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Discussion Paper

Deutsche Bundesbank
No 10/2021

Inter-cohort risk sharing with long-term guarantees: Evidence from German participating contracts

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ISBN 978–3–95729–818–8 (Internetversion)

Non-technical summary

Research Question

Participating contracts offered by life insurers are retail financial products used for long-term saving (in addition to risk protection). They allow investors to diversify risk both between different investments and over time. This is achieved through risk sharing between cohorts, investors who concluded their contracts at similar times and thus at the same guaranteed interest rates. To provide investors with a stable return on their policies, life insurers build up reserves in good times that they can tap into in bad times, when their investment return is low. Through the build-up and release of these reserves, investors share their investment income with other cohorts, e.g. future investors. We investigate the extent to which inter-cohort risk sharing is present in the German life insurance sector.

Contribution

Using supervisory data spanning the period from 2000 to 2018 on life insurance contracts of German life insurers, we calculate the extent of inter-cohort risk sharing. Against the background of low interest rates, we also analyze to what extent binding guaranteed interest rates influence the effectiveness of inter-cohort risk sharing.

Results

The paper shows that new investors are currently still benefiting from the fact that high reserves were built up in the past, which are now slowly being reduced. The risk sharing between cohorts is limited, however, as the proportion of cohorts whose guarantees become binding increases. For example, binding guarantees reduce inter-cohort transfers by 10 basis points per year in the period 2000-2018. This is modest compared to the average transfer of 40 and 150 basis points. However, the effect of binding guarantees is concentrated in the most recent period of ultra-low rates and is likely to increase if rates remain low.

Nichttechnische Zusammenfassung

Fragestellung

Neben der Risikoabsicherung dienen Kapitallebensversicherungen zum langfristigen Sparen. Diese Produkte ermöglichen es, Risiken sowohl zwischen verschiedenen Kapitalanlagen als auch über die Zeit zu diversifizieren. Dies wird durch Risikoteilung zwischen Kohorten, Anlegern, die ihre Verträge zu ähnlichen Zeitpunkten und damit zu gleichen Garantiezinsen abgeschlossen haben, erreicht: Um eine schwankungsarme jährliche Rendite für ihre Anleger zu erreichen, bilden Lebensversicherer in guten Zeiten Reserven, auf die sie in schlechten Zeiten zurückgreifen können, also wenn ihre Investitionen nur geringe Erträge einbringen. Durch den Auf- und Abbau von Reserven teilen Anleger ihre Kapitalerträge mit denen anderer Kohorten, beispielsweise zukünftigen Anlegern. Wir untersuchen, inwieweit Risikoteilung zwischen Kohorten im deutschen Lebensversicherungssektor genutzt wird.

Beitrag

Anhand aufsichtlicher Daten zu deutschen Lebensversicherern berechnen wir für den Zeitraum von 2000 bis 2018 den Umfang der Risikoteilung zwischen Kohorten. Im Hinblick auf das Umfeld niedriger Zinsen analysieren wir außerdem, inwiefern bindende Garantiezinsen den Umfang der Risikoteilung beeinflussen.

Ergebnisse

Das Papier zeigt, dass neue Anleger aktuell noch davon profitieren, dass in der Vergangenheit hohe Reserven aufgebaut wurden, die nun langsam abgebaut werden. Die Risikoteilung zwischen Kohorten wird jedoch eingeschränkt, da der Anteil der Kohorten größer wird, deren Garantien bindend werden. So verringern bindende Garantiezinsen kohortenübergreifende Transfers um 10 Basispunkte pro Jahr. Dies ist im Vergleich zum durchschnittlichen Transfer gering, der zwischen 40 und 150 Basispunkten liegt. Jedoch konzentriert sich der Effekt bindender Garantiezinsen auf die jüngste Periode extrem niedriger Zinsen und dürfte größer werden, falls die Zinsen anhaltend niedrig bleiben.

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Inter-Cohort Risk Sharing with Long-Term Guarantees: Evidence from German Participating Contracts*

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Abstract

Long-term minimum return guarantees sold by European life insurers increasingly become binding as interest rates decline. While participating contracts embedding these guarantees are designed to share market risk across investor cohorts when guarantees are not binding, we study how binding guarantees distort inter-cohort risk sharing. Using regulatory data on participating contracts in Germany, we find that binding guarantees reduced inter-cohort transfer by 10 basis points per year in the period 2000–2018. This is modest compared to the average transfer, which is in the range of 40–150 basis points. However, the effect is concentrated in the recent period of ultra-low interest rates and may grow larger if interest rates remain persistently low.

Keywords: Life insurers; Participating contracts; Long-term investment; Inter-cohort risk sharing; Minimum return guarantees

JEL classification: G22; G52

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1 Introduction

Against a backdrop of population ageing and a decline of pay-as-you-go and defined benefit pension plans around the world, households increasingly rely on their own savings to finance their retirement, exposing them to market risk. Households can invest directly in financial markets by managing market risk according to life cycle portfolio optimization principles. Alternatively, households can buy investment products sold by financial intermediaries, which often include insurance against market risk. Life insurers are major providers of such investment products in the EU and increasingly so in the US. As of 2018, in the EU, investments in life insurer participating contracts amount to 4 trillion euros, which represents 16% of household financial wealth. In the US, investments in life insurer variable annuities come to 1.5 trillion US dollars, with a significant fraction including insurance against market risk.[1]

Participating contracts sold by European life insurers rely on two sources of market risk sharing.[2] First, they share market risk between investor cohorts through a reserve mechanism that buffers shocks to asset returns and smoothes investor returns across cohorts. Reserves are built-up in good years, used in bad years, and passed on between successive cohorts of investors, spreading market risk across investor cohorts. Second, participating contracts include minimum return guarantees that provide investors with downside protection against market risk. The persistent decline in interest rates has led insurers to lower the level of return guarantees in new contracts. However, because guarantees usually apply over long periods of time, the average level of guarantees in outstanding contracts is sticky, and is now above the risk-free yield curve in many European countries (see EIOPA, 2018, pp. 71–72). In Germany, as of 2018, one-quarter of outstanding guarantees are binding in the sense that the return paid on the contract is equal to the minimum guaranteed return of the contract (see Figure 2).

Inter-cohort risk sharing is a powerful mechanism for sharing risk. It achieves risk sharing that cannot take place in financial markets, because financial markets do not allow households to trade with future cohorts (Gordon and Varian, 1988; Allen and Gale, 1997). When return guarantees are low and are not binding, participating contracts achieve inter-cohort risk sharing on a large scale (Hombert and Lyonnet, 2019). By contrast, there is no evidence on how binding guarantees interact with inter-cohort risk sharing. In this paper, we study the impact of the provision of long-term return guarantees on inter-cohort risk sharing in participating contracts.

Return guarantees can interact with inter-cohort risk sharing in two ways. Ex post—after market risk is realized, minimum return guarantees constrain the set of transfers between investor cohorts that can be achieved. For example, when interest rates decline and long-term bonds held by insurers earn high returns, inter-cohort risk sharing involves hoarding these high returns as reserves and sharing them with new investor cohorts. High return guarantees on old contracts constrain insurers' ability to do so. Ex ante—before

[1] Aggregate summary statistics for Europe are taken from EIOPA (https://www.eiopa.europa.eu/tools-and-data/insurance-statistics_en) and those for the US are from Koijen and Yogo (2018) and Ellul, Jotikasthira, Kartasheva, Lundblad, and Wagner (2018).

[2] Participating contracts combine an investment product that includes insurance against investment risk, and in some cases life insurance products such as annuities and death benefits. Our focus is on the investment dimension.

market risk is realized, outstanding return guarantees may shift supply of and demand for new participating contracts. Demand for new contracts can depend on outstanding guarantees because reserves and asset returns are pooled between investor cohorts. Therefore, for a given investor and for given asset returns and reserves, binding return guarantees on other investors' contracts with the same insurer mechanically reduce that investor's contract return. Outstanding return guarantees may also alter insurers' incentives to issue new contracts through balance sheet effects (Koijen and Yogo, 2015).

We focus on participating contracts in Germany using regulatory and financial statement data for the period 2000–2018. During this period, the share of binding return guarantees increased from 0% to 24% as a result of the combination of high return guarantees granted in the 1990s and early 2000s and declining interest rates. We first establish that reserves are used to insulate contract returns from fluctuations in asset returns. The volatility of annual contract returns is 1% per year, whereas that of asset returns is 5% over the sample period. Reserves absorb the bulk of asset return fluctuations at the annual frequency. The extent to which contract return smoothing translates into inter-cohort redistribution depends on how long reserves are hoarded compared to contract maturity, and on the impact of binding return guarantees.

We find that inter-cohort transfers are sizeable over 2000–2018. We quantify inter-cohort transfer for a given investor as the difference between the total return earned over the contract holding period and the counterfactual return that would have prevailed without reserve management. Households holding a contract over the 2000–2018 period experience large negative inter-cohort transfers. They earn returns that are 0.4 to 1.5 percentage point per year lower than they would have been if insurers had not used reserves to smooth contract returns, depending on the characteristics of contracts they hold (regular vs. single premiums and lump-sum vs. annuity payout). Investors over the last two decades have thus been net contributors to the inter-cohort risk sharing mechanism: they contributed 0.4–1.5% of their investment every year during their holding period. The reason is that declining interest rates generated high returns on long-term bonds, which make up 80% of the asset portfolio. These high returns are not paid out to current investors but hoarded as reserves that will be shared with future investors.

To assess the impact of binding guarantees on inter-cohort risk sharing, we compare the above transfer amount estimated using actual contract returns, which are in some instances constrained by binding guarantees, with the transfer amount estimated using counterfactual contract returns that would have prevailed if return guarantees were never binding, taking as given the amount of reserves at all points in time. That is, we take the total payouts across all investor cohorts in any given year in the data and estimate how the distribution of payout across cohorts would have differed if return guarantees were slack for all cohorts. The comparison reveals that return guarantees reduce inter-cohort transfers, albeit by a small amount during the sample period. The reduction in the transfer amount is between zero and 0.1 percentage points, which is modest compared to the total transfer of 0.4–1.5 percentage points per year. The effect is modest because guarantees bind only at the end of the sample period—it may grow larger in the near future. This estimate takes reserves and investment amounts as given but both may be endogenous to the level of outstanding return guarantees. This is the issue we investigate next.

We study how insurers manage reserves. First, we replicate the evidence from French participating contracts that the pass-through of asset returns to contract returns is close to zero at the annual frequency (Hombert and Lyonnet, 2019). The difference between the asset return and contract return is absorbed by reserves. Reserves, in turn, are credited to (or debited from) contracts in future years at a rate of 1.8% per year. Second, we show that insurers with higher return guarantees in outstanding contracts do not pay lower returns on new contracts when outstanding guarantees start to bind after 2011. Since these insurers pay higher returns on old contracts, whose high guarantees are binding, they pay a higher average contract return when we aggregate on their entire book of contracts. This implies that insurers with larger outstanding guarantees tend to deplete their reserves faster, on average. Depleting reserves may reduce the scope for inter-cohort risk sharing in the future.

We then study how investment flows are impacted by outstanding guarantees. Purchases of new contracts are lower when the level of guarantees in outstanding contracts is higher. This is consistent with new investors anticipating that high guarantees in outstanding contracts will consume reserves in the future, crowding out returns on new contracts. The effect of outstanding guarantees on the purchases of new contracts is more pronounced for single premium contracts than for regular premium contracts. This is consistent with the fact that single premium contracts are purchased by wealthier, more financially sophisticated households, on average. Sophisticated households are more likely to figure out that high outstanding guarantees will weigh on the return on new contracts.

The negative relationship between purchases of new contracts and outstanding guarantees is also consistent with a supply-side response. Insurers may charge fees on new contracts in a way that is correlated with the level of guarantees in outstanding contracts. Because our data set does not include information on fees, we study another supply-side response that we are able to observe: run-offs. Insurers running off their portfolio stop selling new contracts and focus on managing and honoring the stock of outstanding contracts. Entering run-off, therefore, can be interpreted as an extreme case of an inward shift in the supply curve. The number of insurers in run-off takes off after 2010. However, we find that the decision to run off is not correlated with the level of outstanding return guarantees.

This paper contributes to the literature on market risk sharing in retail savings products. Hombert and Lyonnet (2019) study inter-cohort risk sharing in participating contracts in France over 2000–2015. During this period, return guarantees were not binding in France because life insurers traditionally extended lower guarantees in France compared to Germany. Our contribution is to study how binding guarantees interact with inter-cohort risk sharing. Albrecht and Weinmann (2015) argue that German participating contracts are designed to achieve inter-cohort risk sharing. Kablau and Weiß (2014) investigate the development of reserves used for risk sharing over time in a scenario of low interest rates. Förstemann (2019) and Kubitza, Grochola, and Gründl (2020) analyze the potential demand-side responses for German participating contracts when interest rates rise which depletes unrealized capital gains. Eling and Kiesenbauer (2012) study whether policyholders respond to profit sharing declarations. Return guarantees implementing cross-sectional risk sharing without inter-cohort risk sharing, are studied by Koijen and Yogo (2018) and Calvet, Célérier, Sodini, and Vallee (2020).

Our paper also contributes to the literature on the impact of life insurers on financial stability. On the one hand, the long maturity of life insurers' liabilities allow them to be contrarian investors and have a stabilizing effect on asset prices (Timmer, 2018; Chodorow-Reich, Ghent, and Haddad, 2020; Fache Rousová and Giuzio, 2019). As a recent example, German insurers increased their holdings of risky bonds during the market turmoil in the spring of 2020 when credit spreads spiked (Deutsche Bundesbank, 2020). On the other hand, financial constraints affecting life insurers can lead them to amplify shocks to asset prices (Ellul, Jotikasthira, and Lundblad, 2011; Ellul et al., 2018) and to reduce the provision of market risk insurance when their capital position weakens (Koijen and Yogo, 2015). Our contribution is to show how protracted low interest rates make guarantees in participating contracts binding, which partly undoes the large-scale inter-cohort sharing of market risk achieved by these contracts. This may threaten insurers' ability to be contrarian investors and hence negatively affect the contribution of the sector to financial stability.

