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**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, I perform an empirical analysis of life insurance securitizations by public listed insurers between 1999 and 2011. I 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.

**Key words** Securitization · Life Insurance · Default Probabilities · Multivariate Model
**JEL Classification** G22 · G32 · G33

## 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

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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 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.

This paper contributes to the literature by analyzing the risk implications of the securitizing of life insurance products. I show empirically that life securitizations 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. In addition, 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, $\mu_A$ 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). I 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 $\mu_A$ 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 $\sigma_{A,t}$, I 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. $\Delta DLI_{Adj}$, of life securitizing firms can be calculated by (adopted from Hagendorff et al., 2011, p. 10 and Vallascas and Hagendorff, 2011, p. 905):

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

In order to understand the concrete risk impacts of the life securitization, I 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, my analysis is based on 30 trading days around the deal date. Let $\eta$ 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:

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

A positive value of $\Delta DLI_{Adj}$ 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 my 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

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

and type. In total, 24 insurance companies created a deal volume of $ 29.6 billion. Figure 1 gives an

| Insurer (Values in $ mn.) | Embedded Value | Mortality | Regulation XXX/aXXX | Grand 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.

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 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.

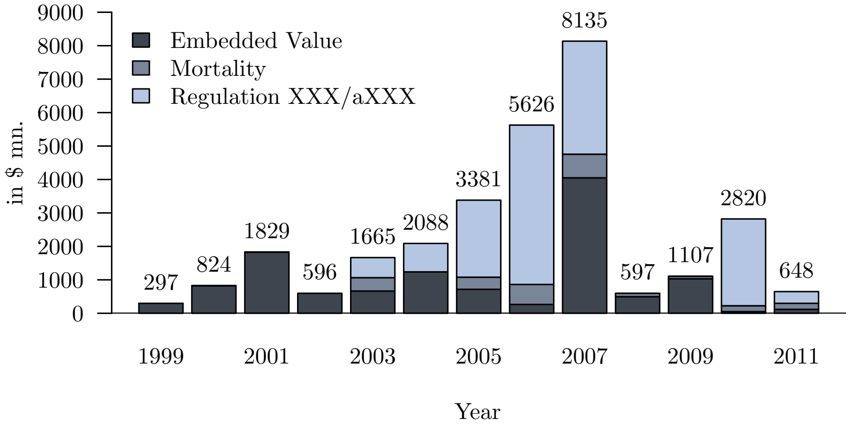


Figure 1: Historic life securitization transactions from 1999 to 2011. Figures are in $ million and categorized by Regulation XXX/aXXX securitization, mortality securitizations, and embedded value securitizations. The data on the issues has been obtained from SwissRe, Artemis, Trading Risk, as well as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

| 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 industry giants 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.

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.

| 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.

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), I 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 ($\eta$ 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, I 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.

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

[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.

| | N | mean(%) (t-Statistics) | median(%) (Wilcoxon-Test) | $\Delta \mathrm{DLI}_{\mathrm{Adj}} > 0$ N | % |
|---|---|---|---|---|---|
| $Pre-Issue\ DLI_{Adj,[\eta-31;\eta-2]}$ | 51 | 1.49231%* | -0.00063% | | |
| $Post-Issue\ DLI_{Adj,[\eta+2;\eta+31]}$ | 51 | 1.24548%* | -0.00108% | | |
| $\Delta DLI_{Adj}$ | 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.

respective accounting year.

The analysis confirms the hypothesis, that life securitization is a suitable tool for lowering the ruin probability of an insurance company. 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. 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, I perform several robustness tests (analogous to Hagendorff et al., 2011). Firstly, I 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, I 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, I 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, I 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.

| 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.

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.

# 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 $\Delta DLI_{Adj}$. 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, I 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

- $\Delta DLI_{Adj}$ represents the industry adjusted change in the issuer's default probability that has been calculated for each life securitization deal in Section 3.1,
- $\alpha$ 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
- $\epsilon$ 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, I expect that the size of the insurer will have a positive impact on the effect or risk reduction via securitization. I base my expectation on the special characteristics of the life portfolio. While the law of large numbers might still be valid for mortality risk, longevity risk will not be diversified by increasing portfolio size (see, for example, Ngai and Sherris, 2011, De Waegenaere et al., 2010, or Milevsky et al., 2006). In contrast, it can become even more dangerous for larger insurers. Therefore, I 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. $RoE$ represents the return on assets defined as the pre-tax profit divided by the total equity 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 as well as effects from the accounting of acquisition expenses may distort the profitability picture of RoE-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

