Intergenerational Risk Sharing in Life Insurance: Evidence from France*

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May 31, 2018

Abstract

We study intergenerational risk sharing taking place in one of the most common retail investment products in Europe—life insurance savings contracts—focusing on the 1.4 trillion euro French market. Using regulatory and survey data, we show that contract returns are an order of magnitude less volatile than the returns of assets backing the contracts. Contract return smoothing is achieved using reserves that absorb fluctuations in asset returns and that generate intertemporal transfers across generations of investors. We estimate the average annual amount of intergenerational transfer at 1.4% of contract value, i.e., 17 billion euros per year or 0.8% of GDP. While theory asserts that intergenerational risk sharing cannot take place in competitive markets because it relies on non-exploited return predictability, we show that: (a) contracts returns are indeed predictable; (b) investor flows barely react to predictable returns; (c) observed fees offset the estimated gain from exploiting contract return predictability.

*We thank Anastasia Kartasheva, Robert Novy-Marx, conference participants at NBER Insurance Workshop, European Winter Finance Conference, seminar participants at Autorité de Contrôle Prudentiel et de Résolution, Chinese University of Hong Kong, Hong Kong University, Hong Kong University of Science and Technology, Singapore Management University, Nanyang Technological University, Deutsche Bundesbank, for helpful comments. We thank Autorité de Contrôle Prudentiel et de Résolution and in particular we thank Frédéric Ahado, Anne-Lise Bontemps-Chanel, Fabrice Borel-Mathurin, Charles-Henri Carlier, Edouard Chrétien, Pierre-Emmanuel Darpeix, Olivier DeBandt, Dominique Durant, Henri Fraisse, Samuel Slama, for access and assistance in putting together the data as well as comments.

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1 Introduction

Against a backdrop of secular decline in government-provided pensions and defined benefit pension plans around the world, life insurers are increasingly offering retail savings products with embedded insurance against market risk (Koijen and Yogo (2018)). Insurance against market risk can be provided to households through two different mechanisms (Allen and Gale (1997)). The first one is cross-sectional risk sharing between the insurer and households. The insurer bears part of the risk and provides households with returns partially hedged against market risk. Cross-sectional risk sharing is implemented by guaranteed return products like the ones studied by Koijen and Yogo (2018) in the US.

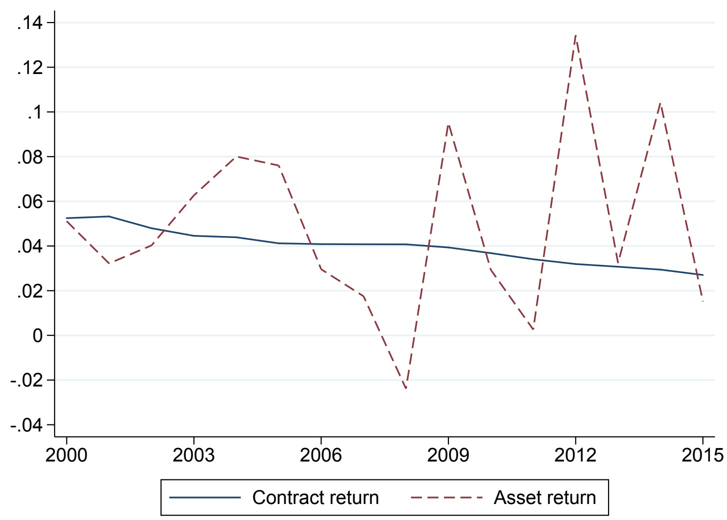
The other way to provide households with insurance against aggregate risk is to share risk intertemporally across generations of households, as was traditionally done in defined benefits plans and by Social Security. Intergenerational risk sharing is implemented by the most common type of life insurance contracts in Europe. Although the details of these products vary across countries (as well as their name: "Euro-denominated", "participating", "with profits", etc.), their common key feature is that they are backed by reserves that absorb fluctuations in market return over time and that are passed on between successive generations of investors. These products account for 80% of aggregate life insurance premiums in Europe in 2014 (Insurance Europe (2016)).

We focus in this paper on the French life insurance market, which is a large and mature market. At the end of 2015, the value of Euro-denominated life insurance contracts in France is 1.4 trillion euros, which represents 80% of aggregate life insurance provisions and 30% of aggregate household financial wealth. These savings products work as follows. When a retail investor buys a life insurance contract, an account is created on which she can deposit and withdraw cash. Cash in all outstanding accounts associated to insurance contracts sold by the insurer is pooled into a single fund invested in asset markets and managed by the insurer. At the end of each year, account values are credited at a rate that is different from, and typically smoother than the rate of return of the fund's assets. It implies that account values diverge from the fund asset value. The difference between the two make up fund reserves. The role of these reserves is to cushion fluctuations in asset returns in order to smooth contract returns over time. Crucially, fund reserves are owed to (current or future) investors and are passed on between successive cohorts of investors as investors redeeming their contract give up their share of reserves while new investors share in existing reserves. Thus, fluctuations in the level of reserves over time generates redistribution across cohorts of investors.

We use regulatory and survey data from the national insurance supervisor. Our objective is twofold. The first one is to provide evidence of private implementation of intergenerational risk sharing. To this aims, we study the smoothing of contract returns through fund reserves and quantify the transfers across "generations" of investors it induces, where we define a generation as a cohort of investors characterized by their entry date and exit date in the contract, i.e., two investors are said to belong to different generations if they hold contracts over different periods. The second objective is to determine the patterns of insurers' and investors' behavior that make intergenerational risk sharing possible. To this aim, we analyze the implications of return smoothing for the predictability of contract returns and how household flows respond to this predictability.

Regarding the first objective, we have four main findings. The first finding is that contract returns are significantly smoother than funds' asset returns. This finding is illustrated in Figure 1, which plots value-weighted average asset returns and contract returns over 2000–2015. While the annual volatility of asset returns is 4.4%, the volatility of contract returns is only 0.9%. The smoothing of contract returns reflects insurance against market risk. This insurance may arise because fluctuations in asset returns are absorbed by insurer equity or because they are absorbed by fund reserves, i.e., by past and future generations of investors.

Figure 1: Asset Returns vs. Contract Returns. The solid blue line plots value-weighted average contract returns. The dashed red line plots value-weighted average asset returns.



The second finding is that fluctuations in asset returns are absorbed by fund reserves. Fluctuations in fund reserves explain almost entirely the wedge between asset returns and contract returns. In contrast, cross-sectional transfers between investor accounts and insurers are an order of magnitude smaller and less volatile than fluctuations in fund reserves. Fund reserves, which represent on average 11% of account values, fluctuate with realized asset returns: they increase when asset returns are high and they decrease when asset returns are low.

The third finding is that the amount of investor account value transferred across time through fluctuations in fund reserves is large. The average annual transfer between current investors and fund reserves is equal to 3.7% of account values. Evaluated at the 2015 level of aggregate account value of 1,200 billion euros, it amounts to an annual 44 billion euros that shifts from year to year on average, or 2% of GDP.