2 Participating contracts

2.1 The German savings market

Participating contracts sold by life insurers in Germany are retail financial products used for long-term saving that combine an investment component and, in some cases, an insurance component such as an annuity. Participating contracts represent 15% of aggregate household financial wealth and 62% of life insurers' provisions in Germany in 2018. The other main components of household financial wealth are deposits (40%), stocks and investment funds (20%), pension plans (10%), and other insurance claims (10%).[3] Concentration in the market for participating contracts is relatively low: the Herfindahl-Hirschman index is 8%, the share of the top 5 life insurers is 45%, and there are about 80 life insurers selling participating contracts in 2018.

2.2 Contract cash flows

Participating contracts have an accumulation phase during which the account value grows. At the end of this phase, the account value is paid out to the investor either as a lump sum or as an annuity.

During the accumulation phase, the account value grows over time for two reasons: premiums paid by the investor and returns paid by the insurer. Two types of contracts exist regarding the schedule of premium payments during the accumulation phase. In regular premium contracts, investors pay annual premiums following a schedule fixed at the creation of the contract. The typical schedule is a constant premium over time. Some contracts include the option to increase premiums; less common are pre-scheduled premium increases. In single premium contracts, investors pay a single premium at the creation of the contract. The total account value appears on the liability side of the insurer's balance

[3]These 10% consist of 5% other life policies, 3% unit-linked contracts, which are regular pass-through mutual funds, and 2% non-life. The other main life policies sold by life insurers are term life policies, which are insurance contracts against mortality risk (3%) and disability insurance (1%). In this paper, we use the term "participating contracts" to refer to participating savings contracts only even though term life and disability policies are also participating in the sense that they have reserve mechanisms similar to that of participating savings contracts.

sheet as premium reserves. Premiums collected from investors are invested in a portfolio of assets through a common fund managed by the insurer.

At the end of each calendar year during the accumulation phase, investors' accounts are credited at a rate of return that we will refer to as the contract return. The contract return is decided by the insurer subject to several rules.

Insurers commit to a minimum guaranteed return, which is fixed at the creation of the contract for the entire life of the contract. It applies each year of the contract, which means that, in each year, the contract return for a contract is at least as high as the minimum guaranteed return of this contract. Regulation imposes a cap on the minimum guaranteed return that insurers are allowed to offer. The cap is revised regularly by the Ministry of Finance and was set until recently at 60% of the ten-year yield on AAA-rated bonds (see Appendix B.1 for details). Although insurers are allowed to offer a minimum guaranteed return below the cap, they never do so. The minimum guaranteed return is always equal to the regulatory cap as of creation of the contract. It implies that there is no variation in the guaranteed return of contracts sold at a given point in time either between or within insurers. The evolution of the minimum guaranteed return over time is plotted in Figure 1. It increases up to 4% on contracts sold in the mid-1990s before following the declining trend in interest rates to reach 0.9% on contracts sold in 2018.

Even where the minimum guaranteed return is not binding, the contract return usually differs from the current asset return. Insurers use reserves to buffer shocks to asset returns and smooth contract returns over time. Insurers retain part of asset returns as reserves in years when asset returns are high, and use reserves in years when asset returns are low. The important feature of reserves is that they belong to the investors collectively and are passed on between successive cohorts of investors. New investors are entitled to distribution of reserves accumulated before they purchased a contract. Conversely, investors whose contract ends lose their right to distribution of outstanding reserves, which will be distributed to future investors.

Insurers are required by regulation to distribute to investors at least 90% of the asset income in excess of the minimum guaranteed return. The timing of distribution, however, is not synchronized with that of asset returns, because asset returns can be hoarded as reserves before being credited to investors' accounts. Reserves are eventually credited to investors' accounts in the form of a regular bonus paid each year to all outstanding contracts and a terminal bonus paid at end of the accumulation phase. The contract return in a given year is equal to the minimum guaranteed return plus the regular bonus chosen by the insurer.

Finally, insurers are required by law to distribute the same contract return in a given year to all investors, irrespective of when they purchased their contract. Investors holding a contract with a lower guaranteed minimum return are paid a higher regular bonus such that all investors earn the same contract return. The only exception is when the minimum guaranteed return is binding for some investors and not for others. In this case, all investors earn the same contract return except those holding a contract with a guaranteed return above that return, who instead earn their guaranteed return.

An investor may surrender her contract before the end of the accumulation phase. In this case, she gets back the account value as of the time she surrenders the contract but loses her right to future distribution of reserves. She also loses the terminal bonus paid at the end of the accumulation phase. An investor may also set a regular premium contract to inactive by stopping payment of the annual premium. In this case, the investor continues to earn the same contract return including the guarantee, the regular bonuses and the terminal bonus as if she had continued to pay the annual premiums.

At the end of the accumulation phase, the account value is paid out to the investor either as an endowment or as an annuity. The form of the payout is fixed at the creation of the contract. During the sample period, one-third of contracts specify an endowment payout and two-thirds an annuity payout.[4] When the payout is annuitized, the contract return continues to be credited to the account every year during the payout phase. The length of the accumulation phase is fixed at the creation of the contract. It varies across contracts from zero (an annuity single premium contract with immediate annuitization) to over thirty years.

2.3 Reserves

The two key features of reserves is that they are ultimately owed to investors, and that they are pooled across investor cohorts. Reserves have three components (see Appendix B.2 for a detailed description of the regulatory and accounting framework of reserves):

1. Profit sharing reserve (PSR). It represents cumulated asset and underwriting income that has been recognized as income according to the (historical cost) accounting principles applying to life insurers, but that has not yet been assigned to investors' accounts. Funds in the PSR must eventually be paid to investors, but not to a specific cohort until they are actually credited to investors' accounts.

2. Unrealized capital gains represent cumulated asset income that has not yet been recognized as income according to historical cost accounting. When these returns are realized and recognized as asset income, the insurer will have to credit at least 90% of them either directly to investors' accounts or to the PSR. Therefore, at least 90% of unrealized capital gains are ultimately owed to investors.

3. Additional interest provision (AIP). Against the backdrop of declining interest rates, the AIP was created in 2011 to force insurers to recognize economic losses on outstanding minimum return guarantees. Calculation of the AIP is based on outstanding contracts whose minimum guaranteed return is higher than a benchmark interest rate equal to the 10-year moving average of the 10-year swap rate. The AIP is equal to the positive part of the difference between the present value of these contracts' future payouts discounted at the benchmark rate and the same present value discounted at the guaranteed rates of the contracts.

Introduction of the AIP does not affect the total amount of reserves holding contract returns fixed. It requires insurers to recognize losses on outstanding guarantees, reducing accounting asset income. As soon as the AIP is released, it will increase accounting asset income. Less accounting asset income leads to lower profit sharing reserves. Thus, the impact of the AIP is to move funds from profit sharing reserves to the AIP. If insurers realize capital gains in order to boost asset income and keep contract returns at the same level as if the AIP had not been introduced, the impact of the AIP is to move funds from unrealized capital gains to the AIP. Which scenario actually prevails affects the composition but not the total amount of reserves.

[4] Some annuity contracts include the option to switch to endowment.

3 The accounting of inter-cohort redistribution

In this section, we present a simple framework of the accounting of inter-cohort redistribution in participating contracts.

Let us denote by $V_{i,j,t}$ investor i's account value with insurer j at the end of year t. The account value evolves according to

$$V_{i,j,t} = (1 + y_{i,j,t})V_{i,j,t-1} + (1 + 0.5y_{i,j,t})Premium_{i,j,t} - (1 + 0.5y_{i,j,t})Payout_{i,j,t} + TerminalBonus_{i,j,t}. \quad (1)$$

where $y_{i,j,t}$ is the contract return paid by the insurer at the end of year t. $Premium_{i,j,t}$ is the premium paid by the investor during year t. $Payout_{i,j,t}$ is the payout to the investor which can be a lump sum or an annuity paid at the end of the accumulation phase. $TerminalBonus_{i,j,t}$ is the terminal bonus paid at the end of the accumulation phase.

When premium payments or payouts take place over the course of the year, the contract return is paid on a pro-rata basis. Equation (1) implicitly assumes that premium payments and payouts take place mid-year or uniformly throughout the year such that they earn half the annual contract return. It simplifies formulas to define the yearly average account value as

$$\bar{V}_{i,j,t} = V_{i,j,t-1} + 0.5Premium_{i,j,t} - 0.5Payout_{i,j,t}. \quad (2)$$

As described in Section 2, the insurer must pay the same annual contract return to all investors whose minimum guaranteed return is not binding. Where the guarantee was binding for some investors, the insurer would pay the minimum guaranteed return. That is,

$$y_{i,j,t} = \max(y^u_{j,t}, y^g_{i,j}), \quad (3)$$

where $y^u_{j,t}$ is the contract return paid to investors whose guarantee is not binding (u stands for *unconstrained*) and $y^g_{i,j}$ is investor i's minimum guaranteed return (g stands for *guaranteed*). The contract return in excess of the guaranteed rate, $y_{i,j,t} - y^g_{i,j}$, is the regular bonus. We denote by $y^a_{j,t}$ the average contract return paid in year t by the insurer across investors (a stands for *average*):

$$V_{j,t} = V_{j,t-1} + y^a_{j,t}\bar{V}_{j,t} + Premium_{j,t} - Payout_{j,t} + TerminalBonus_{j,t}, \quad (4)$$

where $V_{j,t}$ is total account value summed across investors, $Premium_{j,t}$ is total premium, $Payout_{j,t}$ is total payout, and $TerminalBonus_{j,t}$ is total terminal bonus.

Insurers accumulate reserves, which are pooled across investors and appear on the liability side of the insurer's balance sheet:

$$A_{j,t} = V_{j,t} + R_{j,t}, \quad (5)$$

where $A_{j,t}$ is total assets backing the contracts and $R_{j,t}$ is total reserves, both measured at the end of year t. Note that the balance sheet identity (5) does not include insurer equity nor assets belonging to the insurer. Total assets evolve according to

$$A_{j,t} = (1+x_{j,t})A_{j,t-1} + (1+0.5x_{j,t})Premium_{j,t} - (1+0.5x_{j,t})Payout_{j,t} - InsurerIncome_{j,t}, \tag{6}$$

where $x_{j,t}$ is asset return and $InsurerIncome_{j,t}$ is insurer income. We define total assets including half of net flows as

$$\bar{A}_{j,t} = A_{j,t-1} + 0.5Premium_{j,t} - 0.5Payout_{j,t}. \tag{7}$$

Combining (4), (5), (6) and (7), we obtain the accounting identity

$$x_{j,t}\bar{A}_{j,t} = y^a_{j,t}\bar{V}_{j,t} + TerminalBonus_{j,t} + InsurerIncome_{j,t} + \Delta R_{j,t}. \tag{8}$$

Equation (8) describes how asset income is split between contract return in the current year, terminal bonus paid to ending contracts, insurer income, and change in reserves $\Delta R_{j,t} = R_{j,t} - R_{j,t-1}$. Therefore, participating contracts include two mechanisms providing investors with insurance against asset risk: shocks to asset returns can be absorbed by insurer income and by reserves to make contract returns less volatile than asset returns. The insurer mostly provides downside protection through minimum guaranteed returns. This reflects cross-sectional risk sharing between insurers and investors. Variation in reserves leads to intertemporal risk sharing between investors holding contracts in different periods of time.

Reserve management is a necessary condition for generating inter-cohort risk sharing but not a sufficient condition. The amount of inter-cohort risk sharing depends upon three factors: the extent to which reserves absorb shocks to asset returns; the speed at which reserves are distributed relative to contract maturity; and the extent to which minimum guaranteed returns bind differently across investor cohorts. Intuitively, there is more inter-cohort risk sharing when a higher share of asset risk is absorbed by reserves. Conversely, there is no inter-cohort risk sharing if reserves do not fluctuate. Second, there is more inter-cohort risk sharing when reserves are held for longer relative to the holding period of contracts. Conversely, if reserves mean revert quickly such that changes in reserves over contracts' holding periods are small, there will be little inter-cohort risk sharing. Finally, binding minimum return guarantees interact with inter-cohort risk sharing because they impose a floor on the contract return of each investor cohort, which translates into bounds on the amount of transfer between cohorts that can be achieved.

We follow the methodology of Hombert and Lyonnet (2019) to quantify the amount of inter-cohort redistribution in participating contracts. The methodology is based on comparing actual contract returns with counterfactual contract returns that would have prevailed if reserves had remained constant, holding fixed asset returns and insurer income and assuming return guarantees do not bind in the counterfactual. The counterfactual contract return is determined by setting $\Delta R_{j,t} = 0$ in (8):

$$y^*_{j,t}\bar{V}_{j,t} = y^a_{j,t}\bar{V}_{j,t} + \Delta R_{j,t}. \tag{9}$$

The transfer from reserves to investor i in year t is

$$(y_{i,j,t} - y^*_{j,t})\bar{V}_{i,j,t} = \left(-\frac{\Delta R_{j,t}}{\bar{V}_{j,t}} + \left(y_{i,j,t} - y^a_{j,t}\right)\right)\bar{V}_{i,j,t}. \tag{10}$$

Minus the change in reserves is a (positive or negative) transfer from reserves to investors holding a contract in year t. When return guarantees are not binding, changes in reserves are shared evenly among investors proportional to individual account values. When return guarantees are binding for some investors, there is an additional layer of transfers from contracts with low guaranteed returns to contracts with high guaranteed returns.

The lifetime net transfer for investor i holding a contract with insurer j from year t_0 to t_1 is

$$\sum_{t=t_0}^{t_1} \left(-\frac{\Delta R_{j,t}}{\bar{V}_{j,t}} + \left(y_{i,j,t} - y^a_{j,t} \right) \right) \bar{V}_{i,j,t}. \tag{11}$$

Equation (11) shows that transfers can only happen between investor cohorts, that is, between investors whose holding periods are different. Indeed, if two investors have the same stream of $\bar{V}_{i,j,t}$ up to a multiplicative factor, they experience lifetime net transfers of the same sign, that is, they are necessarily on the same side of the redistribution scheme. Transfers can only take place between investors with different contract holding periods, even if possibly overlapping.

