{(j),\mathcal{C}}$ for the total bond price $P_{65}^{(j)}$. For example, within a $T = 20$ year transaction, the coupon payments of the most junior tranche, the B+ tranche, are in total higher than the principal payment that is made (€ 3.33 compared to € 2.58). Over all tranches and in the case $T = 20$, the sum of all coupon payments $\sum_j P_{65}^{(j),\mathcal{C}}$ represent 35.6% (= 7.236/20.349) from the total bond price $\sum_j P_{65}^{(j)}$. This ratio is only 20.6% (= 2.076/10.057) when the time horizon is $T = 10$ years. This effect can be expected since the coupon payments are stable over the entire time period while the principal payments are at risk each year anew. Furthermore, a doubling of the duration results in a total bond price that is slightly higher than twice the initial one. Prolonging the duration, for instance, from $T = 10$ years to $T = 20$ years, the total price of the transaction $\sum_j P_{65}^{(j)}$ rises from € 10.06 to € 20.35. However, this effect can almost be neglected. Comparing the annual costs – € 1.01 over 10 years with € 1.02 over 20 years – reveals an increase of only 1.2% is observed.

T	Tranches j		B+	BBB−	A	AAA	Sum
5	Attachment point	$p_{65}^{\lambda(j)}$	79.913%	95.641%	99.380%	99.900%	
	Principal payments	$P_{65}^{(j),\mathcal{P}}$	1.021	1.122	1.142	1.145	4.429
	Coupon payments	$P_{65}^{(j),\mathcal{C}}$	0.273	0.175	0.095	0.051	0.594
	Bond price (total)	$P_{65}^{(j)}$	1.294	1.297	1.236	1.195	5.023
10 (reference case)	Attachment point	$p_{65}^{\lambda(j)}$	69.435%	89.363%	98.218%	99.638%	
	Principal payments	$P_{65}^{(j),\mathcal{P}}$	1.715	2.022	2.113	2.131	7.981
	Coupon payments	$P_{65}^{(j),\mathcal{C}}$	0.955	0.612	0.331	0.178	2.076
	Bond price (total)	$P_{65}^{(j)}$	2.671	2.634	2.444	2.309	10.057
15	Attachment point	$p_{65}^{\lambda(j)}$	61.904%	84.582%	96.136%	98.963%	
	Principal payments	$P_{65}^{(j),\mathcal{P}}$	2.211	2.725	2.919	2.979	10.833
	Coupon payments	$P_{65}^{(j),\mathcal{C}}$	1.990	1.276	0.689	0.370	4.325
	Bond price (total)	$P_{65}^{(j)}$	4.201	4.001	3.608	3.349	15.159
20	Attachment point	$p_{65}^{\lambda(j)}$	56.802%	80.409%	93.507%	97.825%	
	Principal payments	$P_{65}^{(j),\mathcal{P}}$	2.576	3.264	3.570	3.704	13.113
	Coupon payments	$P_{65}^{(j),\mathcal{C}}$	3.330	2.134	1.153	0.619	7.236
	Bond price (total)	$P_{65}^{(j)}$	5.905	5.398	4.723	4.323	20.349

Table 5: Results of the sensitivity analysis of the securitization prices with regard to different maturities $T = 5, 10, 15, 20$ of the transaction. Values shown are in € for the parameterization (except for T) from the reference case given in Table 3.

Portfolio structure

Next, we address the impact of different portfolio structures on the prices of the securitization. For our study, we typically consider four different tranches in our securitization transaction. In order to test the impact of different tranche layouts on the price of the portfolio hedging, we apply in the following four different portfolio securitizations. First, we reconsider the "medium"-rated securitization with AAA, A, BBB−, and B+ tranches introduced in the reference case (see Section 4.3). The second approach is a synthetic securitization with "top"-rated tranches, i.e. the portfolio is sliced in a AAA, AA+, AA, and B+ tranche. The third securitization structure represents a "poor"-rated deal with BB+, BB, BB−, and B+ tranches. The last calculation is based on a securitization that entails each S&P rating class between B+ and AAA, i.e. 14 different tranches. If the insurer targets more risk-averse investors with its securitization, it is more likely that the company will pursue a strategy that generates more highly rated tranches ("top" structure). However, if more risk-affine investors are addressed, a synthetic securitization with a higher proportion of riskier tranches is structured ("poor" structure). In Table 6 we report the results from the sensitivity analysis for the structures "medium", "top", and "poor". Figures 11(a)–(d)

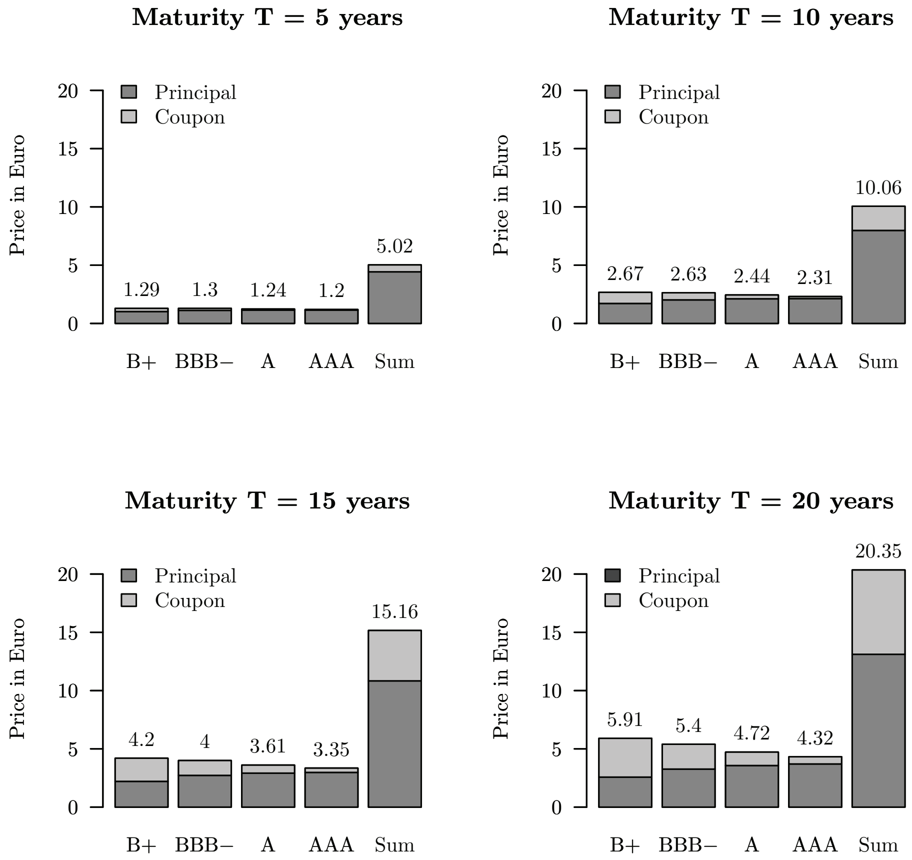

Figure 10: Results of the sensitivity analysis of the securitization prices with regard to different maturities $T = 5, 10, 15, 20$ of the transaction. Values shown are in € for the parameterization (except for T) from the reference case given in Table 3.

illustrate the tranche prices for all four different securitization structures.

Given the parameterization of the reference case given in Table 3, the calculations reveal that a more poorly rated portfolio with tranches B+, BB−, BB, and BB+ – which represent the first four tranches starting from B+ – yields the highest securitization price with $\sum_j P_{65}^{(j)}$ = € 10.48, whereas a portfolio consisting of highly rated tranches (B+, AA, AA+, and AAA) accounts for the lowest price with € 9.84. This is a difference of 6.5%. The reference case with a securitization structure of medium quality accounts for a price of € 10.06. A securitization including all 14 S&P tranches from B+ to AAA is priced € 9.89. The ratio of all principal payments to the total bond price, $\sum_j P_{65}^{(j),\mathcal{P}} / \sum_j P_{65}^{(j)}$ varies from 67.9% (“poor” structure) to 84.2% (“top” structure) and is strongly related to the rating and the default probabilities

"Medium" (reference case)	Tranches j		B+	BBB−	A	AAA	Sum
	Attachment point	$p_{65}^{\lambda(j)}$	69.435%	89.363%	98.218%	99.638%	
	Principal payments	$P_{65}^{(j),\mathcal{P}}$	1.715	2.022	2.113	2.131	7.981
	Coupon payments	$P_{65}^{(j),\mathcal{C}}$	0.955	0.612	0.331	0.178	2.076
	Bond price (total)	$P_{65}^{(j)}$	2.671	2.634	2.444	2.309	10.057
"Top"	Tranches j		B+	AA	AA+	AAA	Sum
	Attachment point	$p_{65}^{\lambda(j)}$	69.44%	99.13%	99.46%	99.64%	
	Principal payments	$P_{65}^{(j),\mathcal{P}}$	1.913	2.118	2.123	2.131	8.285
	Coupon payments	$P_{65}^{(j),\mathcal{C}}$	0.955	0.220	0.202	0.178	1.556
	Bond price (total)	$P_{65}^{(j)}$	2.868	2.338	2.325	2.309	9.840
"Poor"	Tranches j		B+	BB−	BB	BB+	Sum
	Attachment point	$p_{65}^{\lambda(j)}$	69.435%	75.803%	81.742%	86.821%	
	Principal payments	$P_{65}^{(j),\mathcal{P}}$	1.550	1.682	1.799	2.085	7.116
	Coupon payments	$P_{65}^{(j),\mathcal{C}}$	0.955	0.882	0.808	0.723	3.368
	Bond price (total)	$P_{65}^{(j)}$	2.505	2.564	2.608	2.807	10.484

Table 6: Results of the sensitivity analysis of the securitization prices with regard to different tranche structures of the transaction. The portfolio structure "medium" corresponds to the reference tranches introduced in Section 4.3. Values shown are in € for the parameterization from the reference case given in Table 3.

of the tranches.

Reference yield, risk-free interest and underlying population

The objective of this paragraph is to summarize the findings from studying the impact of changes in the reference yield y, in the risk-free interest rate r_{f} (used for discounting the payments, see Section 3.4), and in the considered subset of the population underlying our mortality forecasts.

Table 7 reports the results from our sensitivity tests. The input parameters of the reference yield y, the discount factor r_{f}, and the effect of gender consideration in mortality forecasting are analyzed. Testing for the impact of the reference yield y on which the tranche spreads are applied, as expected we observe that the values of the principal payments $P_{65}^{(j),\mathcal{P}}$ remain unaffected. The more senior tranches, such as A or AAA, in particular benefit from an increase in the reference yield. While the coupon payments $P_{65}^{(\mathrm{B+}),\mathcal{C}}$ for the B+ tranche show a total increase of 12.9% from € 0.96 ($y = 1\%$) to € 1.08 ($y = 2\%$), the additional coupon value for the AAA tranche yields € 0.12 (difference in $P_{65}^{(\mathrm{AAA}),\mathcal{C}}$ when y changes from 1% to 2%), which corresponds to an increase of 68.5%. Rising the reference yield y from 1% to 4%, the B+ tranches receives an increase of 38.5% while the coupon payments are more than tripled for the most senior AAA tranche (from € 0.178 to € 0.545). Changes in the risk-free interest r_{f} also show expected

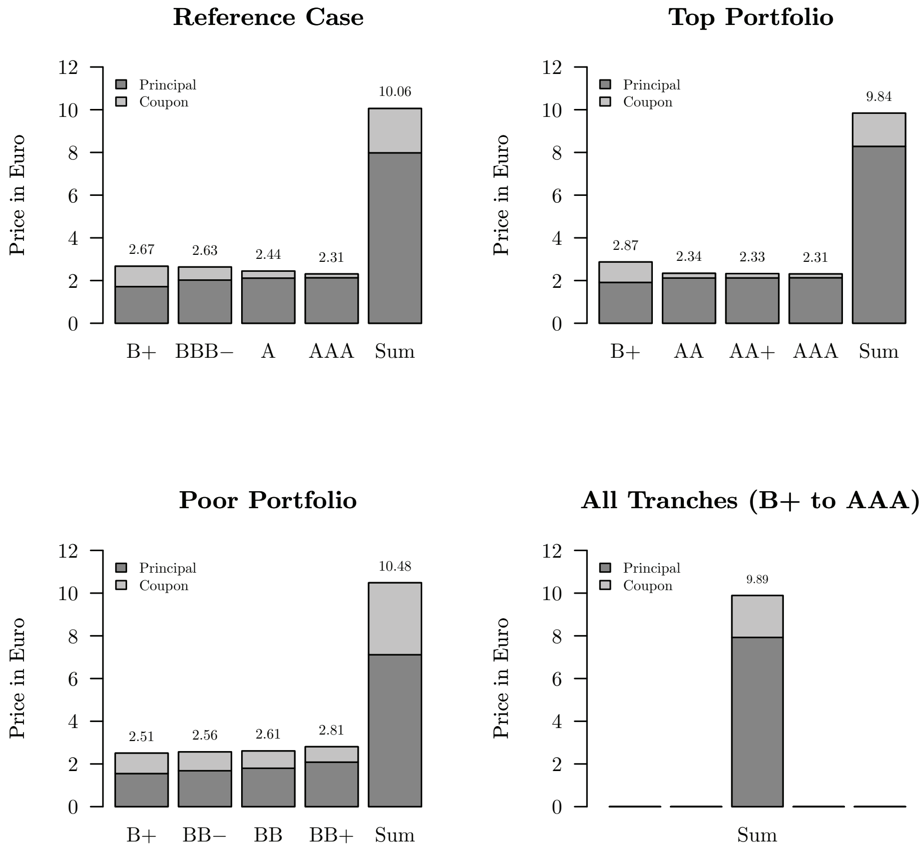

Figure 11: Results of the sensitivity analysis of the securitization prices with regard to different tranche structures of the transaction. The portfolio structure "medium" corresponds to the reference tranches introduced in Section 4.3. Case (d) reports the total bond price when $N = 14$ tranches are created including all ratings from B+ to AAA. Values shown are in € for the parameterization from the reference case given in Table 3.

effects with all prices decreasing for higher values of the discount rate r_f. Finally, the data shows that the consideration of gender in the forecasting of future mortality rates, and thus also the valuation of the securitization, is of minor importance. The tranche prices only differ at the second digit.