The fourth finding is that the amount of account value transferred across generations of investors is large. Transfers across years overstate transfers across generations of investors, because investors hold their contracts for longer than one year. Investors receive positive transfers in some years (when contract return is above asset return) and negative transfers in other years (when contract return is below asset return) that partially net out. For instance, if annual transfers from fund reserves are i.i.d. and normally distributed, then the expected lifetime net transfer for an investor with a holding period of T year is equal to $1/\sqrt{T}$ of the expected annual transfer. Given an average holding period of 12 years, this back-of-envelop calculation yields an average transfer across generations of investors of 1.1% per year.

To obtain a more precise estimate of intergenerational transfers, we use information on inflows and outflows at the insurer-year level to estimate the share of each generation in total account value. Combining this estimate with annual transfers between investor accounts and fund reserves, we calculate that the amount of annual transfers across generations of investors is 1.4% of total account value on average. Evaluated at the 2015 level of aggregate account value of 1,200 billion euros, it amounts to an annual 17 billion euros that shifts across generations of investors on average, or 0.8% of GDP.

The second objective of the paper is to analyze the patterns of insurer and investor behavior that make intergenerational risk sharing possible. We study how contract returns are related to the accumulated stock of reserves; how this creates predictability in contract returns; and how investors react to this predictability. These issues are crucial, because they determine the possibility (or impossibility) to implement intergenerational risk sharing, thereby diversifying risks that cannot be diversified at a given point in time. It is well-known that, although intergenerational risk sharing improves over cross-sectional risk sharing from a welfare perspective, competitive markets cannot implement intergenerational risk sharing because it requires future generations to share risk occurring before they start participating in the market (Stiglitz (1983), Gordon and Varian (1988)). More crucially, even if an intermediary implements a mechanism that achieves intergenerational risk sharing, it can undone by competition from financial markets (Allen and Gale (1997)). The reason is that, if investors invest with the intermediary only when reserves are high and invest directly in financial markets when reserves are low, then the risk sharing mechanism unravels. It implies that the implementation of intergenerational risk sharing requires some friction making investor flows imperfectly elastic to the level of reserves.[1]

[1] An extreme form of friction is mandatory participation in the risk sharing mechanism as in some government- or employer-provided pension plans. In this case, the first best allocation can be achieved as studied by Ball and Mankiw (2007) and Gollier (2008).

We proceed in several steps to analyze investor flows' sensitivity to future contract returns. First, we test whether future contract returns are predictable. The specification of the test is guided by the models of Allen and Gale (1997) and Gollier (2008), in which the optimal contract return is an increasing function of the level of fund reserves. The intuition is rooted in the role of reserves as a buffer against fluctuations in asset returns. When the asset return is high, part of it is hoarded as reserves for future distribution, leading to a high level of fund reserves that predicts large future contract returns. Conversely, when the asset return is low, insurers draw on reserves, leading to a low level of fund reserves that predicts low future contract returns.

We find robust empirical support for this prediction. A higher level of fund reserves predicts higher contract returns after controlling for insurer and year fixed effects. Our estimates show that a one euro increase in the level of fund reserves is associated with an additional 2.9 cents of annual contract return, that is, 2.9% of extra fund reserves are distributed every year. We run regressions without insurer fixed effects and portfolio sort analysis to confirm that the level of fund reserves predicts future contract returns. An investor switching from an insurer with low reserves to an insurer with high reserves earns higher contract return by 34 basis points per year on average.

Second, we find that the sensitivity of investor flows to these predictable returns is at best weak, both in terms of statistical significance and economic magnitude. Separate tests for inflows, voluntary outflows (redemptions), and involuntary outflows (at investor death) show that only the former reacts to the level of reserves.

Third, to shed light on the reasons why investor flows are barely elastic to fund reserves, we estimate the expected costs and benefits of switching from an insurer with low reserves to an insurer with high reserves. The benefits of doing so depends on the predictive power of reserves for contract returns, the speed at which this predicability decays over time, and the investor's holding period. We show that return predictability decays at the same rate as the rate of mean reversion of reserves, which depends, in turn, on the rate at which reserves are distributed to investors' accounts, the unconditional net flow rate, and the sensitivity of flows to reserves. We calibrate these moments in the data and estimate that the present value of switching to an insurer with one standard deviation higher reserves is 1.2% of the invested amount. Given that the fees incurred when doing so are of the order of 3% of the invested amount, there does not seem to be profit opportunities that investors could take advantage of.

Previous research has analyzed other arrangements implemented by financial intermediaries to share aggregate risk. Variables annuities studied by Koijen and Yogo (2015, 2018) share market risk between households and insurers but, unlike the Euro-denominated contracts we analyze, not across generations of households. Defined benefits (DB) pension plans studied by Novy-Marx and Rauh (2011, 2014) have an element of intergenerational risk sharing like in Euro-denominated contracts, because DB sponsors have the option to increase the contributions of futures employees or may be bailed out by future taxpayers. One important difference, however, is that DB sponsors fully commit to a rate of return for households, whereas insurers selling Euro-denominated contracts only commit to a minimum guaranteed rate and can adjust returns distributed to households depending on investment returns.

The rest of the paper is organized as follows. The institutional framework is described in words in Section 2 and in equations in Section 3. Section 4 presents the data and summary statistics. Section 5 shows evidence on intergenerational risk sharing. Section 6 shows evidence on the relation between reserves, contract returns, and investor flows. Section 7 concludes.

2 Institutional Framework

After a brief overview of the French savings landscape in Section 2.1, we describe how Euro-denominated life insurance contracts work in Section 2.2 and how fund reserves are used to smooth contract returns and to implement transfers across generations in Section 2.3.

2.1 French Savings Landscape

The composition of the average French household's financial wealth can be decomposed into three parts of approximatively equal size (Insee (2016)). One third is invested in risky securities and investment funds, which can either be held directly, or through tax-advantaged special vehicles. One such vehicle is unit-linked contracts, which are sold by life insurers and through which households can hold mutual funds. Those contracts benefit from the same tax treatment as Euro-denominated contracts (described below). Another third is held in short-term instruments including checking accounts and savings accounts. In particular, there are several types of regulated savings products that benefit from advantageous tax treatments. The interest rates on those products are typically fixed by the government, and the amount that can be invested is limited. The most widespread of these regulated savings product is called *Livret A*. It is fully tax free and has an investment limit of 23,000 euros per household member (including children). The interest rate set by the government has averaged the one-year risk-free rate over 2001–2015.

The last third of households' financial wealth is invested in the Euro-denominated contracts we study in this paper. The size of the market for Euro-denominated contract is 1.4 trillion euros in 2015 (ACPR (2016)), out of the aggregate 4.5 trillion euros of household financial wealth. Market concentration is relatively low with a Herfindahl-Hirschman Index around 800 and total market shares of the top 5 life insurers slightly below 50%. The main types of life insurers are subsidiaries of insurance holding companies, subsidiaries of banks holding companies, and stand-alone life insurance companies.