Equation (11) also shows that participating contracts achieve inter-cohort redistribution only if reserves vary to absorb shocks to asset returns and do not mean revert too quickly such that changes in reserves over the lifetime of a contract do not net out. Equation (11) also implies that return guarantees interact with inter-cohort risk sharing. In the next sections, we use this accounting framework to study contract return smoothing and inter-cohort redistribution in German participating contracts.

4 Data

We use data from financial statements and regulatory Solvency I accounts that insurers file with the German insurance supervisor BaFin. The data covers all companies with life insurance provisions regulated at the federal level in Germany for the years 2000 to 2018. The number of insurers declined from 118 in 2000 to 83 in 2018, mostly due to mergers and acquisitions and consolidation of subsidiaries. There were no exits due to insolvency or liquidation. We drop insurers specialized in term life contracts, defined as those with a share of term life provisions to total provisions above 75%. We also drop a few small insurers with significant data gaps. The final sample has 80 unique insurers and 1,304 insurer-year observations.[5]

The aggregate account value increases from 600 billion euros in 2000 to 770 billion euros in 2018 (all amounts are in constant 2015 euros). The real growth rate in aggregate account value is 1.3% per year over the sample period, which is equal to that of German GDP over the same period. Table 1 reports summary statistics at the insurer-year level weighted by the share of each insurer in aggregate account value. The average (median) insurer has 9.2 (3.8) billion euros of account value. Premiums represent on average 8.0% of account value, of which 6.3% are regular premiums throughout the accumulation phase of regular premium contracts and 1.7% are single premiums paid at the purchase of single premium contracts. The ratio of reserves to total account value is 18% on average.

The regulatory filings under Solvency I contain information on the portfolio allocation

[5]See Appendix C for details on sample construction.

of directly held assets. Unfortunately, they do not contain information on the composition of assets held through investment funds. The average composition reported in the regulatory filings is therefore 43% bonds, 19% loans, 2% stocks, 2% real estate, 7% other assets, and 27% investment funds. Information on the allocation of investment funds is available in public Solvency II data starting in 2017, which allows us to determine the "looked-through" portfolio allocation including assets held through investment funds. At the end of 2018, the looked-through allocation is 80% fixed income, 4% stocks, 4% real assets, and 12% other assets including cash.

Asset return is defined as a percentage of account value, that is, using the notation of Section 3

$$AssetReturn_{j,t} = \frac{\bar{A}_{j,t}}{\bar{V}_{j,t}} x_{j,t}. \tag{12}$$

Our measure of asset return is thus leveraged by one plus the reserve ratio, since assets equal account value plus reserves. We use this definition of asset return to make it directly comparable to the contract return. We measure asset income $\bar{A}_{j,t}x_{j,t}$ as accounting asset income (which includes dividends, yields, and realized capital gains) plus the change in unrealized capital gains. Average asset return is 5.3%.

Total contract return includes the annual return equal to the minimum guaranteed return plus the regular bonus, and the terminal bonus paid to contracts reaching the end of the accumulation phase. That is,

$$ContractReturn_{j,t} = y^a_{j,t} + \frac{TerminalBonus_{j,t}}{\bar{V}_{j,t}}. \tag{13}$$

Total contract return is 4.8% on average, split into 3.1% of minimum guaranteed return, 1.3% of regular bonus and 0.4% of terminal bonus.

The regulatory filings contain information on contract returns aggregated over all investors but there is no breakdown by cohort. This is not an issue when return guarantees are not binding because all cohorts of investors earn the same contract return in this case. When return guarantees bind for some investors, however, contract returns differ across cohorts but are not reported at the cohort level in the regulatory filings. We reconstruct cohort-level contract returns using information from a survey that reports account value by cohort.[6] This survey covers most insurers, the sample size is reduced to 1,216 insurer-year observations. We denote by $\bar{V}_{c,j,t}$ the account value in year t for contracts from cohort c. Contract return for cohort c with insurer j in year t is

$$y_{c,j,t} = \max(y^u_{j,t}, y^g_c), \tag{14}$$

where the unconstrained contract return $y^u_{j,t}$ is expressed as

$$\sum_{c \leq t} \max(y^u_{j,t}, y^g_c)\bar{V}_{c,j,t} = y^a_{j,t}\bar{V}_{j,t}, \tag{15}$$

where contract returns aggregated across cohorts on the left-hand side are reported in the regulatory filings.

Contract returns by cohort (weighted-averaged across insurers) are plotted in Figure 2.

[6] See Appendix C.2 for details.

We pool cohorts by minimum guaranteed return, because all investors with the same minimum guaranteed return earn the same return in a given year with a given insurer. The dashed line plots the value-weighted share of contracts whose guarantees are binding. Until 2011, few contracts had a binding guarantee. Accordingly, contract returns are almost identical for all cohorts. Starting in 2011, the share of contracts with a binding guarantee increases steadily and reaches 24% of contracts in 2017. As a result, older contracts which enjoy higher return guarantees earn higher returns than more recent contracts from 2011 on. For instance, contracts purchased between 1994 and 1999 earn a 4.0% return in 2018 while contracts purchased between 2015 and 2016 earn a 3.1% return.[7]

5 Inter-cohort redistribution

5.1 Contract return smoothing

Average asset return is 5.3% per year, and volatility is 5.3% per year. Through their asset holdings insurers are exposed to interest rate risk and stock market risk. Three quarters of the annual variation in asset return is explained by a two-factor model using the return on the German stock index and the return on the Barclays' over-ten-years German sovereign bond index as factors.[8]

The contract return is an order of magnitude less volatile than the asset return, reflecting return smoothing at the annual frequency (Figure 3). Note that contract return smoothing is not driven by the terminal bonus being paid out at the end of the accumulation phase: contract return is equally smooth irrespective whether or not the terminal bonus is included in the definition of contract return (13).

As shown by Equation (8), smoothing of contract returns can be achieved because shocks to asset returns are buffered by reserves or because they are absorbed by insurer income, or a combination of both. To determine the contribution of each mechanism to contract return smoothing, we start by rewriting (8) as

$$ContractReturn_{j,t} - AssetReturn_{j,t} = -InsurerIncome_t - \Delta R_t, \tag{16}$$

where insurer income and the change in reserves are normalized by account value $V_{t-1} + 0.5Premium_t - 0.5Payout_t$. The difference between contract return and asset return on the left-hand side of (16) represents a transfer to contracts held in year t. The transfer is positive when contracts are credited a return higher than the asset return, and negative when the contract return is less than the asset return. The right-hand side decomposes the transfer into the parts funded (or received) by the insurer income and by reserves.

Almost all the difference between the contract return and asset return is absorbed by reserves. By contrast, insurer income barely contributes to contract return smoothing at the annual frequency. As a result, reserves fluctuate significantly over time as shown in Figure 4. For example, the reserve ratio increases after 2012 because declining interest

[7]The return on contracts with a 4% guarantee is slightly above 4% in Figure 2 because it is an average across insurers and the 4% guarantee is not binding for all insurers.

[8]The estimated model is (standard errors in parentheses) $R_t = 0.008\ (0.009) + 0.15\ (0.03)\ DAX_t + 0.47\ (0.07)\ SOV_t + \varepsilon_t$ with $R^2 = 0.77$.

rates generate high returns on the bond portfolio, which are hoarded as reserves. The annual variation in reserves mostly comes from unrealized capital gains because German insurers tend to be buy-and-hold investors (Möhlmann (2020)).

5.2 Inter-cohort transfer

We use Equation (11) to illustrate inter-cohort redistribution in the context of specific examples. The main data limitation is that the sample period is from 2000 to 2018. We can thus calculate lifetime net transfers only for contracts whose holding period falls within the 2000–2018 window. Since an important share of contracts are held over periods of more than 20 years, we cannot calculate inter-cohort transfers realized during the sample period. Because of this data limitation, we leave aside the issue of quantifying aggregate inter-cohort transfers and instead focus on specific examples in which we can calculate transfers.

Example 1: Single premium endowment contract purchased on January 1st, 2000, with maturity date January 1st, 2019 (Figure 5 Panel A). The investor pays a single premium P at the purchase of the contract, collects annual contract returns every year until the end of the accumulation phase, at which point she receives the account value plus terminal bonus as an endowment. The account value plotted in dashed black grows slowly during the accumulation phase as contract returns are capitalized.[9]

Example 2: Regular premium endowment contract purchased on January 1st, 2000, with maturity date January 1st, 2019 (Panel B). The investor pays an annual premium P at the beginning of each year, collects annual contract returns every year until the end of the accumulation phase, at which point she receives the account value plus terminal bonus as an endowment. The account value plotted grows steadily during the accumulation phase as additional premiums are paid and contract returns are capitalized.

Example 3: Single premium annuity contract purchased on January 1st, 2000 with immediate annuitization and investor death on January 1st, 2019 (Panel C). The investor pays a single premium P at the purchase of the contract. There is no accumulation phase. The investor receives an annuity at the beginning of each year until death. The account value decreases over time as annuity payments are made. The contract return is paid every year on the remaining account value. When the contract return exceeds the minimum guaranteed return, the difference is immediately annuitized. Therefore, the annuity payment increases slightly over time.

The annual transfer $\left(\frac{-\Delta R_{j,t}}{\bar{V}_{j,t}} + (y_{i,j,t} - y^a_{j,t})\right)\bar{V}_{i,j,t}$ is plotted in dashed blue on Figure 5. It is normalized by the average account value over the holding period $\frac{1}{19}\sum_{t=2000}^{2018} \bar{V}_{i,j,t}$. Transfers are positive in years in which asset returns are low and negative in years in which asset returns are high. Normalized transfers differ across the three examples because the time profile of account value is different in each case.

Inter-cohort transfer is the net transfer summed over the holding period. It is plotted in solid blue on Figure 5, and summary statistics are reported in Table 2. Inter-cohort

[9] All statistics in Figure 5 are averaged across insurers using total account value as the weight. Detailed calculations are presented in Appendix A.

transfer is negative in all three examples. Investors holding a contract over the period 2000–2018 are thus net contributors to the inter-cohort risk sharing scheme. This is because the high bond returns in the 2000s were hoarded as reserves and shared with future investor cohorts. The annualized net transfer in the case of the single premium endowment contract is −1.1 percentage point per year, that is, the investor earned on her contract a return that was 1.1 percentage point per year lower than what she would have earned without inter-cohort risk sharing. The net transfer is even more negative in the case of the regular premium endowment contract at −1.5 percentage point per year. The reason is that the account value grows steadily over time in the case of a regular premium contract, so the internal rate of return of the contract has a higher weight in the more recent period. Since asset returns are higher during the second half of the sample period, contracts with a higher account value during this period experience more-negative transfers. Conversely, the net return is closer to zero in the case of the single premium annuity contract whose account value decreases over time.

The distribution of inter-cohort transfer across insurers is shown in Panel A of Table 2 for the 57 insurers present in the data throughout the 2000–2018 period. Net transfers are negative for virtually all insurers. There is non-negligible dispersion across insurers. For instance, the net transfer for the single premium endowment contract ranges from −1.4 percentage point per year at the 25th percentile to −0.7 percentage point per year at the 75th percentile.

Minimum return guarantees interact with inter-cohort risk sharing because they impose lower bounds on the returns earned by each cohort. To quantify the impact of return guarantees on inter-cohort redistribution, we compare the net transfer that prevails in the presence of return guarantees with the net transfer that would have prevailed without return guarantees. The net transfer without return guarantees is obtained by assuming all investor cohorts earn the same average return in all years, that is, by removing the term $(y_{i,j,t} - y^a_{j,t})$ from the formula for the net transfer.[10]

Inter-cohort transfer without return guarantees is reported in Panel B of Table 2. Transfers would have been slightly higher without minimum return guarantees, by 6 annual basis points for the single premium contract and by 8 annual basis points for the regular premium contract. This is because the 2000 cohort was promised a high minimum guaranteed return. When the guarantee starts to bind in the early 2010s, the 2000 cohorts earns a higher return than more recent investors and thus contributes less to the increase in reserves. The effect of the guaranteed return is small, however, because guarantees started to bind only at the end of the sample period. One might therefore expect the effect of return guarantees on inter-cohort redistribution to be stronger in the next decade.

6 Contract return

Inter-cohort redistribution arises as a result of contract return smoothing. In this section, we study contract return policy at the insurer level. Our empirical specification builds on Hombert and Lyonnet (2019), who solve for the equilibrium contract return when

[10] The impact of binding guarantees on inter-cohort transfers is not an exogenous quantity given the level of guarantees. It depends on the contract return chosen by the insurer once asset returns are realized, that is, it depends on the choice of unconstrained contract return $y^u_{j,t}$, which determines $y_{i,j,t}$ by Equation (3).

there are no binding return guarantees. They show that perfect inter-cohort risk sharing arises when investor flows are inelastic to reserves, and in this case the contract return only depends on the current reserve ratio. By contrast, when investor flows are elastic to reserves, inter-cohort risk sharing is imperfect and the contract return also depends on the current asset return. We estimate panel regressions at the insurer-year level using the average contract return $y^a_{j,t}$ as the dependent variable, and the reserve ratio and current asset return as explanatory variables.

To account for the presence of binding return guarantees, we augment the specification by including outstanding return guarantees in the contract return policy. We use two measures of outstanding guarantees. The first measure is based on the regulatory calculation of the value of outstanding guarantees. It is equal to the Additional Interest Provision (AIP) normalized by total account value. As described in Section 2 and Appendix B.2, the AIP is a regulatory reserve whose amount is calculated to proxy for the value of return guarantees in outstanding contracts. A caveat to the AIP is that it discounts future cash flow using the 10-year moving average of the 10-year interest rate on German government bonds, whereas the marked-to-market value of outstanding guarantees should be calculated using the current yield curve. Our second measure reflects the economic value of outstanding guarantees. It is calculated using the AIP formula, but uses the current 10-year interest rate instead of the moving average interest rate.[11] If the shadow cost of regulatory capital is zero, insurers should only take into account the economic value of guarantees. If the shadow cost of regulatory capital is non-zero, insurers should also take into account the regulatory value of guarantees.