5 Case Study: Application to an insurance portfolio

After having calculated the individual tranche prices for one underlying age of the annuitant in the previous section, we apply now the numerical results to a real portfolio comprising annuitants of different ages. Furthermore annual annuity payments are no more € 1. In order to simulate our tranching of

y	r_f	Pop.	Tranches j		B+	BBB−	A	AAA	Sum
1%	3%	m.&f.	Principal	$P_{65}^{(j),\mathcal{P}}$	1.715	2.022	2.113	2.131	7.981
			Coupon	$P_{65}^{(j),\mathcal{C}}$	0.955	0.612	0.331	0.178	2.076
			Bond price	$P_{65}^{(j)}$	2.671	2.634	2.444	2.309	10.057
2%	3%	m.&f.	Principal	$P_{65}^{(j),\mathcal{P}}$	1.719	2.027	2.112	2.131	7.989
			Coupon	$P_{65}^{(j),\mathcal{C}}$	1.078	0.735	0.453	0.300	2.566
			Bond price	$P_{65}^{(j)}$	2.797	2.762	2.565	2.431	10.555
3%	3%	m.&f.	Principal	$P_{65}^{(j),\mathcal{P}}$	1.719	2.026	2.112	2.131	7.987
			Coupon	$P_{65}^{(j),\mathcal{C}}$	1.200	0.857	0.576	0.423	3.056
			Bond price	$P_{65}^{(j)}$	2.919	2.883	2.688	2.553	11.043
4%	3%	m.&f.	Principal	$P_{65}^{(j),\mathcal{P}}$	1.717	2.026	2.112	2.131	7.986
			Coupon	$P_{65}^{(j),\mathcal{C}}$	1.323	0.980	0.698	0.545	3.546
			Bond price	$P_{65}^{(j)}$	3.040	3.006	2.810	2.676	11.532
1%	**1%**	m.&f.	Principal	$P_{65}^{(j),\mathcal{P}}$	1.907	2.250	2.344	2.366	8.867
			Coupon	$P_{65}^{(j),\mathcal{C}}$	1.031	0.661	0.357	0.192	2.240
			Bond price	$P_{65}^{(j)}$	2.938	2.910	2.701	2.557	11.107
1%	**2%**	m.&f.	Principal	$P_{65}^{(j),\mathcal{P}}$	1.809	2.134	2.224	2.244	8.410
			Coupon	$P_{65}^{(j),\mathcal{C}}$	0.992	0.636	0.343	0.184	2.156
			Bond price	$P_{65}^{(j)}$	2.801	2.770	2.567	2.428	10.566
1%	**4%**	m.&f.	Principal	$P_{65}^{(j),\mathcal{P}}$	1.632	1.926	2.008	2.026	7.592
			Coupon	$P_{65}^{(j),\mathcal{C}}$	0.921	0.590	0.319	0.171	2.001
			Bond price	$P_{65}^{(j)}$	2.553	2.516	2.327	2.197	9.593
1%	3%	**m.**	Principal	$P_{65}^{(j),\mathcal{P}}$	1.715	2.021	2.113	2.131	7.979
			Coupon	$P_{65}^{(j),\mathcal{C}}$	0.955	0.612	0.331	0.178	2.076
			Bond price	$P_{65}^{(j)}$	2.670	2.633	2.443	2.309	10.055
1%	3%	**f.**	Principal	$P_{65}^{(j),\mathcal{P}}$	1.714	2.020	2.113	2.131	7.978
			Coupon	$P_{65}^{(j),\mathcal{C}}$	0.955	0.612	0.331	0.178	2.076
			Bond price	$P_{65}^{(j)}$	2.669	2.633	2.444	2.309	10.054

Table 7: Results from the sensitivity analysis of the securitization prices with regard to different values of the reference yield $y = 1\%, 2\%, 3\%, 4\%$, of the risk-free interest $r_f = 1\%, 2\%, 3\%, 4\%$, and with regard to different underlyings for the (male and/or female) population in mortality forecasting. Values shown are in € for the parameterization from the reference case given in Table 3. The first setting with $y = 1\%$, $r_f = 3\%$ and including the male and female population corresponds to the reference case. Parameters differing from the reference case are printed in bold. "Pop." stands for population, "m." for the male, and "f." for the female population.

life annuity products, we consider a retail data sample of randomly selected (active) life contracts from a leading German life insurer. The portfolio consists of 20 544 contracts with a total volume of annual guarantied pension payments of € 89.8 mn (nominal annuities). Figures 12 and 13 give a detailed overview on portfolio composition. Since the portfolio contains only annuity contracts in the pay-out phase, the majority of the annuitants is over 60 years old. This effect is illustrated in the distribution of annual payouts per age (see Figure 13). The highest payments are made for the group of retired policyholders over 60 years.

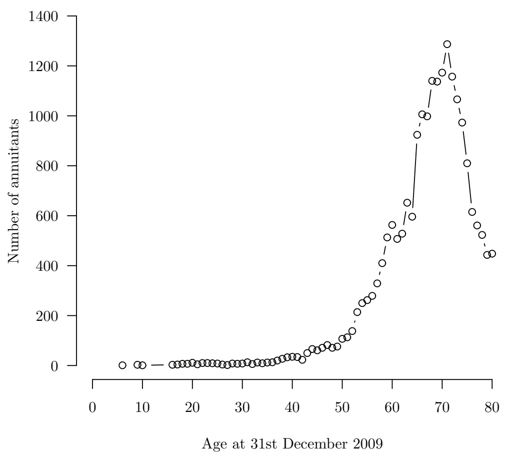

Figure 12: Number of annuitants per age as of 31st December 2009.

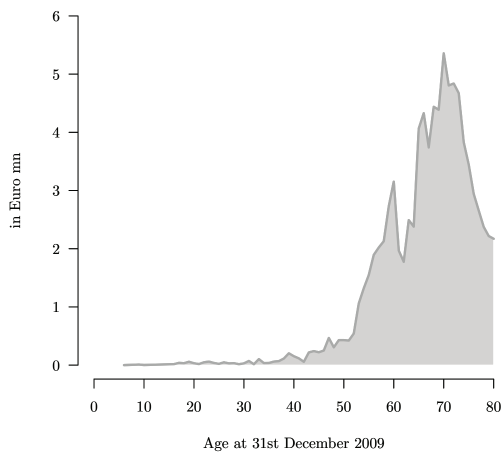

Figure 13: Annual nominal annuity payments in € mn per age as of 31st December 2009. The grey shaded area cumulates to € 89.8 mn in annuity payments.

Our objective is to price the inverse survivor bond linked to a transaction of the described retail portfolio, and thus calculate the price of hedging for the insurer. Thereby, we calculate tranche prices for every age within in the portfolio and sum the individual prices up to the entire portfolio value. The different age groups yield similar tranche prices since attachment and detachment points are evaluated on the basis of the survival probabilities of the respective age. The results of the portfolio valuation are presented in Table 8. As for the reference case in Section 4, we calculate the inverse survivor bond for a maturity of $T = 10$ years using the value $\lambda = 0.2$ for the market price of risk.

The insurer effectively receives a payment of € 766.0 mn (€ 89.8 mn for T years, discounted to $t = 0$). The bond price equals $\sum_j P_{\text{all}}^{(j)} =$ € 903.1 mn which yields costs of € 137.1 corresponding to 17.9% of the payment in $t = 0$ (see also Section 4.4). At first glance, this figure seems quite high. However, there a several effects that cushion the issuer's cost. First, the insurer receives the entire investment, i.e. the face value of the bond in time $t = 0$ and has the possibility to generate investment returns with the money that is not paid back to the investors, respectively retained for paying annuities in the event of higher survival rates. In order to compensate the costs, the insurer needs to invest the available capital at an

Tranches j		B+	BBB−	A	AAA	Sum
Total prices of gender-indifferent securitization						
Principal payments	$P_{\text{all}}^{(j),\mathcal{P}}$	154.06	181.52	189.73	191.37	716.69
Coupon payments	$P_{\text{all}}^{(j),\mathcal{C}}$	85.79	54.99	29.70	15.95	186.43
Bond price (total)	$P_{\text{all}}^{(j)}$	**239.85**	**236.52**	**219.43**	**207.32**	**903.11**
Securitization of male annuitants in portfolio						
Principal payments	$P_{\text{male}}^{(j),\mathcal{P}}$	88.04	103.65	108.37	109.31	409.37
Coupon payments	$P_{\text{male}}^{(j),\mathcal{C}}$	49.00	31.41	16.96	9.11	106.49
Bond price (total)	$P_{\text{male}}^{(j)}$	137.04	135.06	125.34	118.42	515.86
Securitization of female annuitants in portfolio						
Principal payments	$P_{\text{female}}^{(j),\mathcal{P}}$	66.03	77.81	81.36	82.06	307.26
Coupon payments	$P_{\text{female}}^{(j),\mathcal{C}}$	36.79	23.58	12.73	6.84	79.94
Bond price (total)	$P_{\text{female}}^{(j)}$	102.82	101.39	94.09	88.90	387.20
Total prices of gender-specific securitization						
Principal payments	$P_{\text{all}}^{(j),\mathcal{P}}$	154.07	181.46	189.73	191.37	716.63
Coupon payments	$P_{\text{all}}^{(j),\mathcal{C}}$	85.79	54.99	29.70	15.95	186.43
Bond price (total)	$P_{\text{all}}^{(j)}$	**239.86**	**236.45**	**219.43**	**207.31**	**903.05**

Table 8: Pricing of hedging longevity risk in the retail portfolio with total annual annuity payments of € 89.9mn over 10 years. Reported values are in € mn and represent results for gender-indifferent and gender-specific underlying populations and forecasted future mortality rates.

annural return of 4.2%, to be put in relation to the risk-free rate parameterized as $r_{\text{f}} = 3\%$. Second, the proposed hedge structure starts at the cumulative default probability of the B+ tranche (about 70%-tile) and reaches to the 100%-tile. Even if the insurer keeps the first loss position, a large proportion of the risk is transferred to third parties. However, the issuer can still leverage the reserves from annuitants dying earlier than expected. We do not quantify this effects in this paper. From the investor perspective, the B+ tranche is renumerated with an annual return of 2.3% over the risk free rate. The most senior tranche AAA is still able to generate revenues at 0.8% over the risk free rate.

6 Conclusion

This paper introduces a model for an annuity securitization with the help of an inverse survivor bond. We have taken the perspective of the issuing insurer and calculated the price of hedging for the company. We applied a tranching approach for the securitization based on the percentile tranching method and designed the bond in a way that the principal payments are risk, i.e. depending on the survival rates of the underlying portfolio of annuitants. In order to do so, we first used the Lee-Carter-model for Germany and calculated estimates on future mortality rates. We forecast the survival distribution using 100 000 simulation runs. In a second step, we applied the Wang-transformation to the derived rates in order to incorporate the risk inherent in the annuitant's contract. This distribution serves as the basis for our tranching by slicing the portfolio into different rated tranches according to S&P ratings for insurance-linked securities. Thereby, the first loss position is kept by the issuer and four different tranches are transferred to investors on the capital market. In a next step, we used a classical bond equation to determine the individual tranche prices and the overall costs for the insurer for the securitization of an annuity portfolio. We applied this pricing model to a reference case and perform sensitivity analyses. Finally, in an application to a sample retail portfolio we determined the price for hedging the contracts against longevity risk.

The results show that changes in the reference yield of the coupon payments have a severe impact on the bond price; this effect can be epically observed for highly-rated tranches. Changing the reference yield (such as LIBOR or EURIBOR) from 1% (our reference case) to 2%, causes the coupon payment of a AAA tranche to more than triple on a 10-year maturity. The effect on the bond price due to structural changes in the securitization outlay are also of importance. On a 10-year time period, the total bond price between a “top” rated and “poor” rated portfolio differs by 6.5%.

Considering the issuer as well as the investor perspective, the reference case yields total costs of 17.9% for the insurer from the securitization. At first, this cost loading seems high; however, due to the presented structure of the bond, an annual return of 4.2% on the received capital, which the insurer should invest, is enough to compensate the costs. The transaction is also advantegous for the investors. Investments into the minor B+ tranche are renumerated with an annual yield of 2.3% over the risk-free rate, while the most senior AAA tranche – which bears the lowest default risk – still receives annually 0.8% over the risk-free rate.