The tax system for capital income has a two-tier structure. The first tier is social security contributions, which is a flat rate tax on capital income and whose rate has increased from 10% in 1999 to 15.5% in 2015. The second tier is the income tax. Households can choose to include capital income in their taxable income, in which case it is taxed at the marginal income tax rate (between 0% and 45% depending on total taxable income and household size); or they can choose to pay a flat withholding tax, whose rate depends on the savings vehicle. For life insurance (Euro-denominated contracts or unit-linked) contracts, the withholding tax rate depends on the holding period of the contract: 35% if less than four years; 15% between four and eight years; 7.5% with a tax allowance of 4,600 euros after eight years.[2] The withholding tax is the most favorable option for the majority of households (at least in value-weighted terms).

2.2 Contract Returns

Euro-denominated contracts are savings products sold by life insurers. When an investor buys such a contract, she opens an account with the insurer on which she can deposit and withdraw cash at any time. The cash deposited in investors' accounts is invested in asset markets through a fund managed by the insurer. At the end of each calendar year, the account is credited by an amount equal to the account value times an interest rate (*taux de revalorisation*) that we will refer to as the contract return. Insurers typically charge annual management fees proportional to the account value and exit fees (back-end loads) proportional to withdrawals.

The contract return is chosen at the full discretion of the insurer at the end of each year, subject to two constraints. The first constraint is that the insurer commits to a minimum guaranteed return fixed at the subscription of the contract. Against a backdrop of decreasing interest rates, French life insurers have strongly reduced guaranteed rates close to zero since the 1990s (Darpeix (2016)). In 2015, the average guaranteed return of in-force contracts is 0.4% (see Panel A of Appendix Figure A.1) while 77% of contracts have a zero guaranteed return. For the subset of contracts still open to new subscriptions, guaranteed returns are even lower: 0.1% on average and equal to zero for 87% of contracts. As a matter of comparison, the average contract return in 2015 is 2.6%. It implies that the minimum guaranteed rate is typically not binding. The contract return is strictly larger than the guaranteed return for 94% of contracts over 2011–2015 (see Panel B of Appendix Figure A.1).

Insurers must credit the same return to all investors holding the exact same product, that is, ruled by the same contract. However, insurers are allowed to pay different returns to investors holding products ruled by different contracts. Insurers can have several in-force contracts at a given point time for two reasons. First, insurers can close a product to new subscriptions and create a new one for new clients. They may do so when they want to change the characteristics of the contract, like fees or the guaranteed rate, or for marketing purposes by changing the name of the product. Second, some insurers sell products targeted to specific clienteles. For instance, some insurers sell contracts with minimum investment amounts targeted to a wealthier clientele that may carry lower

[2] See https://www.service-public.fr/particuliers/vosdroits/F22414.

fees than the regular contract. Some insurers also sell group contracts for instance to corporations for their pension plans.

In practice, there is a little bit of dispersion in net-of-fees contract returns across the products sold by a given insurer, part of it because of different before-fees returns, part of it because of different fees. Using exhaustive data on net-of-fees contract returns at the product level collected by the national insurance supervisor for the 2011–2015 period, we calculate in Appendix A.2 that the within-insurer-year standard deviation of annual net-of-fees return is 0.3 percentage points on average during this period. As a matter of comparison, the average net-of-fees return over the same period is 2.7% and the average time-series standard deviation over the longer period 2000–2015 is 1.0 percentage point. Thus, cross-contract dispersion in returns is small relative to the time-series dispersion.

More importantly, cross-contract return dispersion is mostly explained by product fixed effects, which means that the returns of different contracts sold by a given insurer all follow the same time-series variation. When we include a product fixed effect, the residual cross-contract standard deviation of annual contract returns drops to 0.1 percentage points. This feature of the market will be important for our empirical analysis, because it implies that the pattern of intertemporal smoothing of contract returns is the same across all contracts sold by a given insurer, even if the level of contract returns may differ.

The second constraint on contract returns is that life insurers are required by regulation to credit at least 85% of the intertemporal returns of underlying investments plus 90% of the fund net operating income (fees minus operating costs) to investors. Crucially, the regulatory constraint applies intertemporally and imposes no constraint on the timing of contract returns.[3] In the following section, we describe this regulation in more detail and we explain how insurers use fund reserves to choose the timing of contract returns.

2.3 Fund Reserves

Each insurer has a unique fund holding the assets backing all the contracts. The economic balance sheet of the fund is as follows.[4] Assets are equal to the market value of the asset portfolio. Liabilities are equal to total account values plus fund reserves, where fund reserves are by definition equal to the difference between total asset value and total account value.

Fund reserves have two key features that are at the root of the intergenerational risk sharing mechanism. First, they are due to investors. Second, they are pooled across all investors. In particular, new investors share in reserves accumulated by previous investors while leaving investors give up their share of reserves.

[3]Another regulation imposes a constraint on the timing of contract returns, but it is typically not binding. See Footnote 5.

[4]The economic balance sheet differs from the accounting balance sheet because the former is marked-to-market while life insurance accounting principles are mostly based on historical cost accounting.

In the French regulatory framework, fund reserves are made up of three components associated to three components of asset returns.

Profit-sharing reserves At the end of each calendar year, fund income is calculated as the sum of financial income and technical income. Financial income is equal to asset yield (dividends on non-fixed income securities plus yield on fixed income securities) plus realized gains and losses on non-fixed income securities. Technical income is equal to fees paid by investors minus operating costs. The insurer decides on the sharing of the fund income between itself and investors. By law, the investors' share must be equal to at least 85% of financial income plus 90% of technical income.

The share of fund income attributed to investors is further split into a part credited immediately to investor accounts and a part credited to a reserve account called the profit-sharing reserve (*provision pour participation aux bénéfices*). The profit-sharing reserve account can only be used for future distribution to investor accounts. It implies that profit-sharing reserves effectively belong to (current and future) investors.

Crucially, profit-sharing reserves are not attached to the contracts already in force at the time of the creation of the reserve account. Instead, profit-sharing reserves are pooled across all contracts. When a investor redeems her contract or withdraws cash from her account, she gives up the associated right to future distribution of the profit-sharing reserves. Conversely, when a new investor buys a contract or an exiting investor deposits more cash on her account, she shares in the existing profit-sharing reserves.[5]

Capitalization reserves Realized gains and losses on fixed income securities are credited to, or debited from, a reserve account called the capitalization reserve account (*réserve de capitalisation*). The capitalization reserve account can only be used to offset future losses on fixed income securities and cannot be credited to investor accounts or to insurer income. Thus, capitalization reserves represent deferred financial income for the fund. Since at least 85% of the fund financial income must be distributed to investors, it implies that at least 85% of capitalization reserves effectively belong to (current and future) investors.[6]

Unrealized gains Unrealized capital gains are not booked as fund income. Thus, accumulated capital gains and losses create a wedge between the market value and the book value of the fund assets, which makes up the third component of reserves.[7] Since unrealized gains represent deferred

[5] The insurer must credit the funds in the profit-sharing reserve account to investor accounts within eight years. It can therefore hoard up to eight years of contract returns in profit-sharing reserve accounts. In practice, the eight-year constraint is never binding. Profit-sharing reserves represent less than one year of contract returns on average, and two years and a half at the 99th percentile.

[6] Although, for accounting and regulatory purposes, capitalization reserves are booked as insurer equity.