Since insurers may have to use their capital to honor return guarantees if asset returns are insufficient and reserves are depleted, we also include insurer capital in the contract return policy. We include year fixed effects to account for time-series variation in interest rates. We estimate specifications without insurer fixed effects and specifications with insurer fixed effects. All regressions are weighted by the insurer share in aggregate account value in the current year.

Results are displayed in Table 3. In columns 1–2, we only include reserves at the end of the current year before investor accounts and insurer equity are credited, which are equal to lagged reserves plus the annual asset return (see Equation (16)). The coefficient on reserves is positive, and it is statistically significant when insurer fixed effects are included. The coefficient estimated with insurer fixed effects implies that, for each additional euro of reserves, 1.8 cents are distributed to investors at the end of the year. That is, reserves are slowly credited to investors' accounts at a rate of 1.8% per year. The fact that the coefficient on reserves increases when insurer fixed effects are included can be explained by reverse causality. A lower contract return during the sample period (for reasons unrelated to the current level of reserves) leads to higher reserves, generating a negative between-insurer correlation between contract return and reserves. Including insurer fixed effects removes this negative correlation, leading to a higher regression coefficient of contract return on reserves.

Perfect inter-cohort risk sharing implies that the contract return only depends on the current asset return through its effect on reserves. The intuition is similar to that of the permanent income hypothesis, whereby consumption only depends on current income through its effect on permanent income. By contrast, when inter-cohort risk sharing is

[11] See Appendix B.3 for the construction of the adjusted AIP.

imperfect, the contract return depends on the current asset return above and beyond its effect on reserves. We test whether this is the case, in columns 3–4, where we decompose the year-end reserve ratio into the year-start reserve ratio and the current asset return. When insurer fixed effects are included, we hypothesize that the coefficient on the current asset return is larger than the coefficient on lagged reserves is rejected with a p-value of 0.02.

Columns 5–8 show that the average contract return depends positively on outstanding return guarantees. The effect is stronger when outstanding guarantees are measured using the regulatory-based value rather than the economic-based value. The effect of outstanding guarantees on the average contract return is not mechanical, because insurers who issued many contracts with high guarantees before the mid-2000s were able to lower the unconstrained contract return, $y^u_{j,t}$, on more recent contracts whose guarantee was not binding, so as to maintain a target average contract return. Insurers do not do so, however. When we run the contract return regressions using the unconstrained contract return in Table 4, we find that the unconstrained contract return does not depend on the level of outstanding guarantees. This explains why the average contract return, which includes the return on contracts with binding guarantees, is an increasing function of the level of outstanding guarantees. This implies that insurers with larger outstanding guarantees tend to deplete their reserves faster, on average (see Equation (16)).

Columns 9–12 show that higher insurer equity is associated with a higher contract return, on average. Moreover, controlling for insurer equity reduces the coefficient on outstanding guarantees. It means that the fact that insurers do not offset the impact of higher guarantees on the average contract return by lowering the unconstrained contract return, is partly explained by the fact that insurers with high outstanding guarantees also tend to have a larger equity buffer.

We study in Table 5 how contract return (lack of) adjustment to outstanding guarantees depends on insurer capital. If insurers do not lower the unconstrained contract return when outstanding guarantees are high because they gamble for resurrection when they have low capital and high liabilities, then the lack of adjustment should be stronger when insurer capital is low. If, instead, insurers expect to use their capital to absorb losses on outstanding guarantees and to keep offering insurance to new investors, then the lack of adjustment of the unconstrained contract return should be stronger when insurer capital is high. To analyze these mechanisms, we interact outstanding guarantees with a dummy equal to one if the insurer has a capital ratio above the median at the end of the previous year (the median is year-specific). The coefficient on the interaction term is positive in all specifications, and it is statistically significant when outstanding guarantees are measured using the economic-based value. Therefore, among insurers with a high burden of outstanding guarantees, those with less capital lower the contract return paid to investors relative to insurers with more capital. This finding is inconsistent with a simple risk-shifting hypothesis.

7 Flows

We test whether investor flows react to insurers' reserves and outstanding return guarantees. We study separately flows into new contracts and flows into and out of outstanding contracts.

7.1 Purchases of new contracts

We study purchases of single premium contracts and purchases of regular premium contracts separately. In a single premium contract, the investor makes a single payment at the creation of the contract. We measure purchases of single premium contracts at the insurer-year level as single premium payments normalized by total account value. In a regular premium contract, the investor commits to a stream of premium payments throughout the accumulation phase. We measure purchases of regular premium contracts as initial premiums paid on new regular premium contracts normalized by total account value. The measures of purchases of single premium contracts and regular premium contracts are not directly comparable, because the former is based on the total premium, whereas the latter is based on the initial premium and does not take into account the discounted value of future premiums.

Aggregate purchases of new contracts are plotted in Figure 6. Purchases of single premium contracts increase over time, especially after 2008, whereas those of regular premium contracts decrease. The pattern is consistent with a demand-driven explanation. Since the mid-2010s, insurers have paid contract returns above market interest rates, making contracts an attractive investment, at least in the short run. In the long run, however, when insurers have depleted their reserves, they may be forced to cut contract returns. Since the annual contract return is the same for single premium and regular premium contracts and is paid on the outstanding account value, investors have an incentive to front-load the payment of premiums by buying single premium contracts rather than regular premium contracts, in order to benefit from the currently high contract returns.

The spike in purchases of single premium contracts in 2009 and 2010 may be explained by households moving away from equity investing and shifting towards safer investments such as participating contracts in reaction to the financial crisis. This reaction shows up in single premium contracts and not in regular premium contracts, because an investor selling an equity mutual fund to buy a life insurance participating contract needs to make an one-off investment. The surge in purchases of regular premium contracts in 2004 is due to an anticipated tax increase in 2005.[12]

Table 6 presents insurer-year panel regressions for purchases of new contracts. The sample excludes insurer-year observations in which the insurer is in run-off. Run-off means that the insurer has decided to stop selling new contracts and focuses on managing the portfolio of legacy contracts. All regressions include year fixed effects to control for the aggregate fluctuations in purchases of new contracts observed in Figure 6.

Purchases of single premium contracts depend positively on reserves. The regression coefficient of 0.10 in column 1 of Panel A implies that a 10 percentage point increase in reserves leads to a 1.0 percentage point rise in purchases of single premium contracts, which represents a 60% increase (sample mean is 1.7 percentage point in Table 1). The effect on the purchases of regular premium contracts is smaller and statistically insignificant in several specifications. This is consistent with the interpretation described above, that contract purchases that are sensitive to the level of reserves are concentrated in sin-

[12]There is a change in the tax treatment of returns on endowment contracts held longer than 12 years. These returns were tax free for contracts purchased until December 31, 2004, and subject to half of the personal income tax rate for contracts purchased after this date. The tax also applies to lump-sum payments of annuities in the case of annuity contracts that have the option of a lump-sum payment. Annuities are not affected by the tax change.

gle premium contracts because investment and thus contract returns are front-loaded in single premium contracts.

A high elasticity of flows to reserves can lead to reserve dilution. If the elasticity is so high that changes in reserves are offset by reserve-sensitive flows, inter-cohort risk sharing unravels (Allen and Gale, 1997; Hombert and Lyonnet, 2019). The estimated elasticity of flows in single premium contracts to reserves implies that it takes approximatively 50 years for reserve-sensitive inflows to dilute the marginal euro of reserves.[13]

Purchases of new contracts depend negatively on outstanding guarantees as measured by their regulatory value (AIP) or economic value (AIP adjusted using the current yield curve). To assess the magnitude of the effect, we compute the impact of a one cross-sectional standard deviation change in outstanding guarantees measured in 2018. A one cross-sectional standard deviation increase in AIP (1.6 percentage point) is associated with a $1.2 \times 1.6 = 1.9$ percentage point decrease in single premiums (column 1 of Panel A), representing a 110% decrease relative to the mean, and a $0.034 \times 1.6 = 5$ basis point decrease in new regular premiums (column 1 of Panel B), representing a 20% decrease.

Purchases of new contracts also depend negatively on outstanding guarantees as measured by the economic measure of the value of guarantees, but the effect is more muted. A one standard deviation increase in the AIP adjusted using the current yield curve (2.1 percentage points) is associated with a $0.4 \times 2.1 = 0.8$ percentage points decrease in single premiums (column 3 of Panel A), representing a 50% decrease, which is half as large as the effect of the regulatory value of outstanding guarantees. The effect on new regular premiums is also negative but statistically insignificant (column 3 of Panel B).

Flow regressions using outstanding guarantees as an explanatory variable might suffer from reserve causality when insurer fixed effects are not included. Contracts sold before the beginning of the sample period tend to have higher minimum guaranteed returns than those sold during the sample period (Figure 1). Holding fixed the account value in old contracts (with high guaranteed returns), an increase in sales of new contracts (with lower guaranteed returns) reduces the average guaranteed return and thus the AIP. For example, insurers that gain market shares during the sample period for reasons unrelated to return guarantees will tend to have higher sales of new contracts and lower AIP as a fraction of total account value. In this case, the causality runs from sales of new contracts to AIP. We control for this issue by including insurer fixed effects, which absorb the spurious cross-sectional negative correlation between sales of new contracts and AIP.

Consistent with reserve causality creating a negative bias, the coefficient on AIP is less negative when insurer fixed effects are included (columns 5–8 of Panel A). In our preferred specification with insurer fixed effects, purchases of single premium contracts depend negatively on guarantees in legacy contracts. There is no statistically significant relation for regular premium contracts. One explanation for the different sensitivity of regular premium contracts and single premium contracts may be that buyers of single premium contracts are on average wealthier (Deutsche Bundesbank, 2017), wealth being correlated with financial sophistication. Sophisticated investors are more likely to understand that

[13]Denoting by β the sensitivity of annual flows to reserves, a variation in reserves ΔR in a given year changes cumulative flows after T years by $\Delta V \simeq \beta \, T \, \Delta R$, leading to a change in the reserve ratio after T years approximately equal to $\Delta \frac{R}{V} \simeq \frac{\Delta R}{V}\big(1 - \beta T \frac{R}{V}\big)$. Estimated at the sample average reserve ratio (0.18 in Table 1) and using the regression coefficient in column 1 of Panel A for β, $T = 1/\big(0.10 \times 0.18\big) \simeq 56$ years.

high outstanding guarantees will weigh on the return on new contracts, thus their demand for new contracts reacts more negatively to outstanding guarantees. Another explanation for the stronger sensitivity of single premium contracts is that premiums and thus earned contract returns are front-loaded in single premium contracts relative to regular premium contracts. To the extent that a large burden of outstanding contracts has a more negative impact on contract return in the short run than in the long run, single premium contracts are more negatively affected by high outstanding guarantees.

An important caveat is that insurers may adjust fees on new contracts in a way that offsets the effect of reserves and outstanding guarantees on expected returns on new contracts. For example, insurers with high outstanding guarantees may charge lower fees on new regular premium contracts, which would explain why purchases of new regular premium contracts do not decrease when AIP is high. Unfortunately, information on fees in our data set is scarce. In Section 8, we focus on another supply-side response to legacy return guarantees: run-offs.

7.2 Lapses and premium increases

Flows into and out of outstanding contracts are for the most part pre-determined. There are, however, some options that discretionary inflows and outflows are possible in outstanding contracts. First, some regular premium contracts give investors the option to increase the premium permanently during the accumulation phase. Such a decision can be interpreted as an increase in inflows. We measure optional premium increases at the insurer-year level as the change in the amount of the annual premium in the year in which the option to increase the premium is exercised. Panel A of Figure 7 shows that optional premium increases are relatively constant during the sample period.

Second, investors can surrender their contract, and they can set their contract to inactive. When an investor surrenders, she immediately receives the current account value. When an investor sets her contract to inactive, she permanently stops paying premiums but she continues to earn the same contract return, including the guarantee and the regular bonus on her outstanding account value. Investors who surrender or set their contract to inactive usually incur penalties. Such decisions represent outflows, or a decrease in inflows in the case of contracts set to inactive. We refer to these actions as outflows. Our analysis on outflows is related to research on how surrender activity of participating policies is related to interest rates. When interest rates rise, it becomes more financially attractive to surrender and surrender rates tend to increase (Förstemann (2019) and Kubitza et al. (2020)).

We construct three measures of outflows at the insurer-year level. The first one captures both contracts surrendered and contracts set to inactive. It is equal to the yearly premium amounts of contracts surrendered or set to inactive in the current year normalized by total account value. The two other measures focus on surrendered contracts only. One is the number of contracts surrendered in the current year divided by the number of outstanding contracts. The other is the paid-out surrender value (i.e. the account value in surrendered contracts which is paid out to investors) divided by total account value in all outstanding contracts. As shown in Panels B, C and D of Figure 7, the three measures of outflows are fairly constant throughout most of the sample period and decrease somewhat after 2014. Table 1 shows summary statistics at the insurer-year level.

Table 7 presents insurer-year panel regressions of flows into and out of outstanding contracts. Optional premium increases depend positively on reserves (columns 1–2 of Panel A), and surrenders depend negatively on reserves and on outstanding guarantees (columns 1–2 of Panel B, C and D), when insurer fixed effects are not included. The negative effect of outstanding guarantees on surrenders is consistent with holders of outstanding contracts with high guarantees having an incentive not to surrender. However, the coefficients become insignificant when insurer fixed effects are included (columns 3–4 of each panel). The fact that surrenders are insensitive to the level of reserves and outstanding guarantees could be explained by surrender penalty fees, but we cannot directly test this interpretation owing to a lack of data on these fees. However, the fact that optional premium increases do not depend on reserves or outstanding guarantees cannot be explained by penalty fees, because exercising the option to increase the regular premium is typically not subject to fees.

8 Run-offs

In this section, we study a potential supply-side response to changes in reserves and outstanding guarantees: run-offs. Insurers running off their portfolio stop selling new contracts and focus on managing and honoring the stock of outstanding contracts. Entering run-off, therefore, can be interpreted as an extreme case of an inward shift in the supply curve.