Our findings contribute to the current discussion about how insurers can face longevity risk within their annuity portfolios. The fact that the rating structure has such a severe impact on the overall hedging costs for the insurer implies that companies which are willing to undergo an annuity securitization should consider their deal structure very carefully. In addition, we have pointed out that in imperfect markets, the retention of the equity tranche by the originator might be advantageous. Never the less, one has to bear in mind that by this behavior, the insurer is able to reduce the overall default risk in his balance sheet by securitizing a life insurance portfolio; however, the fraction of first loss pieces from defaults increases more than proportionally. The insurer has to take care to not be left with large, unwanted remaining risk positions in his books.

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7 Appendix

7.1 Forecasting future mortality rate for Germany: additional results

Figures 14 and 15 show the values of α_x, β_x, and the forecasted κ_t for the male German population. Figures 16 and 17 report the values for the female German population.

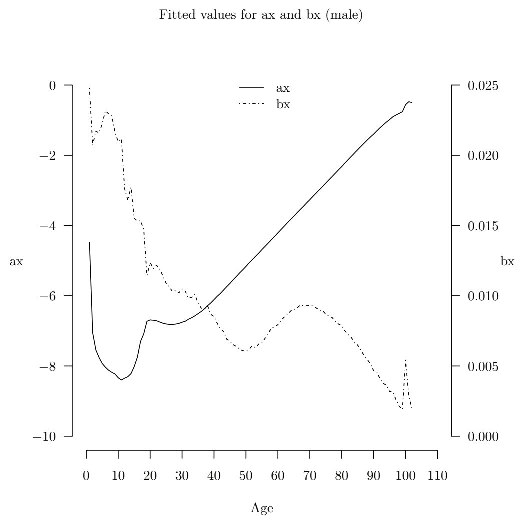

Figure 14: Fitted values for a_x and b_x for ages 0 to 101 for the German male population.

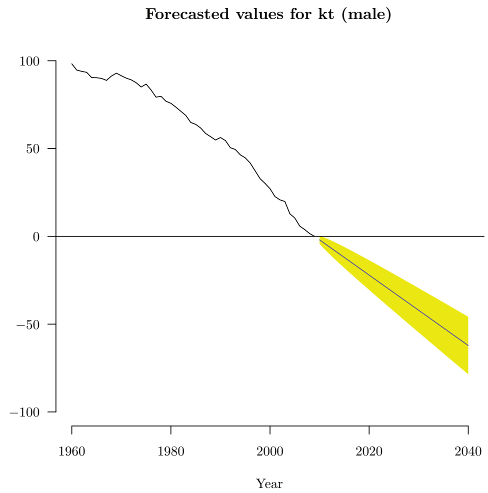

Figure 15: Forecasted values of k_t for the years 2010 to 2040 for the German male population.

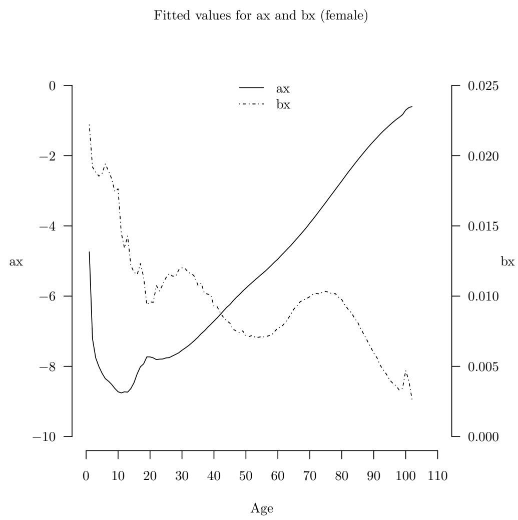

Figure 16: Fitted values for a_x and b_x for ages 0 to 101 for the German female population.

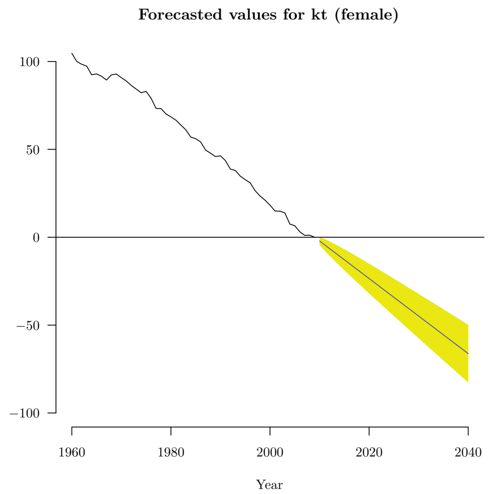

Figure 17: Forecasted values of k_t for the years 2010 to 2040 for the German female population.

7.2 S&P rating classes for insurance-linked securitizations

Table 9 shows the cumulative default probabilities of the S&P rating for insurance-linked securities according to their maturity.

Maturity	AAA	AA+	AA	AA−	A+	A	A−	BBB+
1	0.003	0.010	0.015	0.025	0.040	0.060	0.085	0.234
2	0.027	0.048	0.074	0.106	0.150	0.200	0.264	0.514
3	0.052	0.085	0.133	0.188	0.260	0.340	0.443	0.850
4	0.076	0.123	0.191	0.269	0.370	0.480	0.621	1.246
5	0.100	0.160	0.250	0.350	0.480	0.620	0.800	1.704
6	0.122	0.192	0.310	0.397	0.531	0.655	0.966	1.805
7	0.144	0.224	0.420	0.543	0.719	0.887	1.287	2.261
8	0.204	0.311	0.549	0.713	0.937	1.152	1.648	2.756
9	0.276	0.414	0.700	0.909	1.184	1.451	2.047	3.284
10	0.362	0.536	0.872	1.130	1.458	1.782	2.479	3.842
15	1.037	1.447	2.078	2.617	3.237	3.864	5.051	6.936
20	2.175	2.893	3.858	4.690	5.586	6.493	8.068	10.279
25	3.804	4.853	6.133	7.223	8.337	9.454	11.284	13.667
30	5.885	7.241	8.781	10.066	11.329	12.580	14.553	17.003
$s^{(j)}$	45	65	80	110	140	170	210	300

Maturity	BBB	BBB−	BB+	BB	BB−	B+	B	B−
1	0.353	0.547	1.632	2.525	3.518	4.510	5.824	8.138
2	0.825	1.279	3.211	4.946	6.915	8.885	11.751	16.674
3	1.405	2.177	4.758	7.230	10.095	12.960	17.152	24.004
4	2.073	3.213	6.276	9.380	13.037	16.694	21.921	30.025
5	2.812	4.359	7.763	11.403	15.745	20.087	26.089	34.945
6	2.980	6.316	8.327	12.175	16.832	21.462	27.947	38.234
7	3.672	7.434	9.598	13.826	18.895	24.083	30.999	41.476
8	4.390	8.529	10.831	15.387	20.800	26.457	33.680	44.209
9	5.127	9.598	12.025	16.862	22.563	28.610	36.046	46.543
10	5.876	10.637	13.179	18.258	24.197	30.565	38.145	48.559
15	9.684	15.418	18.383	24.234	30.849	38.096	45.822	55.592
20	13.414	19.591	22.777	28.944	35.737	43.198	50.706	59.851
25	16.980	23.300	26.570	32.808	39.556	46.958	54.169	62.789
30	20.367	26.665	29.933	36.108	42.709	49.936	56.845	65.022
$s^{(j)}$	340	400	490	560	620	680	750	800

Table 9: S&P default table for insurance-linked securitizations reporting cumulative default probabilities (in %) for different ratings and maturities (in years). For each rating the corresponding (yearly) spread $s^{(j)}$ is indicated in basis points (1 bp = 0.01%). See also S&P at `http://www.standardandpoors.com`.

Part IV

Sales Efficiency in Life Insurance: On Growth and Profitability in the German Market

Abstract

German life insurers are facing consolidation tendencies as the major players increase their market share. As a result, insurance companies are being forced to grow to ensure future prosperity. In the past, the industry has shown that growth can be achieved while maintaining profitability. In order to determine what drives sales – and thus growth – in the German life insurance industry, we apply different multi-linear regression models. We use panel data from 1998 to 2011 with characteristics of German life insurers and mostly full market coverage. In our modeling, we distinguish between sales success on the business unit level of life insurance and on the level of specific life products. The sales success drivers for pension insurance as well as term life insurance are analyzed. By doing so, we determine different significant drivers for sales success, which include the total return granted to policyholders, commissions paid to sales partners, the solvency of the insurer, the company (financial) rating, and the firm size.

Jonas Lorson, Joël Wagner (2012), Sales Efficiency in Life Insurance: On Growth and Profitability in the German Market, *Working Papers on Risk Management and Insurance, IVW-HSG.*

1 Introduction

Because life expectancy for most people in the developed world has increased significantly over the last few decades, the need for additional old-age provisioning is becoming more and more important (Bonin, 2009). Individuals' awareness that the state pension system might not be sufficient to maintain their current living standard in the future is increasing (see, for example, Handelsblatt, 2011, and Wirtschaftswoche, 2007b). In order to meet this challenge, private investments in retirement solutions can serve as an additional source of income later on in life. The literature provides several studies that analyze the drivers of life insurance demand in several countries (see, for example, Browne and Kim, 1993, Chen et al., 2001, and Li et al., 2007). Overall, alternative investment opportunities, such as stock market returns, and the national economic situation through, for example, inflation rates, may strongly influence customers' purchase behavior. However, we have seen fewer attempts so far to explain how demand for life insurance products is directed toward specific life insurance companies, or – framed differently – what enables some life insurers to capture a larger market share of the life insurance business than their competitors. With a total volume of 6.3 million new life insurance contracts in Germany in 2011 (GDV, 2012, p. 27) and 81.3 million inhabitants (Statistisches Bundesamt, 2012), almost one in 13 people buys a life insurance contract each year. This highlights the importance of the life insurance market and its products for the financial protection of whole generations. Customers oftentimes see life insurance products as very homogeneous (see, for example, Brown and Goolsbee, 2002, and Dwyer et al., 2000) and thus the question arises what drives customers to choose a specific insurance provider.

In this paper, we analyze the impact of different firm-specific parameters on the overall sales success of life insurance in general and of specific products in particular. In our analysis, we interpret an insurance company's yearly sales success as the proportion of new business premium volume to total premium volume in a given year. For new business, volume is calculated on the basis of the annual premium equivalent. The latter consists of the total value of regular (or periodic) premium payments in the year under review plus 10% of the single premiums collected in the period. In our model, insurance companies are parameterized by sets of independent variables of different types. Among the parameters, we include accounting figures, such as size, customer-oriented drivers, such as customer satisfaction and brand awareness, and performance figures, such as the annual return rates for policyholders. By doing so, we build on and extend the work of Cottin et al. (2007) and Eling and Kiesenbauer (2012), where the latter is closest to our study. The authors used regression models to detect the main drivers of new business in the life insurance industry in the German market. We also make use of multiple linear regression models to determine essential drivers of new business generation. We use panel data covering a time period of 14 years, from 1998 to 2011, including data from about 100 firms (depending on the year) operating in the market. The empirical basis on which we conduct our analysis, corresponds to a set of 895 firm-years with complete data (versus 550 firm-years in Eling and Kiesenbauer, 2012), or, in other words, to companies which represent more than 90% of the German life insurance market in terms of premiums in each year. The contribution of our paper to the literature is threefold: First, we examine the relationship between growth and profitability in the German life insurance market. Second, we adapt the approach of Eling and Kiesenbauer (2012) to a newer and broader data sample, including additional explanatory variables to the model. In this connection, we also focus on brand strength and customer satisfaction. Third, our work addresses the level of specific life products individually and analyzes the growth drivers in pension insurance and term life insurance.

The remainder of this paper is organized as follows. Section 2 describes the motivation for this research, studies growth and profitability in general, and presents a literature overview. Section 3 states our research hypotheses. The model framework and the panel data used are described in Section 4. In Section 5, the outcomes of our analysis are presented and discussed. While Section 5.1 studies the overall relationship of life insurers characteristics and their success in generating new life insurance business, Section 5.2 focuses on two single life insurance products. Finally, Section 6 summarizes the results and concludes.

2 Perspectives on Growth in Life Insurance

In the following, we present our motivation for this research. Section 2.1 describes why it is of interest to analyze the drivers of new business growth in the current market situation in Germany. Section 2.2 gives an overview of the existing literature on growth determinants. Insurance specific studies are discussed as well as research from other financial services areas, such as fund investments. We include the latter due to their similarity to certain life insurance products.

2.1 Motivation: Growth and Profitability in the German Market

In 1998, 119 life insurers operated in the German life insurance market. More than a decade later, the amount of active firms decreased to 94 in 2011 (GDV, 2012, Table 2). This corresponds to a decline of 21%. New regulatory requirements, especially concerning solvency capital and risk management of insurance firms as well as inorganic growth through acquisition, mainly by public insurers, can explain this trend (see, for example, Nektarios, 2010, p. 453). After a phase of deregulation in the 1990s (see, for example, Klumpes and Schuermann, 2011, and Berry-Stölzle and Born, 2012), the regulator has increased his intervention over the last decade. Extending the current insurance regulation (e.g. in Germany, the regulatory framework is based on regulations from the 70ies and 80ies which were only slightly adapted by Solvency I), the European Commission is currently planning the introduction of the new regulatory standard Solvency II (European Commission, 2009). The phenomenon of decreasing firm numbers is accompanied by another trend which concerns the concentration of market dominance by a few firms. Figure 1 shows the development of market share in terms of premium volume of the largest insurance companies for the years 1998 to 2011.