[7] While unrealized capital gains are never booked as fund profit, there are deviations from historical cost accounting principles that force insurers to recognize "long and lasting" unrealized losses to prevent them from running too large unrealized losses. See Appendix A.3 for details.

fund financial income, at least 85% of their value effectively belong to (current and future) investors.

3 The Accounting of Intergenerational Risk Sharing

In this section, we present a simple framework of the accounting of intergenerational risk sharing in a life insurance fund.

$V_{i,t}$ denotes investor i's account value at the end of year t after payment of the annual net-of-fees return $y_{i,t}$. It evolves according to

$$V_{i,t} = (1 + y_{i,t})V_{i,t-1} + Flow_{i,t}, \tag{1}$$

where $Flow_{i,t}$ is net flows of investor i in year t.[8] In line with the institutional framework described in Section 2 and the evidence presented in Appendix A.2, we assume that the insurer pays the same return to all investors in a given year up to an investor fixed effect:

$$y_{i,t} = \eta_t + \xi_i. \tag{2}$$

The value-weighted average contract return is

$$y_t = \sum_i \frac{V_{i,t-1}}{V_{t-1}} y_{i,t}, \tag{3}$$

where $V_t = \sum_i V_{i,t}$ is total account value.

The balance sheet of the fund at the end of year t is

$$A_t = V_t + R_t, \tag{4}$$

where A_t is the market value of fund assets and R_t is fund reserves. Fund assets evolve according to

$$A_t = (1 + x_t)A_{t-1} + Flow_t - \Pi_t, \tag{5}$$

where x_t is the return of fund assets net of the fund operating costs, $Flow_t = \sum_i Flow_{i,t}$ is total net flows, and Π_t is the payoff of the insurer.

Combining (1), (3), (4), and (5), we obtain

$$x_t A_{t-1} = y_t V_{t-1} + \Pi_t + \Delta R_t. \tag{6}$$

Equation (6) describes how asset income (on the left-hand side) is shared between three groups of

[8] We assume here that flows take place at the end of the year after payment of the annual return to simplify the exposition. We relax this assumption in the empirical analysis.

agents (on the right-hand side): (i) current investors who receive $y_t V_{t-1}$; (ii) the insurer who gets Π_t; and (iii) fund reserves whose amount varies by $\Delta R_t = R_t - R_{t-1}$. Since beginning-of-year reserves have been accumulated by past investors and end-of-year reserves are available for distribution to future investors, the change in fund reserves represents a payoff to past and future investors. The last term of (6) is thus at the root of intergenerational risk sharing.

Equation (6) highlights that both *cross-sectional* risk sharing and *intergenerational* risk sharing are potentially at play. Investors may be insured against market risk because fluctuations in asset returns are absorbed by the insurer. This mechanism reflects static (cross-sectional) risk sharing between the insurer and investors. The covariation between Π_t and x_t determines how much insurance is provided by the insurer to investors. Alternatively, investors may be insured against market risk because fluctuations in asset returns are absorbed by fund reserves. This mechanism reflects intertemporal (intergenerational) risk sharing between current insurers and past and future investors. The covariation between ΔR_t and x_t determines how much insurance is provided to investors through intergenerational risk sharing. Both risk sharing mechanisms can be at play simultaneously.

Equation (6) can be compared to analogous decompositions of investment returns for other savings products. In traditional savings products like pass-through mutual funds or unit-linked life insurance products, the first term on the right-hand side moves one-for-one with the fund asset return while the second and third terms are zero. In structured savings products like variable annuities with guaranteed returns, only the first two terms on the right-hand side arise as risk is shared between investors and the insurer while the third term is zero.

To quantify the amount of intergenerational risk sharing, we compare investors' payoff to what they would have received in a counterfactual situation with a constant level of reserves, same asset return, and same insurer payoff. Relative to this benchmark, the payoff of investors holding a contract in year t is higher by $-\Delta R_t$. $-\Delta R_t$ represents a transfer from investors holding a contract in year $t' \neq t$ to investors holding a contract in year t. We denote the amount of *InterTemporal Transfer* between investor accounts in year t and investor accounts in other years by

$$\mathcal{ITT}_t = | - \Delta R_t|. \tag{7}$$

The amount transferred across investors is less than the amount transfer across years, because investors hold their contracts for more than one year. Investors may thus receive positive transfers in some years and negative transfers in other years that partially net out. Given the institutional feature that all investors receive the same return up to an investor fixed effect as specified in equation (2), each investor i receives in year t a transfer proportional to her account value and equal to $\frac{-\Delta R_t}{V_{t-1}} V_{i,t-1}$. Thus, investor i buying a contract at the beginning of year t_i^0 and redeeming it at the end of year t_i^1 receives a lifetime net transfer throughout her holding period $\mathcal{H}_i = [t_i^0, t_i^1]$

equal to[9]

$$\sum_{s\in\mathcal{H}_i}\frac{-\Delta R_s}{V_{s-1}}V_{i,s-1}. \tag{8}$$

Finally, the *Annualized Lifetime Transfer* to investor i in year t, calculated as a constant fraction of the beginning-of-year account value $V_{i,t-1}$, is equal to

$$\mathcal{ALT}_{i,t}=\frac{V_{i,t-1}}{\sum_{s\in\mathcal{H}_i}V_{i,s-1}}\sum_{s\in\mathcal{H}_i}\frac{-\Delta R_s}{V_{s-1}}V_{i,s-1}. \tag{9}$$

$\mathcal{ALT}_{i,t}$ is the net transfer in year t to investor i from other generations of investors. We say that two investors $i\neq i'$ belong to the same generation if they have the same holding period and same timing of investment: $V_{i,t}=\kappa V_{i',t}$ for all t. Two investors of the same generation are always on the same side of the redistribution because $\mathcal{ALT}_{i,t}$ and $\mathcal{ALT}_{i',t}$ have the same sign. In contrast, two investors belonging to different generations can be on opposite sides of the redistribution. Therefore, $\mathcal{ALT}_{i,t}$ represents intergenerational transfer. We denote the total amount of *InterGenerational Transfer* in year t by

$$\mathcal{IGT}_t=\sum_i|\mathcal{ALT}_{i,t}|. \tag{10}$$

In Section 5, we shall quantify intertemporal transfer $\mathcal{ITT}_t$, investor lifetime transfer $\mathcal{ALT}_{i,t}$, and intergenerational transfer $\mathcal{IGT}_t$ in the French life insurance market.

4 Data and Summary Statistics

We use annual regulatory filings (*Dossiers Annuels*) that we obtain from the national insurance supervisor (*Autorité de Contrôle Prudentiel et de Résolution*) for the years 1999 to 2015. The data covers all companies with life insurance operations in France. It contains information on all the variables that appear in the analytical framework of the previous section. The information is reported by type of contracts, which allows us to focus on Euro-denominated contracts. We restrict the analysis to stock insurance companies, which represent 97% of aggregate life insurance

[9]Transfers taking place in different years are not discounted differently because (85% of) asset returns are due to investors irrespective of the level of fund reserves, i.e., investors are entitled to the same share of asset returns whether assets are credited to the reserves or to their accounts. It implies that only the total amount of reserves distribution matters, but not its timing within an investor's holding period.