We construct two measures of run-off. The first is based on insurers' run-off announcements. We use a list of insurers who declared run-off as of 2019 compiled by the regulator. We search for press releases and media reports to retrieve announcement dates. Although entering run-off is not a legally binding decision, all announced run-offs in the data are followed by a permanent drop in sales of new contracts to almost zero. Eight insurers announced that they enter run-off during the sample period. The second measure is based on effective run-offs, defined as a situation in which the insurer does not sell regular premium contracts anymore, even if it did not make a run-off announcement. We use a threshold for new regular premiums divided by total regular premiums of 0.2%, below which we classify insurers as being effectively in run-off. Based on this definition, eleven insurers entered effective run-off during the sample period. Figure 8 shows that the share of aggregate account value of insurers in run-off takes off in 2010 and reaches 8% based on announced run-offs and 10% based on effective run-offs in 2018.

We estimate a linear probability model for the decision to enter run-off. Since run-off is an absorbing state, we drop all insurer-year observations after the year in which an insurer enters run-off. We use the same set of explanatory variables as in the analysis of flows.

The AIP was created in 2011 when interest rates started to drop. Therefore, the AIP starts reflecting outstanding guarantees only after this date. There were only three run-offs when AIP was non-zero. To account for the possibility that run-off decisions may depend on outstanding guarantees before 2011, we use the AIP amount in 2014 instead of the current AIP.

Results are reported in Table 8. The effect of reserves is not significant, even though the coefficient is negative as expected. The effect of outstanding guarantees is not significant.

9 Conclusion

This paper provides the first quantitative analysis of inter-cohort risk sharing in participating contracts in Germany. Focusing on contracts with standard features, we quantify transfers across cohorts in the range of 0.4%–1.5% per year of invested amounts. Investors holding contracts over the 2000–2018 period are net contributors to the inter-cohort risk sharing mechanism because the high bond returns realized during this period are hoarded as reserves and shared with future cohorts. Binding return guarantees on old contracts reduce inter-cohort risk transfer by forcing reserves accumulated over time to eventually be credited back to old contracts. In the sample, the magnitude of this effect is small: it reduces inter-cohort transfers by approximatively 0.1 percentage point. The effect is modest because guarantees bind only at the end of the sample period—it may increase in size in the future if interest rates stay low.

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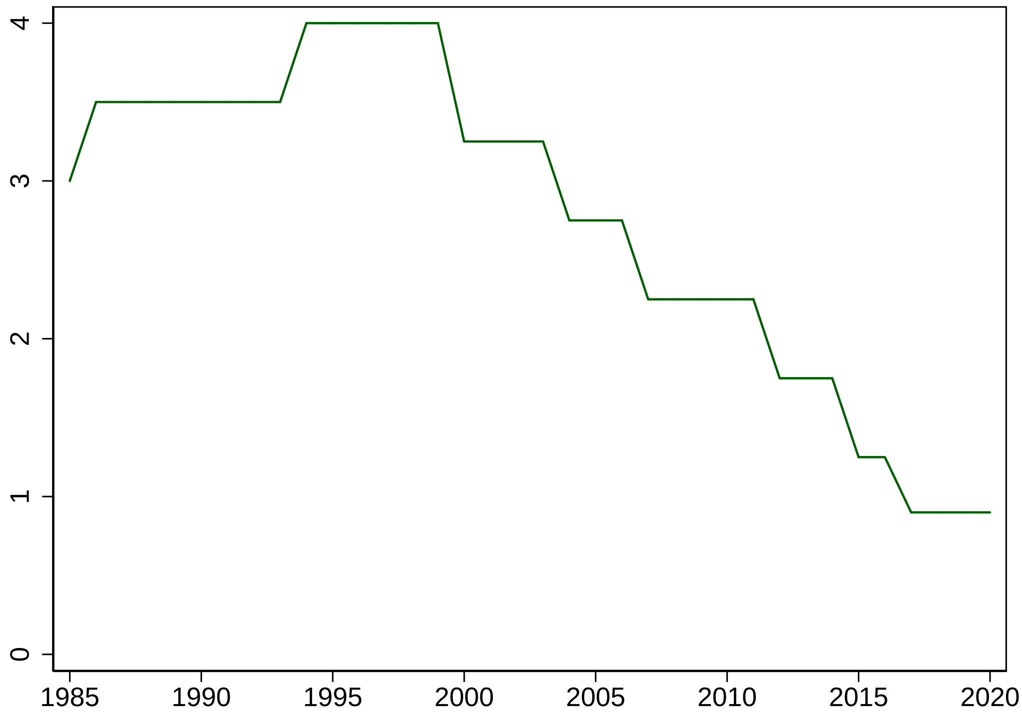
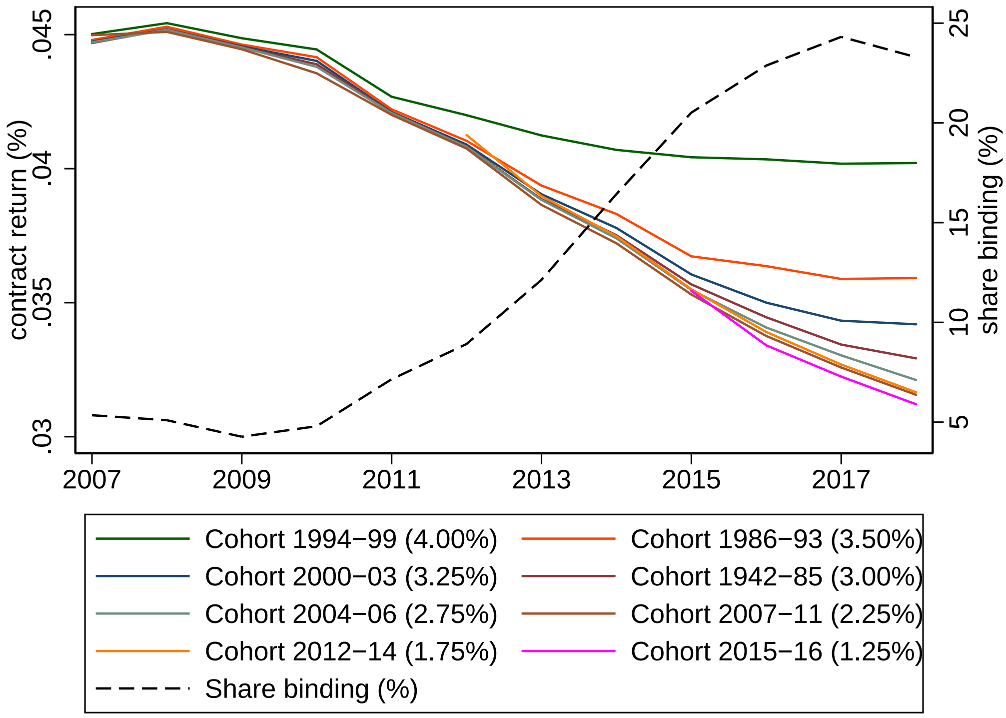
Figure 1: Minimum Guaranteed Return (%)



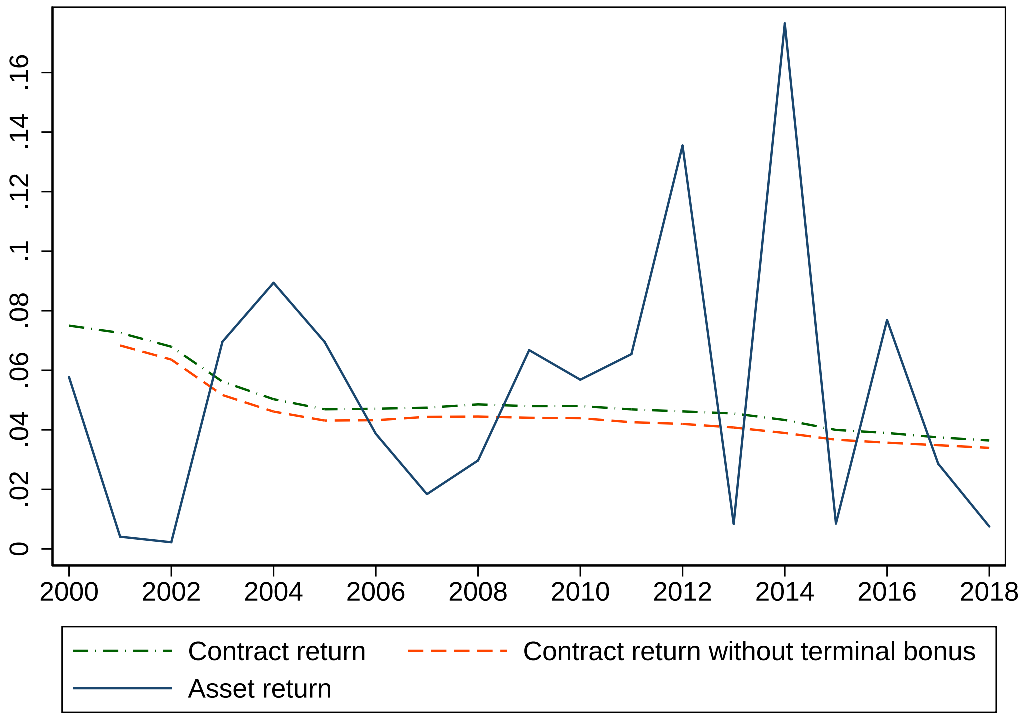
Minimum guaranteed return 1985–2020 as stipulated in the German insurance regulation (section 2 of the Principles Underlying the Calculation of the Premium Reserve, Deckungsrückstellungsverordnung). The minimum guaranteed return is the same for all contracts sold by life insurers in a given year.

Figure 2: Contract Return by Cohort



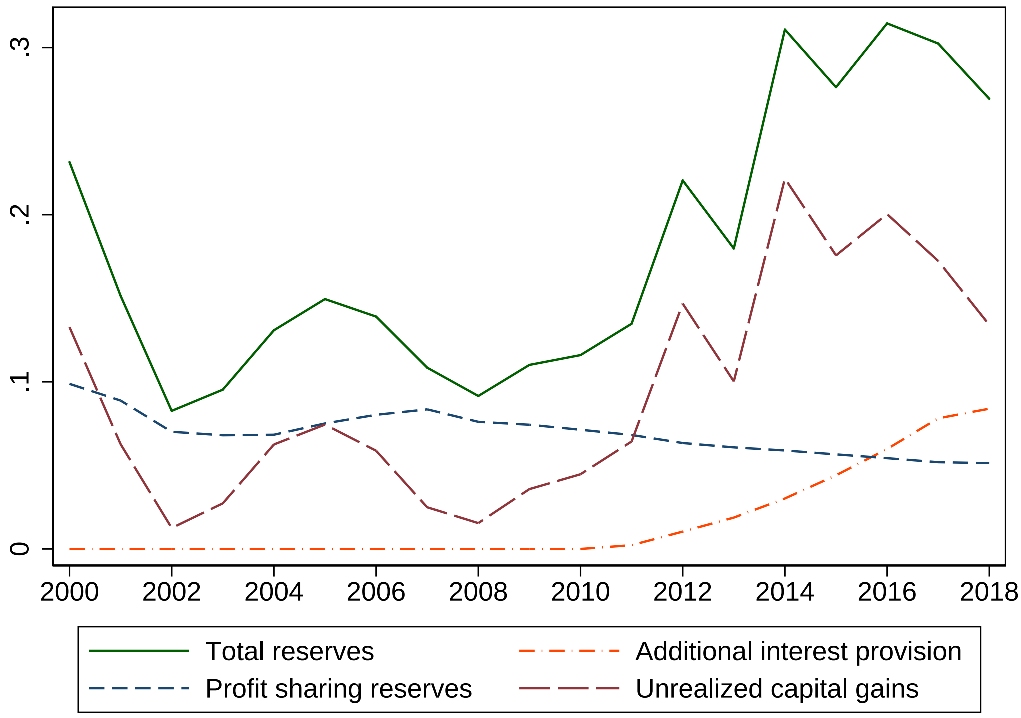
Calculation based on regulatory filings 2007–2018 and a 2011 survey on account value by cohort. Account value by cohort is not available before 2007. The black dashed line is the share of account value in contracts with a binding guarantee. The colored solid lines are annual contract returns for each cohort on average across insurers weighted by account value. Cohorts are pooled by minimum guaranteed return because all contracts with a given guaranteed rate with a given insurer earn the same contract return.