The figures clearly indicate that a concentration has occurred in the German life insurance industry. The five largest insurers have been able to increase their market share by eight percentage points, from 31% in 1998 to 39% in 2011. Today, the ten largest insurers control together more than half of the gross written premiums in the industry. When taking a closer look at the ten largest firms, an analysis shows that the composition of this group has been very stable over time. Very few changes occurred: The same companies that have led the market in terms of size in 1998 are still the largest ones today.

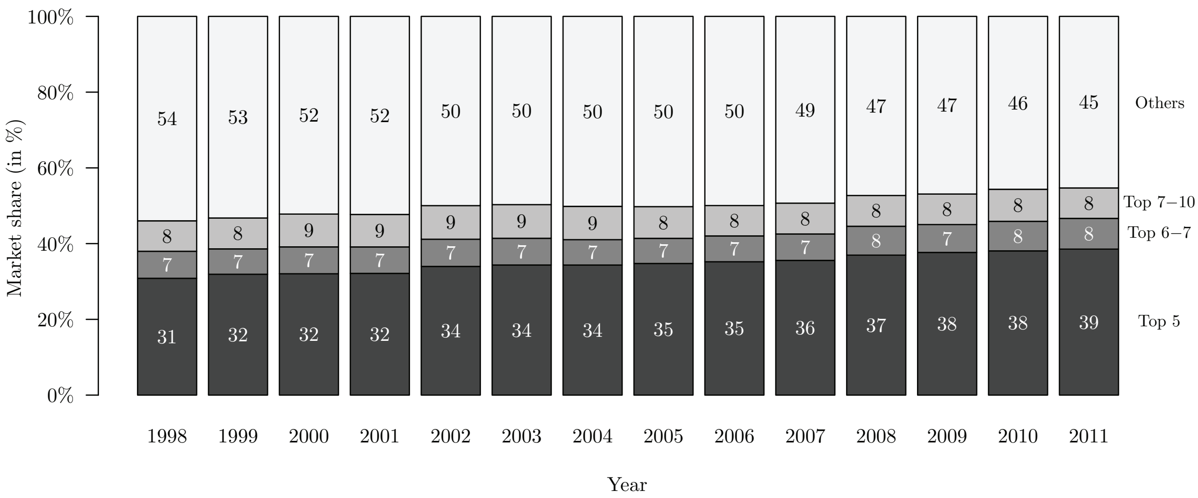

Figure 1: Development of market share for the years 1998 to 2011 in the German life insurance market. Note: Market share is calculated as company life premium volume divided by total market life insurance premiums. The clusters are defined as follows: "Top 5" groups the five largest companies in the respective year, "Top 6–7" the sixth and seventh largest firms, and so on. Under "Others", we account for all companies which are not among the ten largest firms. The underlying premium data is collated on the basis of gross written premium figures included in annual reports.

Furthermore, they have been able to increase their market domination. If one assumes, on the basis of this long historical ovservation, that this trend will continue into the future, more concentration in disfavour of small life insurers will be seen.

When it comes to the strategic positioning of insurers different goals have to be considered. Typically, strategic actions by insurance firms have to be in line with (at least) three oftentimes contradictory targets, i.e. growth, profitability, and safety level. While the first two targets are typically the focus of the owners of or investors in the firm, the safety level is monitored by the regulatory authorities for the protection of customers. From a business development perspective, companies that pursue growth strategies without a sound risk assessment may run into problems in the long run, for example, due to wrong product developments or disadvantageous customer selection criteria. In order to grow their business, managers might also lose sight of profitability if they focus more on growth than on sound underwriting. However, because safety is regulated by the authorities (see, for example, European Commission, 2009, Sect. 4, Art. 101), insurance managers can only actually influence growth and profitability. Even if, similar to the situation found in many other industries, growth is essential for firms if they want to play a vital role in the future, managers should not lose sight of profitability. If growth is only achieved at the expense of prosperity, the impact on the firm's value can be devastating (see, for example, Varaiya et al., 1987, and Longenecker et al., 2005).

In order to evaluate this issue, we analyze the impact of size on growth and profitability in the German life insurance sector. Therefore, we group life insurance companies into quintiles according to their premium volume (annual gross written premiums). While the largest companies are grouped in quintile A, the smallest are in quintile E. For each of the players, we calculate average growth and average profitability. When it comes to growth, we base our analysis on the compounded annual growth rate (CAGR) of gross written premiums (summed up in each quintile). For the sake of our analysis, we define a quintile's profitability as the technical margin. The technical margin is obtained by dividing the companies' operating profit by their technical reserves (both for traditional and fund business). Note that with that definition profitability is based on accounting figures or book values, ignoring any hidden reserves or burdens.

In the following, we consider the time period from 1998 to 2011. Over this time horizon, the gross written premium CAGR is contrasted with the average technical margin (average over the time period). In addition to this overall observation, we separately consider the time period beginning after the start of the last financial crisis (2009) and ending in 2011. The results are illustrated in the graphs in Figure 2.

Three main effects can be observed in this analysis. First, small companies seem to achieve higher growth rates compared to companies in all other quintiles. However, the figures indicate that this growth is realized at the expense of profitability. The smallest players on average have for the entire period under observation a technical margin of -2.9%. However, after the start of the last financial crisis, during the time period from 2009 to 2011, the picture changes. Forfeiting their high growth rates and now only growing at a CAGR of 3.3%, the smallest players have been able to regain profitability. In that time period, they are even the most profitable companies within the comparison with an average technical margin of 0.9%. Second, mid-sized insurers (especially the group of the second largest companies in quintile B) show a weak positioning when it comes to growth. Outperformed by the smallest players as well as the biggest ones, it seems that they might become subjected to the classic "stuck-in-the-middle" phenomenon (Porter, 1985) when addressing premium growth. This moderate development in terms of growth is accompanied by a moderate profitability as well. Finally, the largest firms (quintile A) show in all panels solid – but not outstanding – growth rates while keeping profitability levels at a satisfying level. The analyzed figures indicate that profitable growth is possible in the industry.

In the sequel of this paper we will focus on how this growth can be achieved. Therefore, starting in Section 4, we empirically analyze the drivers of sales success in the German life insurance market.

2.2 Literature Review

As mentioned before, the existing literature covers several examinations of what drives life insurance demand. In one of the earliest studies, Mantis and Farmer (1968) use publicly available data, such as the number of births, population development, and the number of marriages to forecast life insurance demand with a multiple linear regression. Later, Campbell (1980) argues from the perspective of uncertainty of household income due to the death of the wage-earner and the need to "hedge" against this uncertainty with life insurance. Adapting the former model, Lewis (1989) introduces the risk aversion and utility of beneficiaries instead of wage-earners as the drivers of life insurance demand. Browne and Kim (1993) leave

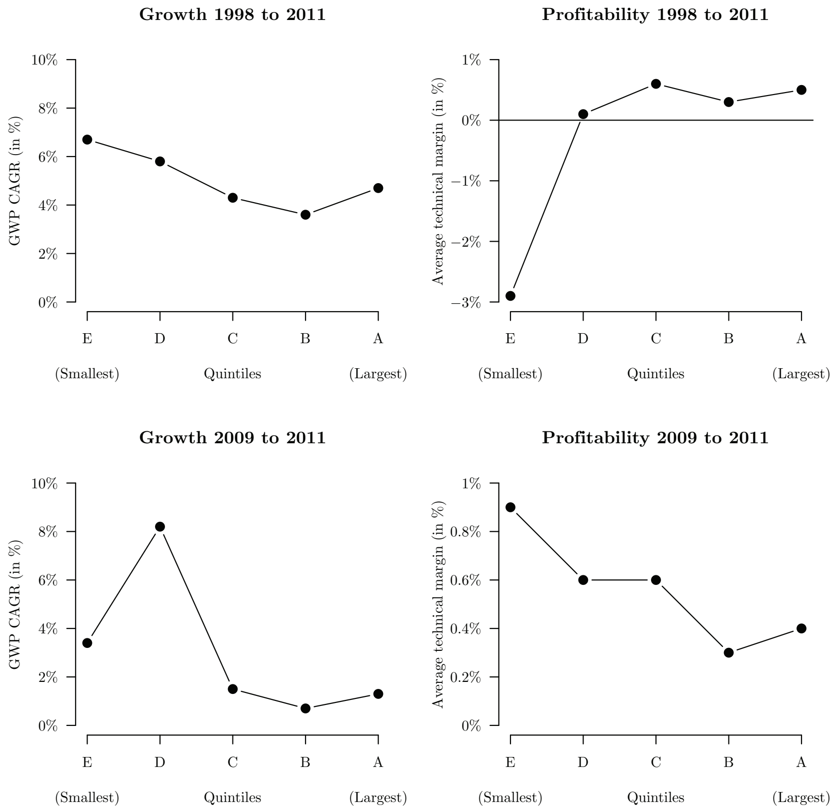

Figure 2: Growth and profitability in the German life insurance industry from 1998 to 2011.
Note: The graphs allow a side-by-side comparison of growth and profitability in the German life insurance market for the time period from 1998 to 2011 (including the period from 2009 to 2011) according to firm size-based quintiles. Quintile A represents the largest firms while quintile E is comprised of the smallest companies in terms of gross written premiums (GWP). Quintile growth is defined as the compounded annual growth rate (CAGR) of the quintile's total GWP for the respective time period; quintile profitability is defined as the average quintile's technical margin.

the personal or family level and analyze the impact of more general drivers on life insurance demand. They identify, for example, national income, government spending on social security, and inflation as determinants of life insurance consumption. Chen et al. (2001) apply cohort analysis to life insurance demand in the United States. One of their conclusions is that the baby boomer generation has a lower life insurance demand than earlier generations. Li et al. (2007) analyze life insurance demand in OECD countries and find a positive relationship between income (and income increases) and life insurance demand.

However, fewer analyses try to explain how this demand is distributed among specific insurance firms, i.e., what enables a given company to outgrow its competitors in Germany. Some studies in the field of life insurance address this issue. Tekülve (2007) examines the years 2003 and 2004 with respect to a potential relationship between surplus participation and new business. Using visual scatter plot analysis and Pearson's correlation coefficients the impact is analyzed. However, further significance tests or the inclusion of additional value drivers are missing. The results of the analysis indicate a positive relationship between the volume of new business and surplus participation. These results are confirmed both in the overall market as well as for subsamples, e.g., with respect to legal form or the age of the company. Cottin et al. (2007) analyze the impact of surplus participation on new business and lapse figures. In their study, they use total return figures including the guarantee rate as surplus participation, but they adjust these numbers for market rates and calculate with the company specific spreads on market performance. The study covers the time period from 1995 to 2004. The authors come to the conclusion that surplus participation has no impact on the sales success of a company in terms of new business volume. However, it should be stated that the authors elaborate critically on their own findings. They are aware that a univariate approach might not incorporate all effects and that further drivers of new business, such as acquisition costs or ratings, should be included in the analysis. Eling and Kiesenbauer (2012), most closely to our study, analyze the impact of different drivers on premium growth in light of market discipline. The authors find a positive relationship between the amount of surplus participation and the growth of new business for German life insurers. In addition, their results show empirical proof for a negative relationship between the surplus participation and the amount of lapses an insurer suffers. Based on a data set of 11 years, from 1998 to 2008, the authors introduce in a multivariate regression model further parameters as potential drivers of sales success besides surplus participation. Additional variables include, among others, company ratings and solvency measures. Some of these will also be considered in our analysis (see Section 4). The findings of Eling and Kiesenbauer (2012) seem at a first glance contradictory to those of Cottin et al. (2007). However, these contradictory results can be explained by some issues inherent in the approach of Cottin et al. (2007). First, a univariate linear regression model is used. Second, the modeling approach differs in the two studies when it comes to the definition of the participation rate. And third, the authors conduct different significance tests. However, all studies point out the importance of financial performance for sales success.

In a related research stream, customer purchase decisions and financial performance are often covered with respect to mutual funds. Sirri and Tufano (1998) show, through an empirical study, that consumers rely heavily in their choice of investment on the past performance of the fund. This finding is supported by several other researchers: Choi et al. (2010) state that in the purchase decisions, individuals emphasize the fund's annualized returns since issue and neglect other, more future oriented and thus maybe more helpful, purchase indicators. With his research, Wilcox (2003) also supports the role of historic performance in consumers' investment decisions. Nor is this clear focus on past performance diminished by conditioned information and explanations that are provided in special information prospectuses (Kozup et al., 2008). One can argue that these theoretical findings can also be transferred to life insurance. When it comes, for example, to annuity products, the policy can be split into two parts: a savings period, or accumulation phase, of capital when the policyholder pays the contributions, and a redemption period, or decumulation phase, when he or she receives the annuity payments. Since policyholders can also close an annuity contract with a single premium payment and immediately begin the decumulation phase, the accumulation – or buildup of capital stock – can also occur as part of a savings contract with a mutual fund.