To see it formally, note that the discount factor in the calculation of lifetime net transfer must be chosen such that aggregate lifetime net transfers is equal to zero (or equal to the difference between initial and final level of fund reserves if these are not equal to zero). Denoting the discount factor by ρ_t and summing over all investors: $\sum_i\sum_{t\in\mathcal{H}_i}\rho_t\frac{-\Delta R_t}{V_{t-1}}V_{i,t-1}=\sum_t\rho_t(-\Delta R_t)$. It follows that ρ_t must be constant. The argument can be illustrated with a numerical example. Suppose there is only one investor starting with $V_0=100$ and investing for two years. Asset return net of insurer payoff is 10% in both years. The initial level of fund reserves is $R_0=0$. The first year return $0.1\times100=10$ is entirely hoarded as fund reserves: $A_1=110$, $V_1=100$, and $R_1=10$. In the second year, asset return $0.1\times110=11$ and fund reserves are credited to the investor account: $A_2=V_2=121$ and $R_2=0$. Annual transfer to the investor is $T_1=-10$ in the first year and $T_2=10$ in the second year. Since there is only one investor, her lifetime net transfer should be zero. Since $T_1=-T_2$, it implies that the discount factor is constant.

provisions. We drop insurers with less than 10 million euros of life insurance provision. Because we need lagged values to calculate the change in fund reserves, the sample period of our analysis is 2000–2015. The final sample has 76 insurers and 978 insurer-year observations.

Table 1 reports summary statistics for the main variables associated to Euro-denominated contracts (see Appendix B.1 for details about variable construction). The average (median) insurer has 13.9 (3.1) billion euros of account value. Inflows (premiums), which include cash deposited in newly opened contracts and in existing contracts, represent on average 10.5% of account value per year. Outflows, which include partial and full redemptions, either voluntarily or at expiration of the contract (investor death), represent on average 8.1% of account value per year.

The combination of positive net flows and compounded contract returns generates an increasing trend in aggregate account value plotted in Figure 2. Aggregate account value grows from 505 billion euros in 2000 to 1,200 billion euros in 2015 (all amounts are in constant 2015 euros). Aggregate growth reflects internal growth of existing life insurers rather than entry of new insurers. The number of insurers in the sample is 65 at the beginning of the period and 61 at the end.

Fund reserves represent on average 10.9% of account value, of which about two-third are unrealized gains (7.5%) and one-third are accounting reserves (2.1% of profit-sharing reserves and 1.4% of capitalization reserves). Figure 3 plots the time-series of aggregate reserves as a fraction of account value over time. Reserves fluctuate widely over time, reflecting active reserve management in order to smooth contract return.

On the asset side, 80.4% of the fund portfolio is invested in government and corporate bonds, 13.5% in stocks, and the rest in real estate, loans, and cash. Average asset return is 4.9% per year.

Average contract return before fees is 4.0% per year. The wedge between average asset return and average contract return is due to three factors. First, the insurer can keep up to 15% of asset return, which represents about 75 basis points on average. Second, part of asset returns have been retained to offset the dilution of fund reserves caused by positive net flows over the sample period. Because new investors share in accumulated reserves while leaving investors give up their share of reserves, reserves are mechanically diluted at a rate equal to the net flow rate. Given the average net flow rate of 2.4% per year during the sample period and the average level of fund reserves of 10.9% of account value, reserves have been mechanically diluted at an annual rate of about 0.25% of account value. It implies that insurers would have had to retain about 25 basis points of asset returns per year in order to keep the ratio of reserves to account value constant. Third, as can be seen in Figure 3, the average reserves ratio is actually higher at the end of the period than at the beginning by about 3.5 percentage points. It implies that insurers have retained over this 15-year period an additional $0.035/15 \approx 25$ basis points per year on average.[10]

[10]The sum of the three effects explains a $75 + 25 + 25 = 125$ basis point wedge between asset returns and contract returns, that is, more than the observed one of about 90 basis points. This is because, beyond the approximations made in these back-of-the-envelop calculations, insurers are allowed to keep up to 15% of asset returns but in practice keep less than that, potentially because of competition.

5 Intergenerational Risk Sharing: Evidence

5.1 Intertemporal Smoothing: The Role of Fund Reserves

Figure 1 shows weighted average asset return and contract return from 2000 to 2015. The key pattern is that the contract return is much less volatile than the return of underlying assets. The annual volatility of asset return is 4.4% vs. 0.9% for contract return.

Contract return smoothing can be implemented by two mechanisms reflected in equation (6). Contract return ($y_t V_{t-1}$) can be hedged against variation is asset return ($x_t A_{t-1}$) by offsetting transfers from the insurer (Π_t) or by offsetting transfers from fund reserves (ΔR_t). To visualize graphically the contribution of fund reserves to contract return smoothing, two series are plotted in Figure 4: the difference between contract return and asset return ($y_t V_{t-1} - x_t A_{t-1}$) and transfers from reserves ($-\Delta R_t$), both aggregated across all insurers and normalized by aggregate beginning-of-year account value (V_{t-1}).

Figure 4 shows that almost all of the difference between asset return and contract return is explained by variation in fund reserves. It means that the smoothing of contract return is generated by intertemporal transfer across investor accounts. The next section analyzes the extent to which these intertemporal transfers translate into intergenerational transfers.

5.2 Intertemporal Transfers and Intergenerational Transfers

We now quantify intertemporal transfer $\mathcal{ITT}_t$, investor annualized lifetime transfer $\mathcal{ALT}_{i,t}$, and intergenerational transfer $\mathcal{IGT}_t$ at the insurer level. We focus on the sample of insurers for which we have data throughout 1999–2015, which leads us to make two adjustments to the sample. First, when an insurer is acquired by another one, their reserves are pooled together. In this case, we consolidate both entities into a single one before the acquisition date such that we have a single insurer with a constant perimeter throughout the sample period.[11] Second, we drop a few insurers that enter or exit during the sample period. The final sample has 50 insurers that we observe continuously from 1999 to 2015 and that account for 94% of the aggregate account value in the initial sample. Our estimates of intertemporal transfers and intergenerational transfers are gathered in Table 2.

Variation in fund reserves generates transfer of investor account value across years. $-\Delta R_t$ is the transfer to investor accounts in year t from fund reserves, that is, from investor accounts in years $t' \neq t$. The value-weighted (equal-weighted) average amount of intertemporal transfer $\mathcal{ITT}_t = |-\Delta R_t|$ is equal to 3.7% (4.2%) of total account value. Evaluated at the 2015 level of aggregate account value of 1,200 billion euros, it amounts to an annual 44 billion euros that shifts from year to year on average, or 2% of GDP.

[11] We apply this procedure for six acquisitions: *Natio* by *Cardif* in 2005, *Generali Assurances*, *GPA*, and *Guardian* by *Generali* in 2006, *Ecureuil* by *CNP* in 2007, and *Assurances Banque Populaire* by *Natixis Assurances* in 2013.