Figure 3: Asset Return and Contract Return



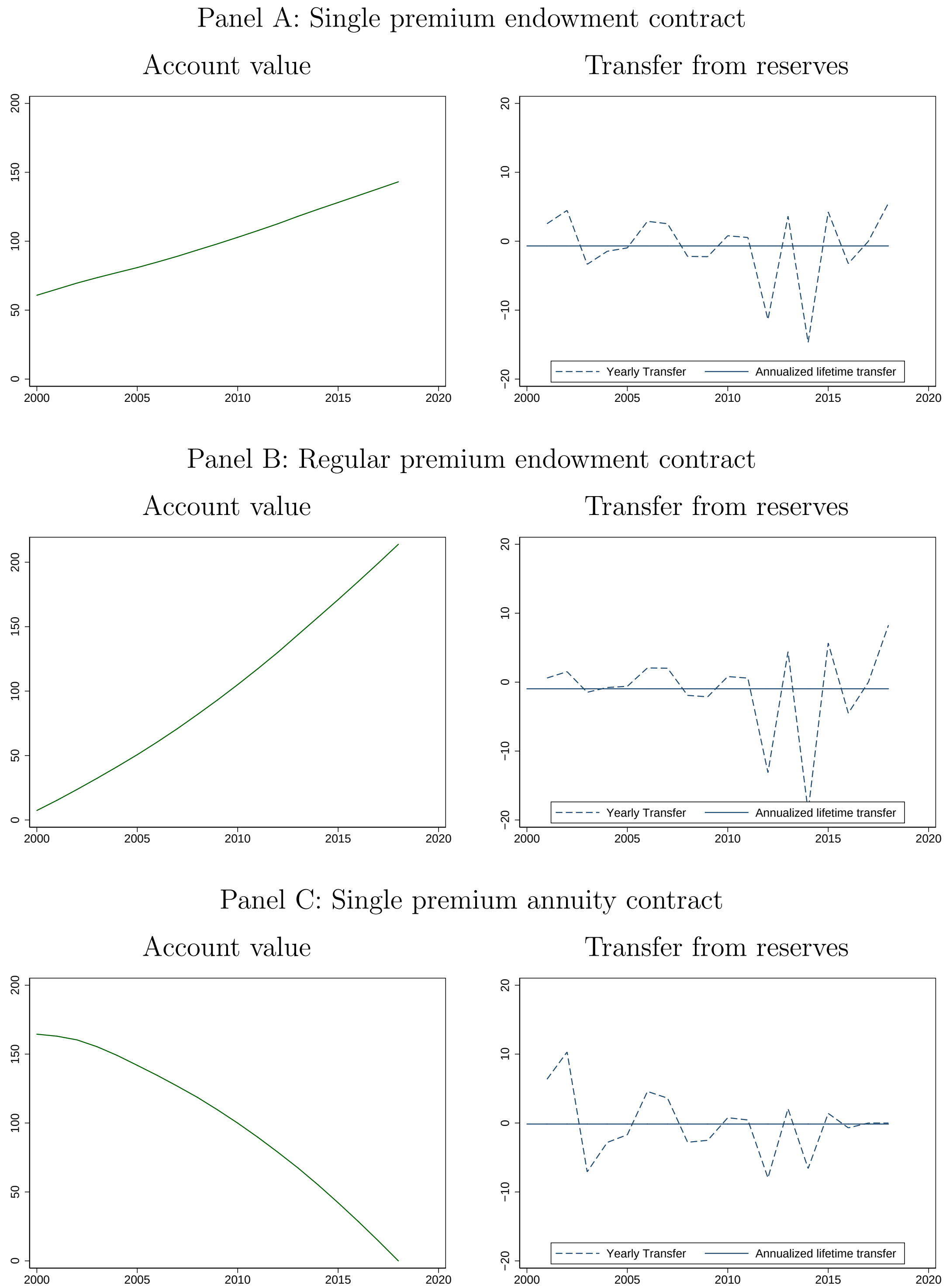
Calculation based on regulatory filings 2000–2018. Weighted average across insurers. Asset return is total asset income including unrealized capital gains divided by total account value. Contract return is total amount credited on investors' accounts divided by total account value.

Figure 4: Reserves (% Account Value)



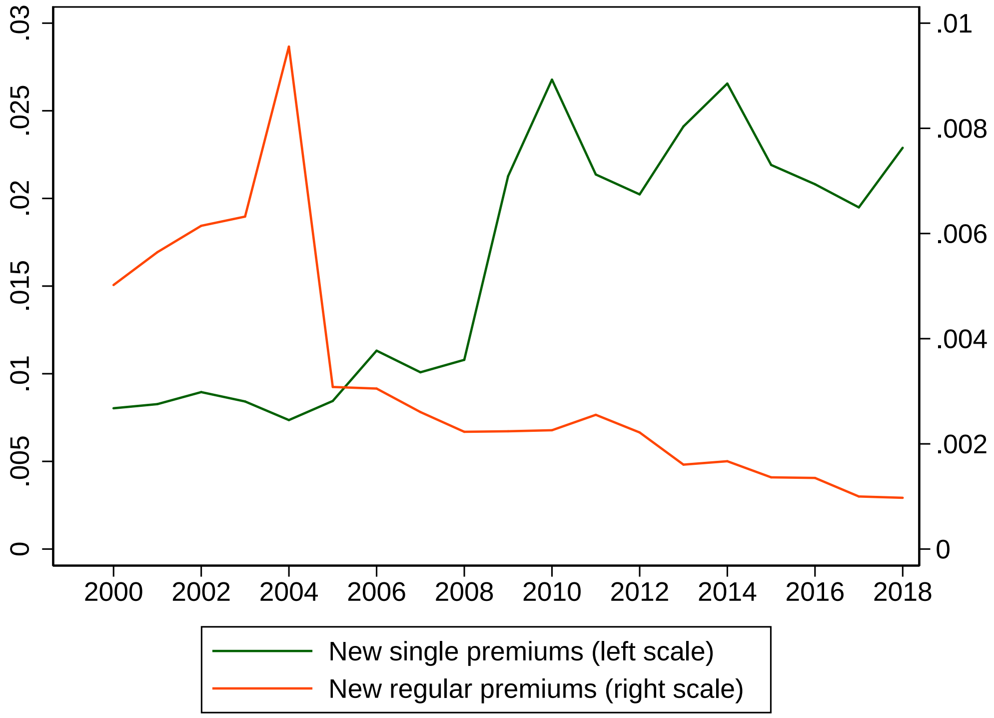
Regulatory filings 2000–2018. Aggregated across insurers. Total reserves are the sum of profit sharing reserves, unrealized capital gains, and the additional interest provision. All reserve amounts are normalized by total account value.

Figure 5: Inter-Cohort Transfers



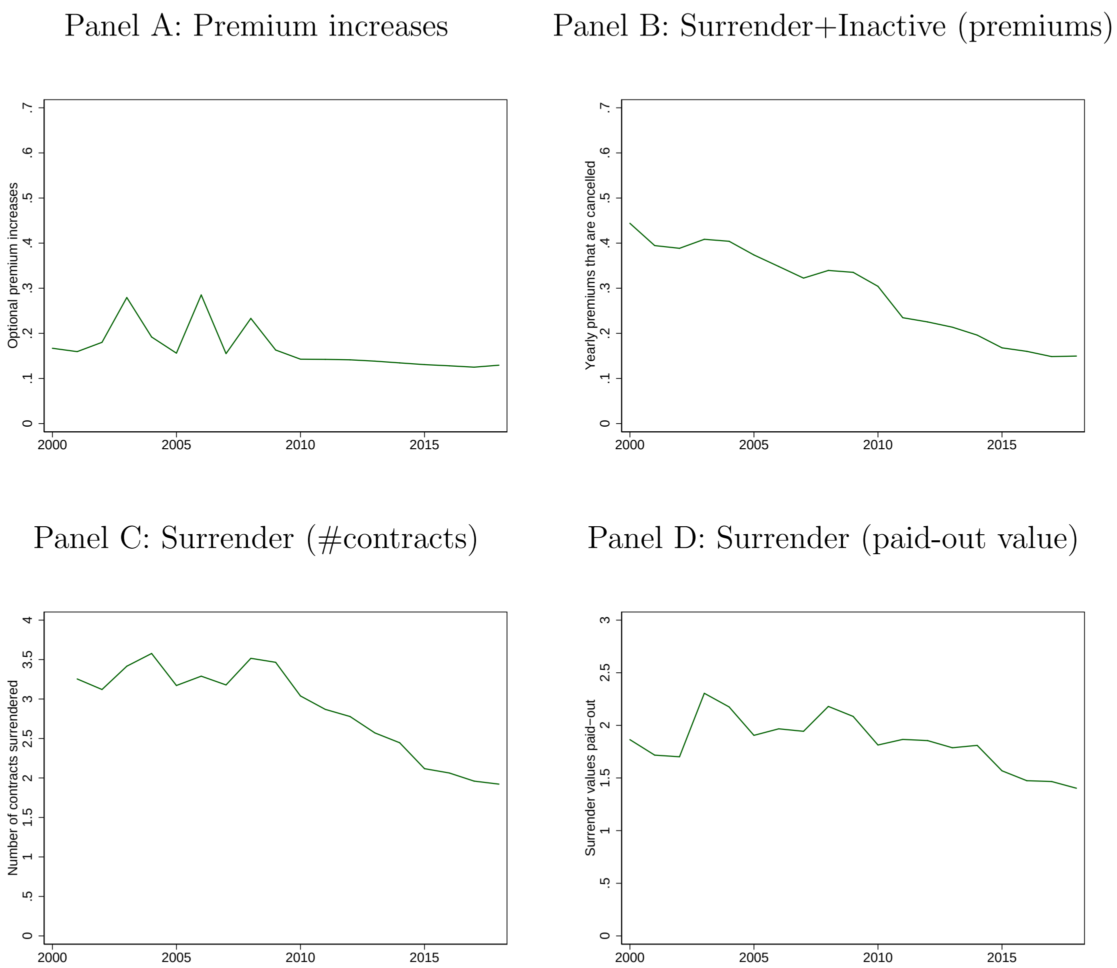
Calculation based on regulatory filings 2000–2018. The left side shows the development of the account value over time. The right side shows annual transfer and annualized net transfer over 2000-18. All statistics are weighted using average account value.

Figure 6: Purchases of New Contracts



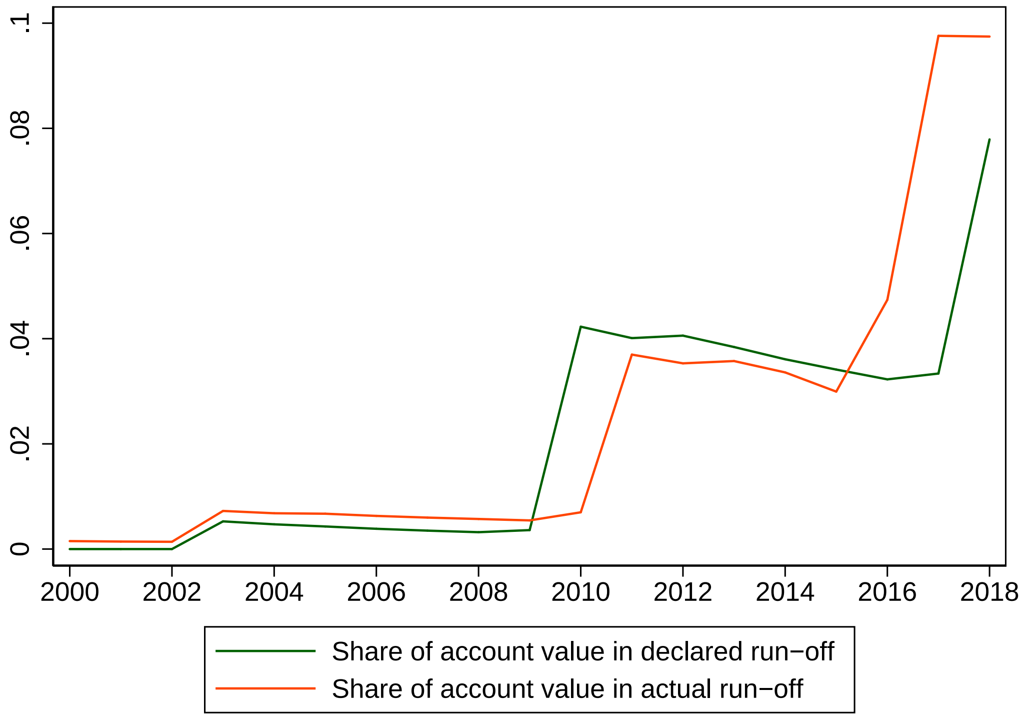
Regulatory filings 2000–2018. Weighted average across insurers. Purchases of new single premium contracts are measured as single premium payments divided by total account value. Purchases of new regular premium contracts are measured as initial regular premium payments divided by total account value.

Figure 7: Flows in Outstanding Contracts



Regulatory filings 2000–2018. Weighted average across insurers. Variables are defined in the text in Section 7.2.

Figure 8: Run-Offs



Regulatory filings 2000–2018 and run-off announcements in press releases and media reports. Share of aggregate account value of insurers in run-off.

Table 1: Summary Statistics

	Mean	S.D.	P25	P50	P75	N
Account value (bn euros)	9.2	17.0	1.2	3.8	12.7	1,304
Reserves (% account value)	18.0	9.7	10.3	16.7	24.8	1,304
Profit sharing	6.9	2.3	5.2	6.7	8.5	1,304
Unrealized gains	9.3	7.8	3.0	7.8	14.3	1,304
AIP	1.7	2.9	0.0	0.0	2.8	1,304
Legacy contracts (% account value)						
Discounted with moving average	1.8	3.1	0.0	0.0	2.8	1,304
Discounted with current rate	5.4	6.4	0.0	0.9	11.4	1,218
Asset return	5.3	5.3	1.5	4.7	7.8	1,224
Contract return	4.8	1.0	4.2	4.7	5.1	1,224
Minimum guaranteed return	3.1	0.3	2.9	3.2	3.3	1,224
Profit sharing	1.7	0.9	1.2	1.5	1.9	1,224
Regular bonus	1.3	0.9	0.8	1.1	1.5	1,224
Terminal bonus	0.4	0.2	0.3	0.4	0.5	1,224
Asset allocation (% total assets)						
Bonds	43.3	11.2	36.0	42.9	49.8	1,304
Loans	18.9	10.5	9.9	17.8	25.3	1,304
Stocks	1.5	2.5	0.0	0.3	2.2	1,304
Real estate	2.4	1.9	1.2	2.0	3.6	1,304
Investment funds	26.8	13.9	17.3	25.1	33.3	1,304
Other assets	7.0	3.8	4.4	6.6	8.9	1,304
Premiums (% account value)	8.0	2.7	6.2	8.2	9.3	1,224
Regular premiums	6.3	2.6	4.3	5.9	7.7	1,224
outstanding contracts (scheduled)	5.8	2.2	4.1	5.4	7.0	1,224
new contracts	0.3	0.5	0.1	0.2	0.4	1,224
outstanding contracts (optional increase)	0.2	0.2	0.1	0.1	0.2	1,224
Single premiums	1.7	1.6	0.5	1.2	2.6	1,224
Surrender + inactive						
premiums (% outstanding account value)	0.3	0.3	0.2	0.3	0.4	1,224
Surrender						
no. contracts (% outstanding contracts)	2.7	1.2	2.0	2.6	3.3	1,213
paid-out value (% outstanding account value)	1.8	1.0	1.2	1.6	2.2	1,224

This table reports summary statistics at the insurer-year level weighted by the share of each insurer in aggregate account value. Regulatory filings 2000–2018. Variables are defined in the text in Section 4.