3 Development of Research Hypotheses

As mentioned before, our aim is to measure new business (NB) as share of new business annual premium equivalent (APE) to the total gross written premiums of the respective fiscal year. By only taking single premiums with 10% into account, the APE figures smooth disturbances of large one-time effects in the P&L of a life insurer. By using this approach, we also avoid the bias that might result from the size of the company, as small companies might realize higher growth rates than larger companies due to their smaller starting base. By focusing on relative new business values, we make companies comparable without having to keep their size in mind.

In the following, we consider distinct variables thar are relevant to insurance distribution. This approach is very close to the work of Eling and Kiesenbauer (2012). We define each parameter and formulate a hypothesis on the impact of the parameter on new business. In Section 4, we will then use the parameters as independent variables in the formulation of several regression models in order to empirically test the hypotheses.

Total Return (RE)

First, we consider the investment performance of the insurer and the total return to policyholders. When it comes to the return that policyholders receive in the German life insurance market, a few uniqe features have to be kept in mind. The return guarantees which insurers grant their policyholders are subject to regulatory constraints. The guaranteed interest may not be higher than the maximum interest rate guarantee defined by the regulator ("Höchstrechnungszins"). Following European Union directives, this threshold may not be higher than 60% of the historic return from government bonds (European Union, 1992, 2002). As a consequence, this maximum interest guarantee is regularly updated. As of January 1, 2012, the maximum guarantee for new life contracts has been reduced from 2.25% to 1.75% (German Federal Ministry of Justice, 2011). Old contracts are not affected and may still have higher guaranteed rates. Usually, insurers keep their guarantees at the maximum value allowed.

Insurers have other means available for paying their customers more than the guarantee rate. Under German law, a company must pass on at least 90% of the proceeds from investment income to policyholders (German Federal Ministry of Justice, 2008, §4). At least 75% of the risk (or underwriting) results and at least 50% of the cost results must be paid to policyholders. Negative results must be retained by the insurer. However, the insurer is free to abstain from its share and can increase the policyholder's participation in all three categories up to 100%.

In our analysis, we consider total return rates for policyholders, i.e., including the maximum guarantee rate as well as the surplus participation component. This total return rate is usually declared yearly during the first quarter of each year. Eling and Kiesenbauer (2012) point out that surplus participation is considered to have a significant impact on the ability to underwrite new business and refer to Zimmermann (1996) and Milbrodt and Helbig (1999). Based on these studies and our discussion in Section 2.2, we state our first hypothesis:

(H1) Higher total returns for policyholders generate higher sales.

Acquisition Costs (*AC*)

In our opinion, a company's acquisition costs for pushing new life business are another important parameter. For example, Fiegenbaum and Thomas (1990) analyze the impact of firms' expense ratios on their strategic positioning. We will focus only on the acquisition costs as a part of the total expenses (omitting, e.g., administration and overhead costs). It can be expected that the higher the acquisition costs are, the more successful the insurer will be in promoting sales through its sales force and underwriting new business. This effect might look contradictory at first sight, as higher costs typically do not go along with the efficiency of a company, however higher acquisition costs in the balance sheet represent higher commissions paid to the sales agents or brokers. Thus, they may tend to be more motivated to sell life insurance products and increase the new business volume of the insurer. Hence, we formulate our second hypothesis as follows:

(H2) Higher acquisition cost levels yield higher sales volumes.

Company Rating (*RA*)

The next category addresses the perception of the insurer in light of rating agencies. Given the numerous product offerings from different insurers, consumers have to identify the best quality product for their needs. However, they often do not possess the resources or skills to accomplish this task. Many different aspects of product quality are used to form a sound product assessment. Overcoming this challenge, a neutral product assessment by a third party can serve as a guide. In general, De Maeyer and Estelami (2011) point out that third-party product ratings play a vital role in consumer purchase decisions. Hence, we postulate:

(H3) Companies with a higher rating are able to achieve a higher new business volume.

Solvency Level (*SO*)

As the foremost goal of regulation (see, for example, Klein, 1995, and Adams and Tower, 1994), ensuring adequate solvency levels is not only of concern to the regulator and existing policyholders, but also for new customers. Consumers may pay less or purchase fewer insurance products from an insurer with a higher potential risk of insolvency (see Wakker et al., 1997, Brockett et al., 2005, or Zimmer et al., 2009). Therefore, we will include an indicator for the financial strength or solvency ratio of the insurance company in our modeling and hypothesize that:

(H4) Higher solvency levels indicate more sales success.

Company Size (*SI*)

Existing literature analyzes the impact of size on different aspects of the insurance industry in several studies. Among others, Hardwick and Adams (2002) examine the impact of size on organic growth rates of life insurance companies in the United Kingdom from 1987 to 1996. The impact of size on firms' competitive behavior is analyzed in Chen and Hambrick (1995). Ability and willingness to tackle other competitors as well as the response speed to competitors' actions often depends on the size of the firm. We will also examine the impact of size on the ability of insurers to write new business in life insurance. Usually, larger companies have more resources than smaller ones. This can translate through, for example, more sophisticated product development departments, more widespread sales organizations, or simply access to larger financial resources. Therefore, we state our fifth hypothesis:

(H5) Larger insurers are able to generate higher new business volumes.

Legal Status (LS)

The legal status of the company is also taken into account. We distinguish between public or stock companies and mutuals. This variable has been included in a variety of prior research. Liebenberg and Sommer (2008) include the legal status of the insurer in their analysis of corporate diversification in the P&C industry. Berry-Stölzle et al. (2012) find that mutual insurers present less unrelated diversification than publicly owned companies. However, when it comes to the analysis of sales, one has to bear in mind that consumers often do not know about the legal status of the company. In addition, it cannot be observed that one of the two company groups has stood out with innovative products or distribution strategies in the past. Thus, we suppose that:

(H6) The legal status of the insurer (public or mutual) has no impact on new business growth in life insurance.

Customer Satisfaction (SA)

In addition to accouting, solvency, and legal company characteristics, we also include several consumer-related firm evaluations. First, we discuss customer satisfaction. Anderson et al. (1994) show a positive relationship between customer satisfaction and economic performance. Luo et al. (2010) prove significant impact of customer satisfaction on the firm value in light of analyst recommendations. A related phenomenon is highlighted by Mooradian and Olver (1997), who point out that satisfied customers can attract new ones through word of mouth and thus drive the sales success of a company. Thus, we formulate an additional hypothesis to be analyzed in the German life insurance market as follows:

(H7) Companies with higher customer satisfaction rating are able to achieve higher sales rates.

Brand Awareness (BA)

Second, we consider the impact of brand awareness or company recognition on sales success in life insurance. It can be assumed that, when making a buying decision, especially in insurance, consumers take in a first place the products of a company into consideration of which they have already heard. For example, Vogel et al. (2008) point out that brand awareness and perception have an important influence on future sales of the company. We introduce the following additional hypothesis:

(H8) Firms with better known brands among consumers are able to achieve a higher new business volume.

Product Rating (OT)

Furthermore, we include the assessment of firms' products into our considerations. In Germany, the consumer magazine *Oekotest* gives grades to single insurance products. This assessment can be interpreted as a product-specific rating. The importance of ratings or independent third-party opinions on the consumer buying decision has already been pointed out in the context of the above hypothesis (H3). Therefore, we introduce our ninth hypothesis on a product-specific level:

(H9) Higher product ratings foster new business volumes.

Price (PR)

Finally, we will consider the average price PR of a policy, which can typically be evaluated for term life insurance. We define it as total premiums for new contracts divided by the number of new contracts. Because term life insurance is a very homogeneous product, we hypothesize that:

(H10) The lower the average price of term life insurance is, the higher the sales success.

4 Model Framework and Data Set

Following the introduction of control variables (see Table 2 below for an overview) and the development of related hypotheses (H1) to (H10), we develop a multiple linear regression model in order to determine the significant drivers in the sales success of life insurance policies. With new business NB being the dependent or response variable, we test different drivers, both accounting focused (e.g., size, costs, etc.) and customer-related ones (e.g., customer satisfaction, brand awareness). In doing so, the approach that we follow is closest to the work of Eling and Kiesenbauer (2012). In the first part, we formally introduce the regression models which will help us to test our hypotheses of business generation drivers. Some of the observed potential drivers have been applied in prior research by many authors (see the references in Section 3), other variables have – to the best of our knowledge – not yet been tested. In the second part, we present our data gathering, discuss the obtained panel data, and provide basic statistical information on the data.

4.1 Design of Regression Models

In the following we formulate several linear regression models each incorporating a selection of the introduced variables. First we will consider a model focusing solely on accounting parameters. The panel data regression model is described by Equation (1) which reads

$$NB = \alpha + \beta_1 RE + \beta_2 AC + \beta_3 RA + \beta_4 SO + \beta_5 SI + \beta_6 LS + \epsilon\,. \quad (1)$$

This model includes the six control variables total return RE, acquisition costs AC, company rating RA, solvency level SO, size SI, and legal status LS as introduced in Section 3. We will apply this panel data regression to the overall life insurance business (including all life products). Thus NB stands for the overall share of new life business APE in terms of gross written premiums. In Equation (1), α is the constant or intercept of the equation and ϵ represents the standard error or disturbance term.[1] In order to test the new business drivers and the robustness of our findings, we will apply Equation 1 to different time periods (subsets) of the panel data. In a reference case (regression R1) we apply the model to the complete panel data which will incorporate the entire 14 years of data from 1998 to 2011. Next we will divide the time period and thus the panel data into three subsamples: (i) first, we test the time period from 1998 until the end of the financial crisis at the beginning of the 21st century, when stock markets regained strength again, i.e. 1998 to 2003, (ii) second, the period of economic recovery until the last financial crisis is analyzed, i.e., 2004 to 2008, (iii) third, we test for the drivers in the period after the last financial crisis by taking a look at the period from 2009 to 2011. Following, we refer to these three regression analyses as (R2) to (R4).

Further, we extend the reference model by adding control variables related to customer satisfaction SA and brand awareness BA. This will allow us to test hypotheses (H7) and (H8). Because data is not always available for some variables, we will include them in two separate extensions of our regression model. Thus, we introduce the following relation,

$$NB = \alpha + \beta_1 RE + \beta_2 AC + \beta_3 RA + \beta_4 SO + \beta_5 SI + \beta_6 LS + \beta_7 SA + \epsilon\,, \tag{2}$$

incorporating the additional control variable SA in the model described in Equation (1). We will apply this model to the time period from 1998 to 2011 and refer to it as (R5). In addition, we define the model (R6), including the variable brand awareness BA as follows:

$$NB = \alpha + \beta_1 RE + \beta_2 AC + \beta_3 RA + \beta_4 SO + \beta_5 SI + \beta_6 LS + \beta_8 BA + \epsilon\,. \tag{3}$$

As mentioned earlier, in addition to testing sales success at the overall business level of life insurance, we also specify the drivers at the level of individual products. We will do so for pension products (including German Riester policies) and term life insurance. In the following we introduce the variables NB_{PE} and NB_{TL} which stand for the new business in pension and term life insurance, respectively. At the product level, product rating data will be available given by OT_{PE} and OT_{TL}.

When it comes to pension products, we include the product rating OT_{PE} in our reference model and use product-specific total return data RE_{PE}, which translates in our regression model (R7) given by

$$NB_{\mathrm{PE}} = \alpha + \beta_1 RE_{\mathrm{PE}} + \beta_2 AC + \beta_3 RA + \beta_4 SO + \beta_5 SI + \beta_6 LS + \beta_9 OT_{\mathrm{PE}} + \epsilon\,. \tag{4}$$

As with pension products, we leave the variables in the reference model unchanged for term life insurance. In contrast to the regression models above, here we exclude the parameter of total return RE from the equation. Because policyholders do not receive an investment return in the traditional term life insurance, this parameter is not of relevance. Instead, we include the term life-specific product rating

[1] In the panel data regression model each variable and the disturbance term is dependent on the respective life insurance company i (firm effect) and the considered year t (time effect). For ease of notation, we omit the indices i, t.

OT_{TL} and the average product price PR_{TL}. The regression equation for our model (R8) then reads:

$$NB_{\text{TL}} = \alpha + \beta_2 AC + \beta_3 RA + \beta_4 SO + \beta_5 SI + \beta_6 LS + \beta_9 OT_{\text{TL}} + \beta_{10} PR_{\text{TL}} + \epsilon\,. \quad (5)$$

An overview of the different regression models is given in Table 1.

Regression	Level	Model
(R1)	Overall Life	Reference case for the time period from 1998 to 2011 (see Eqn. 1)
(R2)	Overall Life	Reference case (R1) but for the time period from 1998 to 2003
(R3)	Overall Life	Reference case (R1) but for the time period from 2004 to 2008
(R4)	Overall Life	Reference case (R1) but for the time period from 2009 to 2011
(R5)	Overall Life	Based on (R1) including the variable customer satisfaction (SA) (Eqn. 2)
(R6)	Overall Life	Based on (R1) including the variable brand awareness (BA) (Eqn. 3)
(R7)	Product	Regression for pension insurance (Eqn. 4)
(R8)	Product	Regression for term life insurance (Eqn. 5)

Table 1: Overview of the defined linear regressions models.