Investor annualized lifetime transfer is smaller than intertemporal transfer, because investors hold their contract for several years and thus receive positive transfers in some years and negative transfers in other years that partially net out over the holding period. To visualize how the annualized lifetime transfer $\mathcal{ALT}_{i,t}$ given by equation (9) depends on the holding period, Table 3 displays its value for the average contract and for every possible holding period $[t^0, t^1]$ during our sample period, $2000 \leq t^0 \leq t^1 \leq 2015$. We do the calculation for an investor who holds the representative contract with underlying fund reserves equal to the value-weighted average level of fund reserves, and invests a constant amount $V_{i,t} = 100$ by withdrawing the interests paid at the end of each year.

Table 3 is displayed as a heatmap. The numbers in the heatmap should be interpreted as the additional annual returns of having invested in the representative contract relative to having invested in a fund that (a) is invested in the same portfolio of assets but (b) do not smooth investor returns with reserves. For instance, the counterfactual can be an investment in a unit-linked contract that would be invested in the same asset portfolio as the Euro-denominated contract.

Transfers for holding periods spanning the 2008 stock market crash and the 2011 sovereign debt crisis tend to be positive. The poor asset returns in these years were offset by large transfers from fund reserves. For instance, an investor buying a contract at the beginning of 2006 and redeeming it at the end of 2011 received an extra return of 1.5 percentage points per year on her contract relative a counterfactual with no reserve management. Taking an ex-post perspective, these investors have been net beneficiaries of the intergenerational redistribution implemented by life insurance.

Transfers for holding periods spanning the recent period of low interest rates are negative. Drops in interest rates led to high bond returns that were not credited to investor accounts, but hoarded as reserves. This hoarding behavior can be seen on Figure 3, which shows that fund reserves increased from 2% of account value in 2011 to 18% of account value in 2015. This makes exit from life insurance contracts in the post-2011 low interest rate environment detrimental compared to the counterfactual with constant reserves. Investors who have redeemed their contracts during this period have been ex-post net contributors of the intergenerational redistribution mechanism.

The high level of fund reserves in 2015 also suggests that insurers might draw on their reserves in the coming years to pay investors returns above market returns, which might be low given the currently low level of interest rates and the potential for an increase in interest rates. In this scenario, the heatmap for holding periods spanning the years to come might turn green again.

The last step is to aggregate individual annualized lifetime transfers $\mathcal{ALT}_{i,t}$ at the insurer level to calculate the amount of intergenerational transfer $\mathcal{IGT}_t$ given by equation (10). A back-of-the-envelop calculation illustrates the relation between intertemporal transfer $\mathcal{ITT}_t$ and intergenerational transfer $\mathcal{IGT}_t$. Suppose intertemporal transfer $\mathcal{ITT}_t$ is i.i.d. and normally distributed with zero mean and all investors have T year-holding periods. Then, expected intergenerational transfer is equal to $1/\sqrt{T}$ of expected intertemporal transfer. During the sample period, the average outflow rate is 8.1%, which implies an average duration of 12 years and an average amount of intergenerational transfer of $3.7\%/\sqrt{12} = 1.1\%$ per year. Accounting for holding period heterogeneity would lead to a higher estimate because of the convexity of $1/\sqrt{T}$.

To have an exact measure of intergenerational transfer, we would need to observe the entire investment history $V_{i,t}$ of all investors. This is not possible since the investment histories of current investors still holding a contract are not over. There are two other data limitations. First, the regulatory data starts in 1999, so we do not observe the entire investment history of investors who entered their contract before 1999 even if they no longer hold a contract in 2015. It implies that we can calculate annualized lifetime transfer $\mathcal{ALT}_{i,t}$ for investors with holding periods within 2000–2015 (we need one lagged year to calculate asset returns). Second, we observe inflows and outflows at the insurer level but not at the investor level. It implies that we know the average holding period but not its entire distribution. To calculate $\mathcal{IGT}_{i,t}$, we assume that the outflow rate is constant across contract age at the insurer-year level and that investors only make one-off investments. Formally, denoting by $V_t(t^0)$ the total account value of contracts subscribed in year t^0, we assume $V_t(t^0) = (1 - \phi_t)(1 + y_t)V_{t-1}(t^0)$ for all $t^0 < t$, where the outflow rate ϕ_t is calculated to match observed outflows at the insurer level: $\sum_{t^0<t} \phi_t(1 + y_t)V_{t-1}(t^0) = Outflow_t$; and account value of new contracts is calculated to match observed inflows at the insurer level: $V_t(t) = Inflow_t$.[12] Under this assumption, we can reconstruct the investment history of all generations of investors and calculate the intergenerational transfer amount $\mathcal{IGT}_t$.

The value-weighted (equal-weighted) amount of intergenerational transfer is equal to 1.4% (1.5%) of account value. Evaluated at the 2015 level of aggregate account value of 1,200 billion euros, it amounts to an annual 17 billion euros that shifts across generations of investors on average, or 0.8% of GDP.

The assumption of outflow rates independent of contract age is likely to under-estimate the amount of intergenerational transfer. Actual outflow rates are decreasing in contract age (FFSA-GEMA (2013)). It implies that the actual dispersion of holding periods is higher than the dispersion obtained under the assumption of age-independent outflow rate, for a given average holding period that we match to the observed one of 12 years. Since expected annualized life transfer is convex in the holding period, under-estimating the dispersion of holding periods leads to under-estimating intergenerational transfer.

6 Contract Return Predictability and Investor Flows

As argued by Stiglitz (1983), competitive markets cannot implement intergenerational risk sharing because it requires future generations to share risk occurring before they start participating in the market. Gordon and Varian (1988) show that generations born after periods of low market

[12] These formulas assume that inflows and outflows take place at year-end whereas in practice they occur throughout the year. To take this into account, we use modified formulas that account for interests accrued during the year. See Appendix B.2 for details.

returns may be worse off in the intergenerational risk sharing scheme, because they expect to be net contributors to the scheme to rebuild depleted reserves. Even if the government or a monopolistic intermediary implements a mechanism that achieves intergenerational risk sharing, Allen and Gale (1997) show that it would be undone by competition from financial markets.

The implication of these results is that the implementation of intergenerational risk sharing requires some market friction making investor flows imperfectly elastic to futures returns. An extreme form of friction is mandatory household participation in the risk sharing scheme, which solves the problem that later generations would not agree to share in past losses in a competitive market. Ball and Mankiw (2007) and Gollier (2008) characterize the socially optimal allocation in such environments. The model of Gollier (2008) is particularly relevant, because it fully characterizes the optimal reserves management of a fund that resembles life insurance funds, except that flows are exogenous in the model. Less extreme forms of frictions such as search costs or horizontal differentiation across insurers, can also make investor flows imperfectly elastic to future contract returns. In this case, even if the level of fund reserves predicts future contract returns, as it does in the optimum characterized by Gollier (2008), investor flows would only partially respond to these predictable returns, thereby sustaining return predictability in equilibrium and enabling intergenerational redistribution.

Given the evidence in Section 5 that sizeable intergenerational redistribution is taking place, we expect that (i) the level of fund reserves predicts future contract returns but that (ii) investor flows are imperfectly elastic to these predictable returns. We test (i) in Section 6.1 and 6.2 and (ii) in Section 6.3.