Table 2: Inter-Cohort Transfers

	Panel A: With minimum guaranteed return							
Contract	Mean	S.D.	P10	P25	P50	P75	P90	N
Single premium, endowment	-1.09	0.46	-1.58	-1.38	-1.18	-0.7	-0.49	57
Regular premium, endowment	-1.46	0.45	-1.90	-1.90	-1.39	-1.1	-0.91	57
Single premium, annuity	-0.36	0.70	-1.18	-0.57	-0.35	-0.13	0.81	57
	Panel B: Without minimum guaranteed return							
Contract	Mean	S.D.	P10	P25	P50	P75	P90	N
Single premium, endowment	-1.15	0.46	-1.64	-1.43	-1.24	-0.8	-0.55	57
Regular premium, endowment	-1.54	0.45	-1.98	-1.98	-1.47	-1.2	-0.99	57
Single premium, annuity	-0.36	0.70	-1.18	-0.57	-0.35	-0.13	0.81	57

This table shows annualised net inter-cohort transfers across insurers with minimum guaranteed return (Panel A) and without minimum guaranteed return (Panel B). Calculation explained in Section 5.2.

Table 3: Average Contract Return

	Average contract return											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Reserves	0.013	0.018**			0.013	0.015**	0.014*	0.016**	0.016*	0.016**	0.016**	0.016***
	(0.0077)	(0.0063)			(0.0077)	(0.0065)	(0.0075)	(0.0059)	(0.0077)	(0.0062)	(0.0075)	(0.0056)
Lagged reserves			0.013	0.021***								
			(0.0078)	(0.0064)								
Asset return			0.012*	0.0057								
			(0.0061)	(0.0061)								
Outstanding guarantees (regulatory)					0.083**	0.066			0.060	0.046		
					(0.034)	(0.043)			(0.037)	(0.037)		
Outstanding guarantees (economic)							0.064***	0.024			0.053**	0.015
							(0.021)	(0.033)			(0.024)	(0.032)
Insurer capital									0.071	0.061	0.064	0.043
									(0.062)	(0.042)	(0.065)	(0.049)
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Insurer FE		✓		✓		✓		✓		✓		✓
R^2	0.843	0.920	0.844	0.921	0.846	0.921	0.858	0.928	0.849	0.922	0.860	0.928
Observations	1,224	1,224	1,224	1,224	1,224	1,224	1,148	1,148	1,224	1,224	1,148	1,148

This table reports results from panel regressions at the insurer-year level using the average contract return as the dependent variable.

Table 4: Unconstrained Contract Return

	Unconstrained contract return											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Reserves	0.011	0.00050			0.011	-0.00051	0.012	0.0035	0.014	-0.00041	0.014	0.0038
	(0.0094)	(0.0083)			(0.0094)	(0.0080)	(0.0090)	(0.0066)	(0.0099)	(0.0082)	(0.0091)	(0.0067)
Lagged reserves			0.012	0.0065								
			(0.0096)	(0.0086)								
Asset return			0.010	-0.0093								
			(0.0065)	(0.0073)								
Outstanding guarantees (regulatory)					0.030	0.022			0.0074	0.019		
					(0.075)	(0.062)			(0.072)	(0.053)		
Outstanding guarantees (economic)							0.049	0.0030			0.036	-0.0021
							(0.034)	(0.037)			(0.032)	(0.033)
Insurer capital									0.075	0.0091	0.071	0.024
									(0.089)	(0.075)	(0.086)	(0.074)
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Insurer FE		✓		✓		✓		✓		✓		✓
R^2	0.806	0.913	0.806	0.914	0.806	0.913	0.816	0.915	0.809	0.914	0.818	0.915
Observations	1,143	1,143	1,143	1,143	1,143	1,143	1,135	1,135	1,143	1,143	1,135	1,135

This table reports results from panel regressions at the insurer-year level using the unconstrained contract return as the dependent variable.

Table 5: Contract Return and Insurer Capital

	Average contract return				Unconstrained contract return			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Reserves	0.015*	0.013**	0.015*	0.014***	0.014	-0.0019	0.013	0.0017
	(0.0082)	(0.0062)	(0.0082)	(0.0048)	(0.010)	(0.0076)	(0.0097)	(0.0057)
Outstanding guarantees (regulatory)	0.049	0.027			-0.0015	-0.0062		
	(0.036)	(0.041)			(0.073)	(0.060)		
High insurer capital	0.063	-0.051	-0.010	-0.10	0.080	-0.063	-0.010	-0.12
	(0.091)	(0.070)	(0.087)	(0.068)	(0.10)	(0.082)	(0.092)	(0.075)
High insurer capital	0.046***	0.054**			0.034	0.042		
× Out. guarantees (regulatory)	(0.014)	(0.019)			(0.022)	(0.026)		
Outstanding guarantees (economic)			0.023	-0.022			0.0045	-0.046
			(0.020)	(0.032)			(0.037)	(0.031)
High insurer capital			0.026***	0.031***			0.028***	0.034***
× Out. guarantees (economic)			(0.0062)	(0.0082)			(0.0067)	(0.0085)
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Insurer FE		✓		✓		✓		✓
Observations	1,224	1,224	1,148	1,148	1,143	1,143	1,135	1,135
R^2	0.851	0.924	0.865	0.934	0.810	0.915	0.822	0.920

This table reports results from panel regressions at the insurer-year level using average and unconstrained contract return as dependent variables with interaction of outstanding guarantees and a dummy equal to one if the insurer has a capital ratio above median at the end of the previous year (the median is year-specific).

Table 6: Purchases of New Contracts

Panel A: Purchases of new single premium contracts

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Reserves	0.10***	0.092***	0.096**	0.086**	0.035**	0.024*	0.026	0.014
	(0.033)	(0.030)	(0.040)	(0.035)	(0.015)	(0.012)	(0.016)	(0.015)
Outstanding guarantees	-1.20***	-1.15***			-0.64***	-0.52***		
(regulatory)	(0.14)	(0.12)			(0.17)	(0.13)		
Outstanding guarantees			-0.40**	-0.36**			-0.21	-0.10
(economic)			(0.16)	(0.16)			(0.14)	(0.13)
Insurer capital		-0.24*		-0.28		-0.42**		-0.59**
		(0.13)		(0.20)		(0.19)		(0.26)
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Insurer FE					✓	✓	✓	✓
R^2	0.509	0.521	0.433	0.448	0.751	0.765	0.733	0.753
Observations	1,161	1,161	1,105	1,105	1,161	1,161	1,105	1,105

Panel B: Purchases of new regular premium contracts

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Reserves	0.0066*	0.009**	0.0062	0.008*	0.0041	0.0059	0.0044	0.0059
	(0.0037)	(0.004)	(0.0037)	(0.004)	(0.0034)	(0.0035)	(0.0039)	(0.0041)
Outstanding guarantees	-0.034***	-0.046**			0.039	0.020		
(regulatory)	(0.012)	(0.016)			(0.033)	(0.026)		
Outstanding guarantees			-0.014	-0.023			0.026	0.012
(economic)			(0.0097)	(0.014)			(0.020)	(0.017)
Insurer capital		0.054		0.060		0.071*		0.075
		(0.040)		(0.046)		(0.038)		(0.046)
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Insurer FE					✓	✓	✓	✓
R^2	0.438	0.450	0.429	0.443	0.697	0.705	0.696	0.702
Observations	1,161	1,161	1,105	1,105	1,161	1,161	1,105	1,105

This table reports results from panel regressions at the insurer-year level with purchases of new contracts as dependent variables. Panel A reports results for single premium contracts. Panel B reports results for regular premium contracts. Purchases of new single premium contracts are measured as single premium payments divided by total account value. Purchases of new regular premium contracts are measured as initial regular premium payments divided by total account value. The sample excludes insurer-year observations in which the insurer is in run-off.

Table 7: Flows in Outstanding Contracts

	Panel A: Premium increases				Panel B: Surrender+Inactive			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Reserves	0.0035*	0.0035*	0.00036	-0.00015	0.0010	0.00047	0.00086	-0.00064
	(0.0018)	(0.0018)	(0.00098)	(0.0010)	(0.0025)	(0.0022)	(0.0012)	(0.0011)
Outstanding guarantees (regulatory)	-0.0010		-0.010		-0.025**		-0.012	
	(0.010)		(0.0077)		(0.011)		(0.0077)	
Outstanding guarantees (economic)		-0.0011		-0.0015		-0.019**		0.012
		(0.0093)		(0.0079)		(0.0085)		(0.0090)
Insurer capital	-0.0035	-0.0044	0.0042	0.00060	0.025	0.031	0.029*	0.015
	(0.0077)	(0.0092)	(0.0075)	(0.0085)	(0.019)	(0.022)	(0.015)	(0.018)
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Insurer FE			✓	✓			✓	✓
R^2	0.246	0.247	0.683	0.684	0.410	0.415	0.786	0.789
Observations	1,224	1,148	1,224	1,148	1,224	1,148	1,224	1,148

	Panel C: Surrender (no. contracts)				Panel D: Surrender (paid-out value)			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Reserves	-0.032*	-0.036**	0.00099	-0.0049	-0.063***	-0.066***	0.0022	-0.0051
	(0.017)	(0.016)	(0.0071)	(0.0065)	(0.021)	(0.021)	(0.0069)	(0.0064)
Outstanding guarantees (regulatory)	-0.087		-0.072		-0.043		-0.032	
	(0.055)		(0.054)		(0.078)		(0.041)	
Outstanding guarantees (economic)		-0.12***		0.035		-0.022		0.082*
		(0.042)		(0.039)		(0.072)		(0.043)
Insurer capital	0.054	0.10	0.12***	0.051	0.18	0.23*	0.11***	0.029
	(0.069)	(0.076)	(0.034)	(0.044)	(0.11)	(0.11)	(0.032)	(0.039)
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Insurer FE			✓	✓			✓	✓
R^2	0.450	0.474	0.879	0.883	0.257	0.285	0.817	0.835
Observations	1,213	1,137	1,213	1,137	1,224	1,148	1,224	1,148

This table reports results from panel regressions at the insurer-year level for outstanding contracts. Dependent variables are premium increases (Panel A), premiums cancelled for surrender and setting contracts to inactive (Panel B), number of surrendered contracts (Panel C) and paid-out surrender value (Panel D). Variables are defined in the text in Section 7.2.

Table 8: Run-Offs

	Announced run-off					Effective run-off				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Reserves	-0.0015	-0.0015	-0.0016	-0.0014	-0.0015	-0.0029	-0.0029	-0.0030	-0.0028	-0.0029
	(0.00089)	(0.00091)	(0.00095)	(0.00099)	(0.00100)	(0.0018)	(0.0018)	(0.0019)	(0.0020)	(0.0021)
Outstanding guarantees (regulatory)		-0.0029		-0.0033			0.00067		0.00029	
		(0.0031)		(0.0030)			(0.012)		(0.012)	
Outstanding guarantees (economic)			-0.00090		-0.0013			0.0022		0.0018
			(0.0019)		(0.0017)			(0.0087)		(0.0087)
Insurer capital				0.0022	0.0031				0.0019	0.0027
				(0.0059)	(0.0063)				(0.0080)	(0.0080)
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.043	0.043	0.047	0.044	0.047	0.061	0.061	0.065	0.062	0.066
Observations	1,170	1,170	1,112	1,170	1,112	1,170	1,170	1,112	1,170	1,112

This table reports results from panel regressions at the insurer-year level with run-off as the dependent variable.

Appendix

A Lifetime net transfers

This appendix shows the calculation of lifetime net transfers in the three examples presented in Section 5.2.

Example 1: Single premium endowment contract. Account value is given by

$$V_{i,j,1999} = 100, \tag{A.1}$$

$$t = 2000, \ldots, 2018, \qquad V_{i,j,t} = (1 + y_{i,j,t})V_{i,j,t-1}. \tag{A.2}$$

Lifetime net transfer (11) is equal to

$$\sum_{t=2000}^{2018} \left(\frac{-\Delta R_{j,t}}{\bar{V}_{j,t}} + (y_{i,j,t} - y^a_{j,t}) \right) V_{i,j,t-1}, \tag{A.3}$$

where $\frac{-\Delta R_{j,t}}{\bar{V}_{j,t}}$ is minus the change in reserves for insurer j between year $t-1$ and year t normalized by average account value over year t, $y_{i,j,t}$ is the return paid on the contract under consideration, and $y^a_{j,t}$ is the average return across all contracts held with insurer j.

Example 2: Regular premium endowment contract. Account value is

$$V_{i,j,1999} = 100, \tag{A.4}$$

$$t = 2000, \ldots, 2018, \qquad V_{i,j,t} = (1 + y_{i,j,t})V_{i,j,t-1} + 100. \tag{A.5}$$

Lifetime net transfer is still given by (A.3).

Example 3: Single premium annuity contract. Annuities are calculated using mortality tables and using the minimum guaranteed return of the contract as discount rate. Since we consider an annuity contract with death on January 1st, 2019, we use a simplified mortality table assuming certain death on January 1st, 2019 to simplify the calculation. Thus, the annuity purchased by the single premium paid on January 1st, 2000 is given by

$$Ann_{i,j,1999} = 100 \frac{y^g_i (1 + y^g_i)^{19}}{(1 + y^g_i)^{19} - 1}. \tag{A.6}$$

The contract return is credited to the account value at the end of each year. When the contract return exceeds the guaranteed rate, the excess return is immediately annuitized. The annuity paid at the end of year t is therefore

$$t = 2000, \ldots, 2018, \qquad Ann_{i,j,t} = Ann_{i,j,t-1} + (y_{i,j,t} - y^g_i)V_{i,j,t-1} \frac{y^g_i (1 + y^g_i)^{2019-t}}{(1 + y^g_i)^{2019-t} - 1} \tag{A.7}$$

The account value evolves according to

$$V_{i,j,1999} = 100, \tag{A.8}$$

$$t = 2000, \ldots, 2018, \qquad V_{i,j,t} = (1 + y_{i,j,t})V_{i,j,t-1} - Annuity_{i,j,t}. \tag{A.9}$$

Lifetime net transfer is still given by (A.3).