4.2 Data Set Definition and Statistics

Data Sources

Following, we detail the data sources for the regression models. On the overall life business level as well as on the two product levels our aim is to cover the period from 1998 to 2011 in our analyses.

All accounting-related data, such as new business figures NB, acquisition costs, and company size are derived from the individual companies' annual reports. When it comes to the size of the firm SI, we consider the amount of gross written premiums as well as the amount of technical reserves and equity of the insurance company. We define the solvency level SO as the ratio of the book value of equity to total insurance provisions. Acquisition costs AC are measured as the cost ratio defined as total yearly acquisition costs divided by gross written premiums. Furthermore, we include for each company information about their legal status LS, with mutuals coded as 0 versus public companies coded as 1. The latter figures have been derived from press research and searches on the companies' websites.

Data on the current total return RE for life policies in the German market was derived from Assekurata (2005, 2006, 2007, 2008, 2009, 2010, 2011) for the years 2004 to 2011, and Map-Report (2005) for the earlier years 1998 to 2003. Assekurata analyzes on a yearly basis the total returns that policyholders receive for their life insurance policy. In doing so, they distinguish by product type and tariff generation (indicated by the tariff's guarantee rate). The latter is a specialty of the German market and several other European life markets (such as Switzerland, Austria, and France). For the current total return *RE* we consider figures for the most recent tariff generation in the respective year. For example, in 2011 all figures correspond to contracts with a guarantee rate of 2.25%. When it comes to product type, the values shown represent the average of four different product categories: classic whole life insurance, classic annuity insurance, and the two German pension schemes "Riester-Rente" and "Ruerup-Rente". Typically, insurers grant the same total return to all these policies. The return figures do not incorporate potential future returns from the policyholder's participation in hidden reserves on the insurer's books, as this participation is not guaranteed and can also be omitted. Therefore, we apply the figures of the total return for the policyholder excluding maturity bonus. The latter is only paid to the policyholder if the policy is kept until maturity. Given a life market lapse rate of 4.3% in Germany in 2011 (Map-Report, 2012), it is clear that many customers will not receive this additional income. Therefore, we exclude it from our analysis. Map-Report does not differentiate between the same product categories as Assekurata does. As a result, a combined average value of the different product types is used in the regression for each year.[2] It is worth taking a closer look at the historic development of these total return *RE* figures as well as the corresponding descriptive statistics (see Table 5). One can observe that the remuneration for life insurance policies has declined steadily over the last few years. While a policyholder received on average a total return of 7.2% in 1998, he only gets 4.1% in 2011. This trend can be observed across the entire market. There are variations in return figures among individual companies (different minimum and maximum values), but the standard deviation is relatively small. This indicates that large parts of the industry provide quite homogeneous investment returns for their policyholders.

Figures for insurance company ratings (variable *RA*) are derived from two different sources. First, and in order to be able to compare our results to Eling and Kiesenbauer (2012), we make use of the so-called "Finsinger rating".[3] This rating is available for the years 1999 to 2011, and reported by Wirtschaftswoche (1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011). Second, we include the yearly life insurer ratings of Morgen & Morgen (called the "M&M Rating"), a German rating company that also provides detailed analyses for financial service products. Their ratings are publicly available at `www.morgenundmorgen.com` for the years 1998 to 2011. The M&M Rating combines different key figures for insurance companies, among others, cost ratios, financial strength, investment performance, and lapse volumes. Both the Finsinger rating and the M&M rating provide a scale of 1 to 5 ("stars"), with 5 being the best.

The company YouGov, formerly known as Psychonomics, regularly conducts a representative survey across Germany in which also the customer satisfaction in different dimensions is analyzed. These dimensions include, for example, overall satisfaction with a company, as well as satisfaction with premium levels, service, and the sales force. We use the empirically observed values for overall satisfaction with the

[2]As mentioned before, our approach is close to the approach of Eling and Kiesenbauer (2012). The authors state that they use the arithmetic average of all tariff generations (Eling and Kiesenbauer, 2012, p. 174). Our analysis, however, is based on the figures for the latest tariff generation since this represents the only policy category that new customers can invest in. In addition, we do not model the rate relative to the market average, since it can be assumed that a potential policyholder is interested in the absolute return he or she might receive from the policy. Since this figure is fixed in the first quarter of year, we can directly link the values to the new business of the same accounting year and do not have to adjust for potential time discrepancies.

[3]This rating by Finsinger, a scientist in the Department of Finance at the University of Vienna, is published once a year in the magazine Wirtschaftswoche, a national German weekly economic journal.

insurer as input for our customer satisfaction variable SA. Data points are available for the years 2003, 2008, and 2010 (see YouGov, 2003, 2008, 2010). Wherever years are not covered by available data in our analysis, we interpolate linearly the figures for the respective year. No data is available before 2003.

Data for brand awareness are derived from reports by German magazine Stern (2003, 2005, 2008). In 2003, 2005 and 2007, Stern conducted representative statistical surveys on the brand recognition of different companies in Germany, including insurers. In these surveys, interviewees have been asked to rate the company with respect to perceived publicity, sympathy and their willingness to buy from the insurer (on a scale from 1 to 5). We linearly interpolate the missing years 2004 and 2006 so as to get a continuous data sample from 2003 to 2007. No additional studies were conducted before 2003 or after 2007.

In addition, when it comes to the product-specific level, we include the rating OT for individual life insurance products. Therefore, we use the assessments of the magazine Oekotest. An evaluation for pension insurance ("Riester-Rente") products is available for the years 2007, 2008, 2009, and 2011 (see Oekotest, 2007a, 2008b, 2009, 2011) and for term life insurance for the years 2007, 2008, and 2010 (see Oekotest, 2007b, 2008a, 2010). The assessment provided is based on the German school grading system, ranging from 1 (very good) to 6 (fail). If several products of one insurer are tested, we use the best rating. In the individual tests, data is aggregated for different types of customers, e.g., male, 30 years old, non-smoking, or female, 40 years old, smoking. We use the average values for all provided combinations. Missing annual values are again linearly interpolated.

An overview of the variables introduced in Section 3 and the aboved described sources for the data is provided in Table 2.

Market Coverage

Furthermore, Table 3 shows figures representing the amount of market coverage. The covered share of premiums in terms of market premiums as well as the number of available company data points are given for each year. The figures show that on the level of overall business, data availability is very good, reaching levels of 100% for accounting data. Most of the variables – see in particular also total return RE and the ratings RA – are available for companies whose premium volume represents more than 90% of the market's gross written premiums. For the early years of our analysis, the return figures and the rating variables are slightly less well covered. However, the available data points always cover more than 70% of the market's premiums. The variables customer satisfaction SA and brand awareness BA are not available for all years. As previously noted, they are also interpolated for several observation periods (see values marked with * in Table 3).

On the product-specific level, data availability is less comprehensive. While new business figures for both products, NB_{PE} and NB_{TL}, can still be fully derived, the product assessment by the magazine Oekotest was only introduced in 2007 and thus leads to a reduction of the panel data for several years. Furthermore, it must be noted that third-party sources (Oekotest, as well as Stern and YouGov) do not aim to cover the entire industry, which is reflected in the lower rates of market coverage.[4]

[4]Overall, we use unprocessed data, that is, if mergers or name changes of insurers occur, we ignore them historically and include the new data point in the respective year in our analysis and leave the historic names or companies in the future

Description	Variable	Source
New Business	NB	Companies' annual reports
Total Return	RE	Assekurata (2005–2011) and Map-Report (2005)
Acquisition Costs	AC	Companies' annual reports
Company Rating	RA	Finsinger rating (see Wirtschaftswoche, 1999–2011) and M&M rating (see Morgen & Morgen at www.morgenundmorgen.com)
Solvency Level	SO	Companies' annual reports
Company Size	SI	Based on premiums, equity and reserves taken from companies' annual reports
Legal Status	LS	Companies' annual reports and websites
Customer Satisfaction	SA	Stern (2003, 2005, 2008)
Brand Awareness	BA	YouGov (2003, 2008, 2010)
Product Rating	OT	Pension insurance (Oekotest, 2007a, 2008b, 2009, 2011), term life insurance (Oekotest, 2007b, 2008a, 2010)
Price (term life)	PR	Companies' annual reports

Table 2: Overview of introduced variables and related data sources.

Descriptive Statistics

Table 4 provides descriptive statistics for the independent variable NB, i.e., the share of new business, in our regression models. The proportion of new business of the total gross written premiums in life insurance has shrunk steadily over the last few years. Even small increases in new business generation such as in 2004, when legal changes took place in the next year and purchases by customers were brought forward, could not stop this trend.

Table 5 presents the summary statistics of a selection of the panel data control variables. We report basic statistics on the gross written premiums, equity and reserves, displaying the mean, minimum, maximum, several quantile values and the standard deviation of their respective distributions in the different years from 1998 to 2011. Further statistics are provided for total policy return RE, acquisition costs AC and solvency level SO. Finally, the mean and standard deviation of the Finsinger and M&M ratings are provided. With respect to the premium volume (gross written premiums), the dispersed minimum and maximum values show that the insurer sample covers a broad range of companies in terms of size. The smallest firms accounts for less than € 1 million annually, while the largest is € 14.8 billion (in 2011). When looking at the data, we further notice that the distribution in terms of premium volume of the companies in the panel positively skewed, i.e., presents a right tail distribution. Similar effects are

blank.

Year	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11
Overall life insurance business variables														
NB, AC, SO, SI, LS	98% 114	98% 112	100% 116	100% 115	100% 106	99% 103	100% 101	100% 100	100% 97	100% 98	100% 98	100% 98	100% 97	100% 92
RE	72% 69	71% 68	73% 69	73% 69	76% 69	77% 67	94% 79	90% 81	92% 81	91% 75	92% 79	91% 79	91% 76	95% 72
RA (Finsinger)	– –	86% 78	94% 81	90% 77	91% 79	92% 75	94% 72	92% 72	94% 74	94% 75	94% 77	90% 71	90% 71	93% 69
RA (M&M)	80% 65	83% 66	85% 65	85% 68	89% 68	92% 75	96% 75	94% 77	96% 77	96% 77	96% 75	91% 75	94% 70	94% 69
SA	– –	– –	– –	– –	– –	63% 27	62%* 26*	63%* 26*	65%* 27*	66%* 27*	70% 32	69%* 30*	74% 35	– –
BA	– –	– –	– –	– –	– –	72% 38	76%* 39*	77% 42	72%* 31*	75% 33	– –	– –	– –	– –
Product-specific variables														
NB_{PE}	91% 109	96% 109	98% 110	98% 109	98% 100	98% 99	99% 97	99% 96	98% 94	99% 93	98% 92	98% 91	98% 90	98% 88
OT_{PE}	– –	– –	– –	– –	– –	– –	– –	– –	– –	49% 26	52% 26	42% 21	37%* 15*	43% 18
NB_{TL}, PR	96% 106	96% 106	98% 106	98% 107	98% 99	98% 98	99% 96	99% 97	98% 93	98% 92	99% 92	98% 91	98% 89	98% 87
OT_{TL}	– –	– –	– –	– –	– –	– –	– –	– –	– –	60% 36	64% 46	27%* 22*	43% 33	– –

Table 3: Data availability and market coverage of the variables used in the panel data.
Note: Data coverage is expressed as a share of market premiums in the respective year (% figures). The numbers below represent the number of companies. * denotes missing underlying data, however data has been interpolated. Company size SI is based on gross written premiums, equity and reserves. Company rating RA is based on Morgen & Morgen (M&M) and Finsinger ratings.

slightly present when it comes to the reserves, acquisition costs AC and solvency levels SO.

5 Empirical Results and Discussion

Section 5.1 describes the results on the overall life insurance business level. Overall success drivers for the sale of life insurance policies in Germany are presented, before Section 5.2 goes a step deeper and analyzes the impact at a product-specific level, i.e., pension and term life insurance.