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

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, I follow the approach of Hagendorff et al. (2011) and include these two variables in the 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. I 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, I 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, I 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, I 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 as well as for the five performed robustness tests in Section 3 are summarized in Table 6. The insurer specific characteristics $Issuer_i$ in the regression on the change of default probability $\Delta DLI_{Adj}$ 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

| Variable | Base Case | RobTest 1 | RobTest 2 | RobTest 3 | RobTest 4 |
|---|---|---|---|---|---|
| INTERCEPT | -0,02776<br>(-1,083) | 0,00106<br>(0,186) | -0,09807<br>(-1,493) | -0,00005<br>(-0,334) | -0,07441<br>(-1,28) |
| SIZE | **0,00131****<br>(2,222) | -0,00011<br>(-0,766) | -0,00004<br>(-0,028) | -2,54E-06<br>(-0,716) | **0,00271***<br>(2,036) |
| LEVERAGE | 0,00807<br>(0,3) | 0,00099<br>(0,163) | 0,1232<br>(1,644) | 0,00006<br>(0,387) | 0,03761<br>(0,616) |
| RoA | -0,03249<br>(-0,347) | -0,00144<br>(-0,059) | -0,1025<br>(-0,408) | **0,00198*****<br>(3,413) | 0,17878<br>(0,841) |
| PREVIOUS | 0,0002<br>(0,917) | 0,00001<br>(0,149) | 0,00019<br>(0,369) | 0<br>(0,221) | 0,00019<br>(0,379) |
| LOSSRATIO | **0,00241***<br>(1,777) | 0,00024<br>(0,47) | **-0,00595***<br>(-2,001) | **0,00003*****<br>(3,206) | 0,00311<br>(1,015) |
| UWSUCCESS | **-0,008****<br>(-2,268) | -0,00074<br>(-0,554) | 0,01<br>(1,321) | **-0,00007*****<br>(-3,357) | -0,01208<br>(-1,511) |
| TYPE (Reinsurer) | **0,00282***<br>(1,773) | -0,00015<br>(-0,384) | -0,00239<br>(-0,627) | -0,00001<br>(-1,086) | 0,00301<br>(0,834) |
| HIGHEXP (Yes) | **0,03081*****<br>(13,806) | 0,00003<br>(0,08) | -0,00344<br>(-0,688) | **0,00013*****<br>(9,287) | **0,06312*****<br>(12,473) |
| ISSUESIZE | 0,00578<br>(0,144) | -0,00134<br>(-0,159) | 0,05385<br>(0,6) | 0,00001<br>(0,894) | 0,05465<br>(0,601) |
| GDP | -0,00034<br>(-1,054) | **-0,00022****<br>(-2,689) | **-0,002****<br>(-2,414) | **-0,00001*****<br>(-3,337) | **-0,00172****<br>(-2,321) |
| INTEREST | 0,08696<br>(1,526) | -0,00439<br>(-0,351) | -0,00384<br>(-0,028) | -0,00009<br>(-0,26) | 0,1811<br>(1,401) |
| Adjusted $R^2$ | 0,8843 | 0,2036 | 0,266 | 0,8017 | 0,8702 |
| Observations | 45 | 40 | 39 | 45 | 45 |

Table 6: Regression results on the effect of life securitizations for the issuer's default risk.

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. T-values are shown in brackets. Significant values are printed bold.
The deals from MONY and American Skandia need to be excluded from the regression analysis due to a lack of data.

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.

In addition, almost any robustness test can confirm the previous assumption that insurers with a high ex-ante default probability, i.e. those which were in the fourth quartile, experience a more positive effect from the securitization deals than insurers with lower ex-ante default probabilities.

The transaction characteristic $Transaction_i$ has no explanatory power in my 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. Only the development of the GDP has a significant negative impact for all regressions on the robustness test results.

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.

My 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.

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# 6 Appendix

The following table contains, to the best of my 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 |

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

| Deal Closed | Issuer | Category | Volume ($ mn.) |
|---|---|---|---:|
| 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 |
| 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 |

| Deal Closed | Issuer | Category | Volume ($ mn.) |
|---|---|---|---|
| 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.