6.1 Contract Return Policy

In this section, we investigate how insurers choose contract returns at the end of each year, or equivalently, the amount of reserves they carry forward to the next year. Our analysis is guided by the model of Gollier (2008), who solves for the reserves policy that achieves first best intergenerational risk sharing. At the first best, investor return depends on the level of fund reserves but not on current asset return beyond its effect on reserves. The intuition behind this result is similar to the one for the permanent income hypothesis, according to which the optimal level of consumption depends only on wealth and not on current income beyond its effect on wealth. Conversely, when there is no intergenerational risk sharing as in a pass-through mutual fund, investor return is equal to current asset return.

We study the contract return policy by running panel regressions at the insurer-year level. We regress the contract return chosen at the end of the year by the insurer, on the end-of-year level of reserves just before investor accounts are credited the annual return, normalized by total account value. The regressor is thus equal to the beginning-of-year level of reserves plus the current year asset return (see equation (6)). Using the notations of Section 3, we regress y_t on $\frac{1}{V_{t-1}}(R_{t-1} + x_t A_{t-1})$.

We include insurer fixed effects and year fixed effects and double-cluster standard errors by insurer and year.

Table 4 shows the results for regressions weighted by the insurer share of account value in aggregate account value in the current year.[13] The coefficient on end-of-year reserves in column (1) is positive and statistically significant at the 1% level. The point estimate implies that a one percentage point increase in fund reserves is associated with a 2.9 basis point increase in annual contract return. In other words, out of each additional euro of fund reserves, 2.9 cents per year are credited to investor accounts. At this rate, holding everything else constant, the distribution of the marginal euro of fund reserves to investors would be spread over the next $1/0.029 = 35$ years.

Under first best intergenerational risk sharing, the contract return should only depend on the current asset return through its effect on the level of reserves. If we decompose the year-end level of reserves into beginning-of-year reserves plus current asset return, the contract return should depend on both components equally. To see whether this holds, we include both terms separately in the regression. The results in column (2) show that the relation between contract returns and end-of-year reserves is not driven by current asset returns. Instead, the coefficient on lagged reserves is positive and significant while the coefficient on current asset return is positive but insignificant. The relationship between contract returns and reserves is therefore in line with optimal intergenerational risk sharing.

6.2 Contract Return Predictability

The result that contract returns paid at the end of year are positively related to the level of reserves at the beginning of the year suggests that contract returns are predictable. To test this more formally, we regress contract return on the beginning-of-year level of reserves alone. The coefficient reported in column (3) of Table 4 is still positive, statistically significant at the 1% level, and close to the coefficient on the end-of-year level of reserves in column (1). This result is still not evidence of predictability because the regression includes insurer fixed effects that are estimated over the entire sample period. We remove insurer fixed effects in column (4) and still find a positive coefficient, statistically significant at the 1% level, that is close to the estimate with insurer fixed effects.

To gauge the economic magnitude of contract predictability, we calculate the profitability of a hypothetical long/short portfolio buying contracts of insurers with a high level of reserves and selling contracts of insurers with a low level of reserves. At the beginning of each year, we rank insurers based on their beginning-of-year level of reserves and rescale the rank such that it lies between -1 and 1. The portfolio weights are proportional to the rescaled rank (multiplied by total account value in order to obtain value-weighted returns). Panel A of Table 5 shows the performance of the long/short portfolio. The average return is 34 basis points per year with a t-statistics above

[13] The results for equal-weighted regressions are overall similar and reported in Appendix C.

10. The standard deviation is 13 basis points per year, yielding a Sharpe ratio of 2.6. The market beta of the portfolio is essentially zero, yielding a market-model alpha of 33 basis points per year.

The long/short portfolio is of course not tradable as life insurance contracts cannot be shorted. Its return has nevertheless a relevant economic interpretation. Consider an investor holding a contract with a low level of reserves and considering switching to another insurer with a high level of reserves. The expected gain from doing so is equal to the expected return of the long/short portfolio (ignoring exit fees for now). More precisely, given the linear weighting of the long/short portfolio, its return is equal to the weighted average gain from switching from an insurer with below-median reserves to an insurer with above-median reserves, where the average is taken across all pairs of below-median/above-median insurers and each pair is weighted by the product of the absolute value of both insurers' ranks (multiplied by the products of their total account value to obtain value-weighted returns).[14]

The risk of switching from an insurer with low reserves to an insurer with high reserves is, however, higher than the risk of the long/short portfolio because idiosyncratic contract risks are not diversified. Intuitively, going long one contract and short one contract yields the same expected return but with a higher standard deviation than taking long or short positions in all contracts. To compare the risks of these strategies, we consider portfolios composed of one long position in a contract of an insurer with above-median reserves and one short position in a contract of an insurer with below-median reserves. We calculate the average and standard deviation of returns across all portfolio-year observations associated to all long one contract/short one contract portfolios, using the weighting scheme described in the previous paragraph.

Panel B of Table 5 shows the performance of long one contract/short one contract portfolios. As explained above, the average return of these portfolios is by construction equal to the average return of the long/short portfolio including all contracts. As expected, the standard deviation is higher, because idiosyncratic contract risk is not diversified. The standard deviation is 70 basis points per year, yielding a Sharpe ratio of 0.49. Thus, while switching from a contract with low reserves to a contract with high reserves is profitable on average, it is not a risk-free arbitrage.

Another approach to evaluate the risk-return tradeoff when switching from contract L with low reserves to contract H with high reserves, is to recognize that investors may not care about the riskiness of the return difference $y_H - y_L$, but may rather care about the difference in riskiness of y_H relative to that of y_L. Panel C of Table 5 shows the average and standard deviation of returns for contracts with above-median reserves and for contracts with below-median reserves, using the same

[14]Proof: Denoting by i and j the scaled ranks of the below-median insurer and above-median insurer, respectively, and by V_i and V_j their total account value, the weighted average is equal to

$$\frac{\sum_{i<0<j}(-i)jV_iV_j(y_j-y_i)}{\sum_{i<0<j}(-i)jV_iV_j} = \frac{\sum_{i<0}(-i)V_i\sum_{j>0}jV_jy_j - \sum_{i<0}(-i)V_iy_i\sum_{j>0}jV_j}{\sum_{i<0}(-i)V_i\sum_{j>0}jV_j} = \frac{\sum_{j>0}jV_jy_j}{\sum_{j>0}jV_j} - \frac{\sum_{i<0}(-i)V_iy_i}{\sum_{i<0}(-i)V_i},$$

where the first term is the return on the long leg of the portfolio and the second term is the return on the short leg.

weights as above, as well as the difference in the mean and standard deviation of returns between the two groups. By construction, the difference in means is still 34 basis points. The difference in standard deviation is 4 basis points, which is small compared to the pooled standard deviation of about 90 basis points. Thus, the risk-return tradeoff seems unambiguously favorable to contracts with high reserves.