5.1 Overall Growth Drivers in Life Insurance

Before running our regression model, we test our panel data for multi-colinearity among the variables. We conduct a maximum-likelihood factor analysis to detect latent meta constructs which we should include in our analysis. In this way, the correlation between similar items should be high while variables that are not related should have low correlations. As expected, the factor analysis yields a strong correlation between variables used to characterize firm size: premium volume, equity, and reserves. Observed factor loadings higher than 0.95 are not surprising, since all parameters are closely related to the insurer's size. For the regression model, we therefore combine these three items by taking the average for the size

Year	’98	’99	’00	’01	’02	’03	’04	’05	’06	’07	’08	’09	’10	’11
New Business Share NB (overall life business)														
Mean	15.0	21.4	12.9	17.0	13.6	14.9	19.9	12.2	11.9	11.5	11.3	9.9	10.1	10.4
Min.	0.0	3.2	0.0	0.0	0.0	0.1	0.0	1.0	0.4	1.1	2.1	2.2	0.0	0.0
25% Ptl.	10.2	14.5	7.9	8.7	9.9	11.2	12.7	7.0	8.4	7.9	8.3	7.4	8.0	8.1
Median	12.1	18.0	10.0	11.2	11.5	13.6	17.7	9.7	11.0	9.8	10.4	9.2	9.5	9.8
75% Ptl.	16.6	23.9	14.5	14.6	14.0	16.5	23.8	12.6	13.4	11.7	12.4	11.7	11.7	12.3
Max.	80.0	84.2	68.8	407.5	96.5	54.3	67.8	174.4	54.0	121.6	59.4	29.3	30.4	30.5
St. Dev.	10.6	13.7	9.8	37.8	10.9	7.5	10.8	17.2	6.5	12.3	6.9	4.6	4.5	4.7
New Business Share for Pension Products NB_{PE}														
Mean	29.6	37.1	19.0	20.9	23.5	22.5	30.4	16.9	17.1	15.2	15.6	13.0	12.7	13.8
Min.	0.6	0.8	0.8	0.1	1.0	0.1	2.7	0.4	1.4	0.7	0.8	1.6	1.4	1.4
25% Ptl.	18.2	24.9	11.5	13.3	14.1	15.2	20.4	8.6	10.2	8.7	9.5	8.2	8.1	9.4
Median	23.2	35.2	15.3	17.6	19.4	19.2	27.8	11.9	13.8	13.3	15.0	11.8	12.3	14.0
75% Ptl.	33.2	44.6	21.2	25.5	24.9	26.0	36.1	18.2	18.8	16.7	18.4	16.1	15.9	16.7
Max.	100.0	100.2	100.0	107.0	105.0	88.1	100.3	100.0	87.4	100.0	78.3	44.9	35.9	38.3
St. Dev.	20.9	19.7	15.2	16.4	18.3	13.8	15.2	16.8	13.0	12.6	10.5	7.2	6.5	7.3
New Business Share for Term Life Products NB_{TL}														
Mean	22.0	20.5	19.1	21.7	19.8	18.6	18.0	16.3	16.0	15.4	13.4	12.3	12.0	10.9
Min.	2.1	2.2	0.8	0.1	1.4	0.6	0.1	0.0	0.8	0.1	1.0	0.0	0.1	0.1
25% Ptl.	13.9	12.1	10.7	12.8	12.4	11.9	10.8	8.9	10.3	9.5	8.2	7.7	7.3	6.9
Median	18.2	17.1	14.4	16.7	15.2	16.7	15.1	13.9	14.4	12.5	11.5	11.9	10.8	10.9
75% Ptl.	23.5	22.8	21.3	25.5	22.4	22.9	20.3	18.6	17.8	17.1	15.8	15.0	14.1	13.4
Max.	100.5	100.7	101.3	100.0	104.9	69.9	100.0	79.8	100.5	80.3	49.3	42.9	45.9	31.3
St. Dev.	17.0	16.1	17.5	17.1	16.3	11.6	13.7	12.6	12.7	12.7	9.1	7.9	8.1	6.4

Table 4: Descriptive statistics for the share of new business NB (overall) and in the product lines pension insurance NB_{PE} and term life insurance NB_{TL}.
Note: Values for new business are sales values for the respective companies in the observed year. New business share is calculated as a percentage of new business APE in terms of total gross written premiums. “Mean” denotes the arithmetic average of all companies, “Min.” / “Max.” the minimum / maximum value found in the sample, “Ptl.” stands for percentile and “St. Dev.” is an abbreviation for the standard deviation.

parameter SI. The internal consistency has been measured with the help of Cronbach’s alpha. It yields a value of 0.953 on a scale with a maximum value of 1. Values higher than 0.7 indicate internal consistency of the variables. Furthermore, given the heavily rightward-skewed distribution of the parameter values (see Table 5), we consider the natural logarithm of the average of premiums, equity and reserves for SI. Another item battery has been detected with the help of the factor analysis. It is also not surprising that the company ratings by both Finsinger and Morgen & Morgen present high factor loadings above 0.7. This result was to be expected, as both items are ratings for life insurers and have several rating criteria in common. We combine the two ratings by taking their average for the regression model and use this average as the company rating variable RA. For this factor, Cronbach’s alpha yields 0.814 and thus supports the consistency of the two variables. The factor analysis yields no further groups of items which should be combined into one factor. However, it still reveals a strong factor loading for both total return RE and solvency level SO. Since the variables total return RE, acquisition costs AC, solvency level SO and legal status LS show no strong correlation with any other variable, we include them as

Year	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11
Gross written premiums (in mn €)														
Mean	428	494	515	512	576	618	632	685	718	730	745	803	878	863
Min.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25% Ptl.	31	33	24	26	37	47	47	57	53	57	57	60	74	78
Median	144	155	128	126	148	191	189	194	215	204	195	199	207	214
75% Ptl.	445	517	540	540	635	648	724	802	846	858	852	855	954	986
Max.	7304	8252	8426	8310	9648	10332	10560	11787	12518	12754	12927	14357	15398	14829
St. Dev.	826	955	989	985	1136	1212	1235	1356	1435	1470	1519	1670	1824	1773
Equity (in mn €)														
Mean	49	54	59	59	68	80	90	96	105	110	115	126	120	126
Min.	2	2	2	0	0	0	0	0	0	0	0	3	3	3
25% Ptl.	6	6	7	7	7	9	9	11	11	12	13	16	17	19
Median	19	21	20	21	28	32	35	38	43	45	49	52	46	52
75% Ptl.	48	52	56	54	84	103	116	131	145	147	157	162	147	154
Max.	849	940	1074	1153	1197	1276	1307	1396	1411	1456	1459	1652	1691	1759
St. Dev.	96	107	121	123	132	146	165	171	181	186	191	210	211	218
Reserves (in bn €)														
Mean	3.4	3.9	4.2	4.3	4.8	5.1	5.3	5.8	6.2	6.6	6.6	7.1	7.6	8.0
Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25% Ptl.	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4
Median	0.8	0.9	0.9	0.8	0.9	1.1	1.2	1.2	1.6	1.7	1.5	1.8	2.0	2.2
75% Ptl.	4.2	4.2	4.7	4.5	4.8	5.1	5.5	5.7	6.3	6.4	6.1	6.4	7.0	7.5
Max.	65.0	70.2	75.2	79.5	88.9	92.7	96.6	106.7	113.2	121.3	124.1	131.2	137.9	143.0
St. Dev.	7.2	8.0	8.7	9.1	10.2	10.7	11.1	12.2	13.0	14.0	14.4	15.2	16.2	17.0
Total Return *RE* (in %)														
Mean	7.17	7.20	7.13	7.06	6.14	4.85	4.38	4.33	4.24	4.27	4.38	4.27	4.19	4.07
Min.	4.50	6.00	5.50	6.00	4.50	3.25	3.00	3.00	3.37	3.47	3.50	3.50	3.25	3.40
25% Ptl.	7.00	7.00	7.00	6.85	6.00	4.49	4.10	4.09	4.00	4.06	4.20	4.07	4.00	4.00
Median	7.25	7.25	7.13	7.00	6.15	4.75	4.30	4.30	4.20	4.25	4.40	4.25	4.23	4.10
75% Ptl.	7.50	7.40	7.35	7.25	6.40	5.00	4.71	4.50	4.50	4.50	4.60	4.50	4.34	4.21
Max.	8.00	8.00	8.00	7.80	7.50	7.50	6.18	5.85	5.40	5.40	5.40	5.00	4.80	4.80
St. Dev.	0.55	0.35	0.38	0.35	0.56	0.78	0.55	0.47	0.41	0.39	0.34	0.31	0.29	0.23
Acquisition Costs *AC* (in % of gross written premiums)														
Mean	14.2	16.4	13.5	14.5	13.1	14.0	17.7	10.6	11.6	11.4	12.0	10.6	10.2	10.9
10% Ptl.	5.7	6.5	4.7	4.9	5.0	6.1	8.0	4.3	4.5	4.3	4.2	4.1	3.7	3.8
25% Ptl.	8.5	10.8	6.4	7.1	7.9	8.8	12.1	6.2	7.3	6.9	6.9	6.2	6.2	6.5
Median	10.9	13.2	9.3	10.2	10.8	11.9	15.4	9.9	10.0	9.8	10.0	9.2	9.5	10.3
75% Ptl.	14.7	19.0	15.7	17.6	16.0	16.2	21.1	13.3	13.5	14.3	14.9	13.3	13.1	14.0
90% Ptl.	22.9	28.9	27.0	28.5	21.8	22.0	29.4	18.2	20.1	21.3	20.6	16.5	16.9	16.6
St. Dev.	12.0	11.4	12.9	13.2	10.0	9.2	11.3	6.8	8.2	7.8	8.6	7.3	6.5	6.7
Solvency Level *SO* (in %)														
Mean	9.8	21.2	19.8	11.0	8.6	9.8	7.6	5.6	9.6	15.1	8.4	6.9	5.1	4.4
10% Ptl.	0.9	0.9	1.0	0.9	0.9	1.0	1.0	1.0	1.0	1.1	1.2	1.2	1.0	1.1
25% Ptl.	1.2	1.1	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.6	1.4	1.4	1.3
Median	1.6	1.6	1.7	1.7	1.7	1.8	2.0	2.1	2.1	2.1	2.2	2.2	2.1	2.1
75% Ptl.	5.0	3.9	5.1	5.1	5.8	5.7	5.1	4.7	4.6	4.9	4.6	4.3	4.6	4.0
90% Ptl.	14.3	19.4	30.4	20.4	18.6	16.3	15.0	9.6	13.1	12.0	15.1	12.9	11.2	10.5
St. Dev.	29.5	134.0	72.2	32.3	22.4	32.7	21.2	11.8	32.8	86.7	20.4	16.9	8.5	6.4
Finsinger Rating														
Mean	–	3.0	3.2	3.0	2.8	2.8	3.3	3.1	3.3	3.4	3.2	3.3	3.3	3.5
St. Dev.	–	1.1	1.2	1.2	1.2	1.3	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3
M&M Rating														
Mean	2.9	2.7	2.6	2.9	3.1	3.0	3.0	3.2	3.1	2.9	2.8	3.1	3.0	3.1
St. Dev.	1.2	1.2	1.2	1.1	1.1	1.2	1.1	1.1	1.1	1.2	1.1	1.2	1.1	1.2

Table 5: Summary statistics for selected panel data control variables.
Note: "Mean" denotes the arithmetic average of all companies, "Min." / "Max." the minimum / maximum value found in the sample, "Ptl." stands for percentile while "St. Dev." is an abbreviation for the standard deviation.

single independent variables in the regression model.[5]

Reference Model (R1)

Having checked our initial data sample for multi-colinearity, we now apply the reference regression model (R1) to the full panel data to derive drivers for sales success in German life insurance (recall the overview of regression models in Table 1). In the period from 1998 to 2011, and for the relevant variables in the model (R1) a total of $N = 895$ full data points or firm-years are available. The results of the regression model for the reference case and full panel data as well as additional statistics are reported in Table 6. We report the estimated beta-coefficients corresponding to the different control variables of (R1) with their corresponding standard error. Further, we present the results of the two-tailed t-statistics including p-value and significance. Here, *,**, and *** represent the significance at the 10%, 5%, and 1% levels, respectively. Finally, we calculate and report the standardized beta coefficient in order to be able to compare the magnitude of the impact of the different variables.[6]

Variables	Est. (β_i)	St. Error	p-value	Sig.	Stand. β_i
α	−0.0336	0.0079	0.0000	***	
RE	0.3405	0.1039	0.0011	**	0.0801
AC	0.6727	0.0263	0.0000	***	0.6621
RA	0.0167	0.0013	0.0000	***	0.3293
SO	0.2890	0.0525	0.0000	***	0.1402
SI	−0.0000	0.0000	0.0181	**	−0.0600
LS	0.0034	0.0031	0.2684		0.0277
Adjusted R^2		0.4747			

Table 6: Empricial results of the reference multiple linear regression model (R1) on sales success in German life insurance.
Note: The two-tailed t-statistics are provided: *,**, and *** represent the respective significance at the 10%, 5%, and 1% levels. "Stand. β_i" stands for standardized beta coefficients.

The linear regression model (R1) is able to explain about 48% (adjusted R^2 value of 0.4747, see Table 6) of the variance and yields several significant variables. Five control variables, namely total return RE, acquisition costs AC, company rating RA, solvency level SO, and company size SI, show a significant impact. The variables return RE and size SI are significant at the 5% level. At a 1% level of significance, three further variables were detected: costs AC, rating RA, and solvency SO. Only the control variable legal status LS has no explanatory power in our empirical findings.

[5] Bartlett's test of sphericity for the factor analysis yielded 335.08 on 12 degrees of freedom. This value is higher than the chi-square reference value and thus the feasibility of the factor analysis is confirmed.

[6] In order to further test the robustness of our results, we conducted several analyses. In order to check for the absence of multi-colinearity in the applied data set in model (R1), we test the variance inflation factors (VIF) of the model. All values are below the commonly accepted threshold of 10; the highest VIF in our model yields 1.15. In order to test for autocorrelation of the standard errors we conducted the Durbin-Watson test. The result of 1.3 is close to the commonly accepted range of 1.5 to 2.5, in which no autocorrelation can be assumed to exist. Finally, we tested for heteroscedasticity. The visual plot of the residuals as well as the Goldfeld-Quandt test yielded no proof of inhomogeneous variance in error terms. We also plotted the results of our regression model and found no indications that the model was inaccurate. Details are available upon request from the authors.