B Regulatory Framework

B.1 Minimum guaranteed return

Section 2 of the Principles Underlying the Calculation of the Premium Reserve (*Deckungsrückstellungsverordnung*) imposes a cap on the minimum guaranteed return (*Höchstrechnungszins*) that insurers are allowed to offer. The cap is regularly revised by the Ministry of Finance. Until 2015, the law (section 65 of the Insurance Supervision Act) specified explicitly that the cap was 60% of the 10-year yield on AAA-rated European sovereign bonds. Since 2015, the law (section 88 of the Insurance Supervision Act) has not specified how the cap should be calculated. As shown in Figure 1, the cap has not been revised since 2017 despite the decline in the 10-year rate.

B.2 Reserves and contract returns

The Minimum Allocation Regulation (*Mindestzuführungsverordnung*) requires insurers to allocate to investors, in addition to the minimum guaranteed return, at least:

- 90% of accounting asset income minus expenses for minimum guarantees minus expenses for the AIP;
- plus 75% (90% since 2014) of risk income;
- plus 50% of other income.

Accounting asset income is calculated as the yield on fixed income securities, dividends on non-fixed income securities, and realized capital gains on the asset portfolio. Unrealized gains and losses on the asset portfolio are not taken into account in the calculation of accounting asset income, even though they represent economic income. Thus, they constitute a component of reserves.

Risk income is generated when insurance claims are lower than calculated; a reason is, for example, prudent calculation of death probabilities. Risk income is usually positive, because insurers are required to do their premium and annuity calculation with prudence.

Other income includes profits stemming from the difference between fees charged to investors and the insurer's operating costs.

The share of income allocated to investors (in addition to the minimum guaranteed return) is credited to a reserve account called the profit sharing reserve (*Rückstellung für Beitragsrückerstattungen*, hereinafter PSR). Funds in the PSR are later credited to investors' accounts in the form of regular bonuses and terminal bonuses. The PSR has four components. First, the unrestricted component that has not yet been allocated to any contract. This represents on average 40% of the PSR. Second, the maturity bonus fund is reserved for payment of terminal bonuses, but it has not yet been decided which contracts it will be allocated to. This represents on average 43% of the PSR. Third, a component earmarked for next year's regular bonus has been allocated to individual contracts and will be credited to these contracts at the end of the next year. This represents on average 12% of the PSR. Fourth, a component earmarked for next year's terminal bonus has been allocated to individual contracts ending next year and will be credited to these contracts at the end of the next year. This represents on average 5% of the PSR. The year-on-year change in total PSR is equal to the share of income retained as PSR minus the part of the PSR earmarked for next year's regular bonus and terminal bonus, which is credited to investors' accounts.

Against a backdrop of declining interest rates, an additional reserve known as the Additional Interest Provision (*Zinszusatzreserve*, hereinafter AIP) was introduced in 2011. We explain this item in the next subsection.

Insurers are largely free to choose the level of reserves, and thus the timing of contract returns. In addition, insurers are required by law to distribute the same contract return to all investors irrespective of when they purchased their contract, unless doing so would imply paying a lower contract return than the minimum guaranteed return (BaFin declaration VerBaFin 07/2004). In such cases, the contract return for contracts whose guarantee in binding is set to the minimum guaranteed return.

Insurers' ability to hold large reserves is limited to a small extent by certain rules. First, if the total PSR exceeds a cap, additional inflows to the PSR are not tax deductible (Section 21 of the Corporate Tax Act). Until 2010, the cap was equal to inflows to the PSR over the past three years. This implies that the insurer can hold up to three years of excess asset income in the PSR without being subject to additional taxes. In 2010, this cap was increased to five years of inflows to the PSR. This cap was removed in 2019. The cap on the PSR does not impose a hard limit on insurers' total reserves because insurers can choose not to realize capital gains in order to hold large reserves while limiting the size of the PSR.[14] In the data, the cap was binding for approximately half of insurer-year observations before 2019.

Second, between 2008 and 2014, investors whose contract expired were entitled to 50% of unrealized capital gains generated since the creation of the contract. This rule was enacted in 2008 by a change in the Insurance Contract Act (Section 153). In 2014, it was limited to unrealized capital gains on non-fixed income assets. Funds earmarked for these payments to contract holders are retained in the profit sharing reserve (more precisely, in the maturity bonus fund) and taken out as the benefit is paid out of the PSR.

B.3 Outstanding guarantees

Our regulatory-based measure of outstanding guarantees is based on the AIP introduced in Appendix B.2. The regulatory formula for the AIP is

$$AIP = \sum_{i=1}^{N} \sum_{t=0}^{15} \frac{CF_{i,t}}{(1 + \min(r^{ref}, y_i^g))^t} - \frac{CF_{i,t}}{(1 + y_i^g)^t}, \tag{B.1}$$

where i indexes contracts, r^{ref} is the 10-year moving average of the 10-year swap rate,[15] y_i^g is the minimum guaranteed return on contract i, and $CF_{i,t}$ is the projected net cash outflow of contract i in year t, which is calculated as the guaranteed payment to the

[14]Holding reserves in the form of unrealized capital gains instead of PSR is costly in terms of solvency requirements, because under Solvency I (i.e, until 2015) part of the PSR qualifies as regulatory capital whereas unrealized capital gains do not. The PSR constitutes a significant part of regulatory capital under Solvency I (6.5%) while equity represents on average 1.7% of account value.

[15]In 2018, the calculation of r^{ref} was changed such that the yearly decline is capped (known as the corridor method). This explains why growth in the AIP slows down in 2018 (see Figure 4).

investor upon expiry (which does not include regular and terminal bonuses because these are not guaranteed) minus regular premium payments. Calculation of the AIP is restricted to cash flows over the next 15 years. The AIP amount is reported in the regulatory filings at the insurer-year level. We define the regulatory-based measure of outstanding guarantees as AIP normalized by total account value.

Our economic-based measure of outstanding guarantees is also based on the AIP formula (B.1) but replaces the 10-year moving average swap rate, r^{ref}, with the current swap rate, r:

$$AIP^{adj} = \sum_{i=1}^{N} \sum_{t=0}^{15} \frac{CF_{i,t}}{(1 + \min(r, y_i^g))^t} - \frac{CF_{i,t}}{(1 + y_i^g)^t}, \tag{B.2}$$

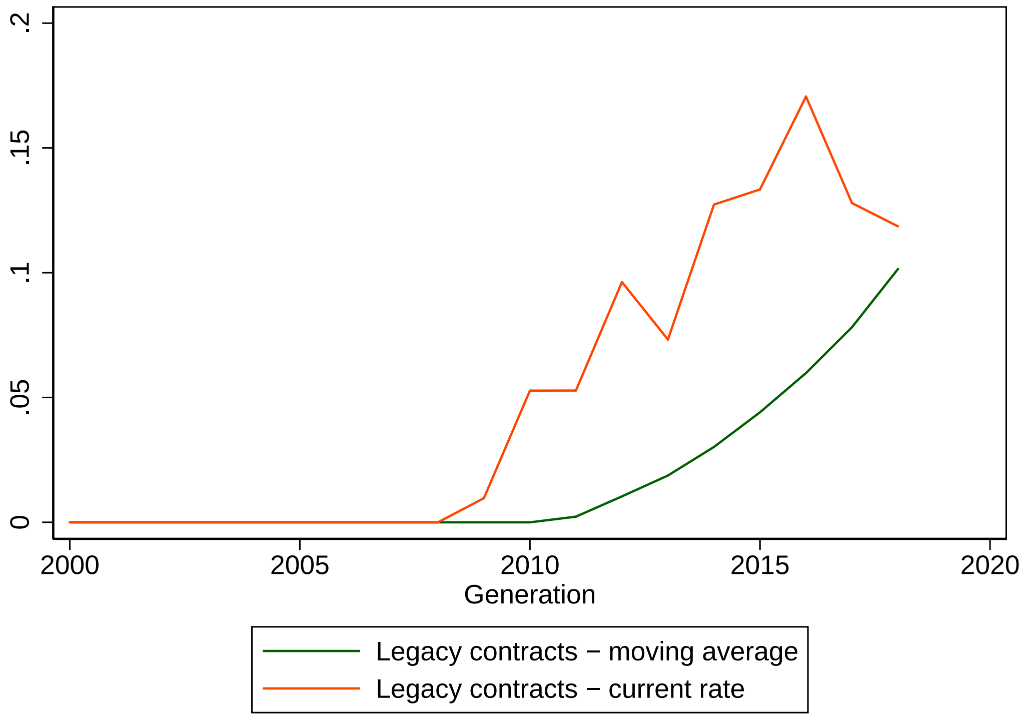
Projected net cash outflow $CF_{i,t}$ is not reported in the regulatory filings. We approximate its value using the assumption that the current account value is equal to the present value of the projected net cash flow, $V_i = \sum_{t=0}^{15} CF_{i,t}/(1+r)^t$, and that the discounted net cash flow $CF_{i,t}/(1+r)^t$ is approximately constant over time. Using a first approximation for small r and y_i^g, this allows us to write that

$$AIP^{adj} = \sum_{i=1}^{N} 8 \max(y_i^g - r, 0) V_i. \tag{B.3}$$

We calculate AIP^{adj} using data on account value by cohort described in Appendix C.2. We define the economic-based measure of outstanding guarantees as AIP^{adj} normalized by total account value.

Figure B.1 plots the regulatory-based and economic-based measures of outstanding guarantees. The former increases more smoothly because of the smoothing effect of the moving average.

Figure B.1: Measures of outstanding guarantees



C Data

C.1 Sample construction

Data gaps Two insurers exit from the regulatory data because they are reorganized into pension funds. We keep these companies in the sample until the year in which they are reorganized. We drop from the sample six small insurers (four of which are regulated at the local level) because of data gaps. In a very few cases, new insurers have been established, in which case we use observations after entry, except for one company founded in 2017 because the sample ends in 2018.

Lines of business Some data items such as payout to policyholders are aggregated across the participating contracts.

This includes policies used for saving, but also term life and other minor life contracts. We focus on participating contracts predominantly used for saving purposes and exclude 16 insurers whose share of term life contracts and unit-linked contracts among all life insurance contracts exceed 75% at any point of time during the sample period.

Mergers and acquisitions There are 41 mergers and acquisitions during the sample period. Table C.2 below shows the distribution of mergers over time. The spike in 2001 is presumably driven by losses in the stock market, triggering consolidation. To avoid jumps in insurer characteristics around these events, we apply the following treatment to the data when Insurer A merges with Insurer B in year t, i.e. in cases in which both insurers report separate annual filings in $t-1$ and a consolidated filing in year t:

- Case 1: The larger insurer, say Insurer A, has a total account value that exceeds 80% of the combined account value of both insurers. We collapse observations of both insurers into a single insurer in all the years before the merger. We are left with a time series for only one insurer. When we run regressions with insurer fixed effects, we assume it is the same entity throughout the sample period.
- Case 2: Neither of the merging firms represents more than 80% of the combined entity. We keep observations for both insurers before the merger. When we construct insurer fixed effects, we assume that the merged entity is a different insurer than either from the merging entities.

Out of the 41 mergers in the sample, 34 fall into case 1 and 7 into case 2.

Table C.2: Mergers and acquisitions

Year	Number of events
2000	2
2001	11
2002	1
2003	2
2004	3
2005	4
2006	1
2007	3
2008	1
2009	2
2010	1
2011	0
2012	2
2013	4
2014	2
2015	0
2016	1
2017	1
2018	0

C.2 Cohort-level account value

We reconstruct $V_{j,t,c}$, the account value of insurer j at the end of year t for cohort c of the minimum guaranteed return. A cohort can correspond to several years of contract vintage, because the minimum guaranteed return is not updated every year (see Figure

1). For instance, the cohort "4%" corresponds to contracts created in the years 1994 to 1999.

We use information from a 2011 survey, which reports account value broken down by the level of the minimum guaranteed return for the years 2007 to 2010. Insurers were also requested to provide forecasts of account value for the years after 2010, based on contracts outstanding at the end of 2010.

For cohorts with guarantees that were no longer offered after 2010 (that is, minimum guaranteed returns strictly above 2.25%), the evolution of future account values is almost deterministic. It is determined by scheduled premiums and expirations. The only non-deterministic part comes from investors redeeming or setting their contract to inactive, which insurers forecast in order to estimate future account values. For these cohorts, we use the forecasted account value provided by insurers to construct $V_{j,t,c}$.

For cohorts with a guarantee that is still offered at the time of the survey in 2010 (that is, a minimum guaranteed return of 2.25%), the evolution of future account values also depends on new business, which insurers are requested to ignore when forecasting future account values. Therefore, we adjust these forecasts using data on actual new business from the regulatory filings from 2011 on as follows:

a. We calculate the actual growth rate of the account value at the insurer-year level:

$$\frac{V_{j,t} - V_{j,t-1}}{V_{j,t-1}}.$$

b. We calculate the forecasted growth rate of the account value at the insurer-year level:

$$\frac{V^f_{j,t} - V^f_{j,t-1}}{V^f_{j,t-1}},$$

where we denote with exponent f insurers' forecasts reported in the survey.

c. We estimate new business at the insurer-year level as:

$$NewV_{j,t} = V_{j,t-1} \times \max\left(\frac{V_{j,t} - V_{j,t-1}}{V_{j,t-1}} - \frac{V^f_{j,t} - V^f_{j,t-1}}{V^f_{j,t-1}}, 0\right).$$

d. We adjust forecasted account values for new business:

$$V_{j,t,c} = V^f_{j,t,c} + \sum_{\tau \in c, \tau \leq t} (1 + r^g_c)^{t-\tau} NewV_{j,\tau},$$

where $\tau \in c$ denotes the set of years associated with cohort c.

Finally, for cohorts with a guarantee that was not yet offered at the time of the survey in 2010 (that is, a minimum guaranteed return strictly below 2.25%), which insurers were not asked to forecast in 2010, future account values depend on new business. For these cohorts, we calculate $V_{j,t,c}$ following steps a. to d. described above, where insurers' forecasts $V^f_{j,t}$ are equal to zero.

Figure C.2 shows the accuracy of forecasted cohort-level account values. The figure shows that the forecast is close to the actual total account value.

Figure C.2: Accuracy of forecasted cohort-level account values