First, it can be observed that higher acquisition costs, i.e., higher monetary incentives for the sales force, strongly drive the generation of new life insurance contracts. Thus, the second hypothesis (H2) is validated (see Section 3). Second, the higher or better the rating of the insurance company is, the higher the new business generation was in the past. The same effect is observed when it comes to the solvency of the insurer, and the same relation holds true for the total return that policyholders receive from the company. These findings confirm the initial hypotheses (H1), (H3), and (H4). In contrast to our initial hypothesis (H5), the size of the insurer has a small negative impact on sales success; this hypothesis is not validated. This may be explained through lower growth rates in a mature market (see also Eling and Kiesenbauer, 2012, p. 178). Having no significant impact, the legal status of a firm can be omitted in terms of new premium growth. This confirms the last hypothesis (H6) in our reference case. When it comes to the magnitude of the impact from significant drivers, the standardized beta coefficients show that the acquisition costs AC (standardized $\beta_i = 0.66$), i.e., the commissions the insurer pays, has the highest influence; it is more than two times higher than the second strongest driver, company rating RA (standardized $\beta_i = 0.33$). The solvency level SO of the company (standardized $\beta_i = 0.14$) as well as the achieved total return RE for the policyholder (standardized $\beta_i = 0.08$) are more or less of equal impact and contribute the least in a positive way toward sales success among the significant variables. The negative impact of size on the ability to generate new business is relatively small.

Our results confirm and extend the findings of Eling and Kiesenbauer (2012) in several ways. We are able to confirm the positive impact of policyholder participation (or policyholder total return) as well as the negative impact of firm size on the generation of new business for the entire period from 1998 to 2011 (see Eling and Kiesenbauer, 2012, Table 2). Second, we complement that knowledge with information about the impact of further control variables, especially the important impact of acquisition costs AC.

Models for Different Time Horizons: Comparing (R1) through (R4)

Repeating our analysis for shorter time intervals using the regression models (R2), (R3), and (R4), we confirmed the above results. Table 7 summarizes the standardized beta coefficients and significance levels for (R1) to (R4) on the overall business level for different time periods.

Within regression model (R2), which addresses the period from 1998 to 2003 until a recovery of stock markets set in after the financial crisis of the early 2000s, all previous significant variables are also significant at the same level, – except for total return RE, which is no longer significant. In total, the adjusted R^2 of the regression model is 0.398. Similarly, model (R3) in the second time period from 2004 to 2008 confirms the previous findings. However, in this case, total return RE is again significant at the 10% level with a positive impact on new business generation. The explanatory power of this model is 0.565. It seems that during periods of crisis and declining stock markets, the overall return of life insurance policies played no major role in consumer decisions. However, when stock markets regained momentum, from 2004 until the beginning of the last financial crisis in 2008, the decision on which insurer to choose for life insurance is again influenced by the total return offered. This effect can be interpreted such that during crises, consumers value the overall safety effect of life insurance (guarantees, regulated investment strategies, no risk of loss due to the nationwide protection system, etc.) and do not

Regression Model	(R1)		(R2)		(R3)		(R4)	
Time Period	1998–2011		1998–2003		2004–2008		2009–2011	
Variables	Stand. β_i	Sign.	Stand. β_i	Sign.	Stand. β_i	Sign.	Stand. β_i	Sign.
RE	0.0801	**	−0.0291		0.0887	*	−0.1214	*
AC	0.6621	***	0.6270	***	0.6818	***	0.6493	***
RA	0.3293	***	0.4134	***	0.3161	***	0.2495	***
SO	0.1402	***	0.1268	***	0.1563	***	0.0484	
SI	−0.0600	**	−0.0873	**	−0.0854	**	0.0606	
LS	0.0277		0.0698		0.0160		-0.0442	
Adjusted R^2	0.4747		0.398		0.5654		0.3848	

Table 7: Empirical results for regression models (R1) through (R4) on sales success in German life insurance for different time periods.
Note: The two-tailed t-statistics are provided: *,**, and *** represent the respective significance at the 10%, 5%, and 1% levels. "Stand. β_i" stands for standardized beta coefficients.

focus on specific performances. However, when stock markets are doing well and returns can be achieved besides the investment in more conservative life products, the performance again becomes important. This trend seems also to be confirmed during the period after the last financial crisis, starting from 2009 (see regression model R4). In this subsample, the return even has a negative impact on overall sales success. Solvency level SO and company size SI are no longer significant. The adjusted R^2 of the model is 0.385. Nevertheless, the results of regression model (R4) should be interpreted with caution. The analysis is only based on a three-year sample. Finally, let us recall that through all models the level of acquisition costs AC (in other words, commissions to sales force) and a company's rating RA have the highest impact on the sales success.

Extension of the Results to Include Customer Preferences (Models R5 and R6)

Let us now turn to the two remaining regression models on the basis of our reference case. In model (R5), we include the control variable customer satisfaction SA. The results are reported in Table 8.

In contrast to the results obtained for reference model (R1), as shown in Table 6, company size SI and solvency level SO no longer appear to be significant drivers in this regression model (R5). However, the other previously significant control variables maintain their explanatory power. In addition, customer satisfaction SA gets significant explanatory power at the 5% level. However, the sign of the estimate is negative. Contrary to our initial hypothesis (H7), customer satisfaction SA has a *negative* impact on sales success. Given that the underlying data sample shrank to less than one-fourth of the original panel with now $N = 202$ data points of firm-years, further research could address this topic again when more data points become available.

In addition, we conducted a variation of the reference case with another consumer-related control variable, the value of brand awareness BA. This last model at the business unit level represents model

Variables	Est. (β_i)	St. Error	p-value	Sig.	Stand. β_i
α	0.1007	0.0788	0.2028		
RE	1.4640	0.6021	0.0159	**	0.1670
AC	0.4985	0.0563	0.0000	***	0.6213
RA	0.0077	0.0033	0.0227	**	0.1995
SO	0.0784	0.1635	0.6319		0.0295
SI	−0.0000	0.0000	0.4108		−0.0509
LS	0.0094	0.0071	0.1870		0.0823
SA	−0.0536	0.0269	0.0481	**	−0.1399
Adjusted R^2		0.3274			

Table 8: Empricial results of regression model (R5) on sales success in German life insurance including the control variable customer satisfaction SA.
Note: The two-tailed t-statistics are provided: *,**, and *** represent the respective significance at the 10%, 5%, and 1% levels. "Stand. β_i" stands for standardized beta coefficients.

(R6). Our empirical results show no significant influence on new business generation. Thus, hypothesis (H8) could not be empirically verified. Apart from company size SI (which is no longer significant), all other control variables maintain their significance levels from the reference case. The adjusted R^2 of the model is 0.467. As was true for model (R5), we must point out that our analysis was based on a smaller subpanel (see also Table 3). Therefore, these results should be interpreted with caution.

5.2 Product-Specific Growth Drivers

After having discussed the impact of different drivers on the overall ability of insurance companies to generate new business in life insurance, we now focus on two specific products: pension and term life insurance. As described above, we apply two more regression models to do this. Model (R7) addresses the growth drivers in pension insurance, and (R8) analyzes the determinants of new business generation for term life insurance. The results are presented below.

Model (R7): Specific Drivers in Pension Insurance

For the performance of underwriting new pension business, we adapt the total return RE figures from the product average (as stated in Section 4.2) to the average of the pension-specific ones (denoted by RE_{PE}), i.e., the average for traditional pension policies, the "Riester-Rente" and "Ruerup-Rente". The results of the multivariate regression model (R7) based on $N = 123$ firm-years are presented in Table 9.[7]

This seventh regression models explains about 31% of the variance (adjusted R^2 of 0.3147). The control variables total return RE_{PE}, acquisition costs AC, company rating RA, and solvency level SO remain significant drivers for selling pension insurance. All have relevant positive influence (in line with the hypothesis stated in Section 4). When looking at the standardized beta coefficients, the magnitude of their influence is relatively comparable to standardized beta coefficients ranging from 0.22 to 0.38,

[7]On this subpanel of data, we have also tested the variance inflation factors. The highest value is 2.0 and thus multicolinearity can be omitted.

Variables	Est. (β_i)	St. Error	p-value	Sig.	Stand. β_i
α	−0.1207	0.0969	0.2160		
RE_{PE}	3.8185	2.0240	0.0624	*	0.2249
AC	0.4675	0.1145	0.0001	***	0.3777
RA	0.0121	0.0058	0.0404	**	0.2311
SO	1.8249	0.5608	0.0016	***	0.3062
SI	0.0000	0.0000	0.7820		0.0258
LS	−0.0008	0.0121	0.9491		−0.0063
OT_{PE}	−0.0051	0.0051	0.3214		−0.1050
Adjusted R^2		0.3147			

Table 9: Empricial results of regression model (R7) on sales success in pension insurance.
Note: The two-tailed t-statistics are provided: *,**, and *** represent the respective significance at the 10%, 5%, and 1% levels. "Stand. β_i" stands for standardized beta coefficients.

respectively. However, it should be noted that the assessment by Oekotest parameterized using the product rating OT_{PE} has no significant explanation power. Hypothesis (H9) in Section 3 cannot be verified. Recall that the regression is based on a much smaller sample size, which is restrained by limited data availability, with a total of $N = 123$ data points.

Model (R8): Specific Drivers in Term Life Insurance

In the last regression model (R8), we analyze the determinants of new business generation in term life insurance. Securing the financial stability of the bereaved – especially for families – in the case of death, this product achieved new sales volumes of 690 000 policies across Germany in 2011 (GDV, 2012, p.35). Table 10 shows the results of the regression model concerning sales success in term life insurance on the basis of $N = 122$ firm-years.

Variables	Est. (β_i)	St. Error	p-value	Sig.	Stand. β_i
α	0.2233	0.0533	0.0001	***	
AC	−0.1580	0.1841	0.3926		−0.0895
RA	−0.0012	0.0081	0.8849		−0.0152
SO	0.3126	0.6409	0.6267		0.0472
SI	−0.0000	0.0000	0.7548		−0.0302
LS	−0.0214	0.0203	0.2955		−0.1011
OT_{TL}	−0.0109	0.0097	0.2672		−0.1196
PR_{TL}	−0.0000	0.0000	0.0794	*	−0.1693
Adjusted R^2		0.01353			

Table 10: Empricial results of regression model (R8) on sales success in term life insurance.
Note: The two-tailed t-statistics are provided: *,**, and *** represent the respective significance at the 10%, 5%, and 1% levels. "Stand. β_i" stands for standardized beta coefficients.

None of the previously significant control variables has any more explanatory power in this model. It is not surprising that, for example, acquisition costs AC are no longer a significant driver, as the commission which sales personnel receive for this product is negligible in comparison to the commission for pension insurance. However, it is surprising that solvency level SO and company rating RA seem to have no relevant impact on the customer's purchasing decision. The same holds true for the control variable parameterizing the Oekotest product assessment OT_{TL}. Finally, the average price PR_{TL} is significant at the 10% level with a negative sign, which supports hypothesis (H10). In the end, note that this model has only an extremely modest overall explanatory power of 0.014.

6 Conclusion

The landscape in the German life insurance market is currently driven by two trends. On the one hand, the number of active insurance companies is decreasing and the market is consolidating. On the other hand, the large remaining players are steadily increasing their market share. While the five largest life insurers had a market share of 31% in terms of gross written premiums in 1998, this group increased its share to 39% in 2011. More than half of the industry's premiums were collected by the ten largest firms in 2011. Insurers must grow to avoid falling behind the industry leaders and thus ensure solid market positioning in the future.

In this paper, we analyze the impact of size on growth and profitability in a time period covering the years from 1998 to 2011. Three main effects can be observed: first, mid-sized insurers are subject to the typical "stuck-in-the-middle" phenomenon: their growth and profitability development is modest. Second, small insurers have been able to achieve high growth rates in the past. Initially realized at the expense of profitability, following the last financial crisis, the smallest players experienced a turn-around in terms of profitability and continued to grow more slowly but profitably during the time period from 2009 to 2011. Finally, the data show that the largest companies were able achieve both satisfying growth rates as well as profitability during all observed time periods. The analysis reveals that profitable growth has been possible in German life insurance in the past.

In a second step, we focus on the success drivers for new business growth and thus build on the findings by Eling and Kiesenbauer (2012). Following a twofold approach, we analyze the impact of different control variables on both the overall life business as well as on a product-specific level. Our analysis reveals that acquisition costs, which mainly represent commissions to sales partners, have a strong positive impact on sales success. Not surprisingly, the empirical data also confirm that the total return that an insurer generates for its policyholders is crucial. In addition, the rating of the company and its solvency fosters new business generation. Furthermore, contrary to our initial hypothesis, customer satisfaction has a slightly negative impact. At the pension insurance product level, most of the significant drivers that have been identified are once again important. In addition, the available panel data reveal that – contrary to our initial hypothesis – the product assessment reports by consumer magazines have no measurable significant influence on the sales performance of a life insurer. Further research could deepen our analysis at the product level. Since product-specific ratings are only available for recent years, the data basis is limited. In the future, an analysis could be conducted using more data points and thus increase the stability of the results for specific product growth drivers.

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