6.3 Flow-Reserves Relationship

In this section, we study whether investor flows respond to the level of fund reserves. Net flows can be decomposed into three components: (+) inflows (premia), which can come from existing investors depositing more money on their account or from new investors; (−) redemptions, which are voluntary outflows; (−) payments at expiration of contracts (investor death), which are involuntary outflows. The latter should a priori not respond to fund reserves, while the former two may. One may also expect inflows to be more sensitive to the level of reserves than redemptions, if redemptions are more likely to be driven by liquidity motives.

Table 6 shows the results of panel regressions of flows on beginning-of-year reserves for the three component of flows taken separately as well as for total net flows. Panel A reports the results using the full sample of insurers. In Panel B, we exclude insurers that enter during the sample period because the dynamics of inflows is likely to be different out of steady state. While the effect of reserves on inflows is not significantly different from zero in the entire sample (Panel A, column (1)), it is positive and statistically significant at the 10% level when we exclude insurers entering during the sample period (Panel B, column (1)). The point estimate implies that one additional euro of fund reserves leads on average to 6.3 cents of additional inflows per year. In contrast, the effect of reserves on outflows coming from redemptions (column (2)) and at contract expiration (column (3)) are not significantly different from zero. The total effect of fund reserves on net flows reported in column (4) is positive but not statistically significant (p-value equal to 0.18 in the sample excluding entrants).

Overall, the sensitivity of flows to the level of fund reserves is, at best, weak. Even focusing on inflows in the sample excluding entrants, where the relationship is statistically significant at conventional levels, the magnitude is small. A one-standard deviation increase in the level of fund reserves is associated with a 0.1 standard deviation increase in inflows. It suggests that fund reserves will not be immediately diluted by investor flows. We analyze this issue more formally in the following section.

6.4 Cost-Benefit Analysis of Switching Insurer

Why don't investors flow more aggressively into insurers with large reserves? In this section, we estimate the costs and benefits of switching from an insurer with low reserves to another insurer with a higher level of reserves. The benefits depend on the predictive power of reserves for returns, the speed at which predictability decays over time, and the investor's holding period. The costs come from fees.

Benefits Consider an investor switching at the beginning of year t from insurer L with a ratio of reserves to account value r_L to insurer H with a higher reserves ratio $r_H > r_L$. The estimates in Table 4 imply that doing so generates an expected return of $0.03 \times (r_H - r_L)$ at a one year horizon. The expected return at a longer horizon depends on the speed at which the predictive power of reserves decays. Intuitively, the predictive power should decay at the rate at which the reserves ratio mean reverts. The reserves ratio mean reverts for two reasons. First, because reserves are progressively credited to investors' account. Second, because inflows dilute reserves, at a rate that depends both on the unconditional level of net flows and on the sensitivity of net flows to the level of reserves.

We make several assumptions to calibrate these effects using the regression estimates. First, as estimated in Table 4, we assume that the contract return is a linear function of end-of-year reserves just before distribution - and denote the slope as $\partial y/\partial r$. Second, as estimated in Table 6, we assume that flows are a linear function of beginning-of-year reserves - and denote the slope as $\partial f/\partial r$. Finally, we assume that asset returns are i.i.d. and independent from past contract returns and past reserves. Then, for small deviations of the reserves ratio $r_t \equiv R_t/V_t$ around its unconditional mean, the reserves ratio mean reverts at an expected rate equal to

$$\delta \equiv -\frac{\partial}{\partial r_t} E[r_{t+1} - r_t] \approx \frac{\partial y}{\partial r} + \overline{f} + \frac{\partial f}{\partial r} \times \overline{r}, \tag{11}$$

where $\overline{f}$ is the average net flow rate and $\overline{r}$ is the average reserves ratio.[15]

The first term of equation (11) reflects that distribution of reserves to investors reduces the reserves ratio at a rate equal to the distribution rate, i.e. at 3% per year (Table 4).

The second term in (11) reflects that positive net flows dilute reserves at a rate equal to the unconditional net flow rate (i.e., expected net flows when reserves are equal to their unconditional mean, both normalized by account value). Average net flows are equal to 2.4% of account value (Table 1).

The third term in (11) reflects reserves dilution induced by the sensitivity of flows to reserves. Intuitively, starting from the unconditional level of reserves, if an increase in the level of reserves attracts flows and thereby the total account value, this reduces the ratio reserves/account value through the denominator. The reduction is equal to the flow-reserves sensitivity times the initial reserves/account value ratio. The upper bound for the flow-reserves sensitivity is 6% per year (Table 6). The average level of reserves is 11% of account value (Table 1). Reserves-induced flows

[15] See Appendix D for detailed calculation.

thus dilute extra reserves at a rate no larger than $0.06 \times 0.11 < 1\%$ per year. Reserves dilution by reserves-induced flows is small because flows barely respond to the level of reserves. For reserves to be fully diluted by investor flows at a one year horizon, the flow-reserves sensitivity would need to be equal to $1/0.11 = 9$, i.e., more than a hundred times larger than it is in the data. To put this number in perspective, it would require that a one standard deviation increase in reserves leads to flows equal to 15 times the sample standard deviation.

Reserves thus mean revert at a rate of $\delta \approx 6\%$ per year. Since expected contract returns depend on the current level of reserves, expected future contract returns conditional on the current level of reserves should mean revert at the same rate as reserves:

$$\frac{\partial}{\partial r_t} E[y_{t+\tau}|r_t] = (1-\delta)^\tau \frac{\partial}{\partial r_t} E[y_t|r_t]. \tag{12}$$

Table 7 shows evidence that expected returns indeed mean revert at rate of about 6% per year. We regress annual contract returns in years t, $t+1$, $\dots t+4$, on the level of reserves at the beginning of year t. The specification in column (1) for contract return in year t is thus the same as the one in column (4) of Table 4. The coefficients in columns (2) to (5) decay at a rate between 6% and 9% per year.

Since the market beta of the long high-reserves/short low-reserves portfolio is zero in Table 5, we use the risk-free rate to calculate the present value of moving one euro from an insurer with a low reserves ratio, r_L, to an insurer with a high reserves ratio, r_H. Denoting by θ the outflow rate, this present value is

$$\sum_{\tau=1}^{+\infty} \frac{(1-\theta)^\tau}{(1+r_f)^\tau}(1-\delta)^\tau \frac{\partial y}{\partial r}(r_H - r_L) \approx \frac{\frac{\partial y}{\partial r}(r_H - r_L)}{r_f + \theta + \delta}, \tag{13}$$

where r_f is an averaged risk-free rate across the yield curve. Using $\partial y/\partial r = 0.03$ (Table 4), $\delta = 0.06$ (previous calculation), $\theta = 0.081$ (Table 1), $r_f = 0.03$, $r_H - r_L = 0.068$ (one standard deviation, Table 1), the present value is 1.2 cents.

Costs The cost of switching insurer comes from fees. Insurers do not charge entry fees (front-end loads) but they charge exit fees (back-end loads).

In progress: We are currently in the process of obtaining data on fees.

Casual observation suggests that exit fees are of the order of 3% of the withdrawn amount. Thus, it does not seem profitable to switch from a contract with low reserves to a contract with higher reserves as the expected gain is offset by fees.

7 Concluding Remarks

We show that Euro-denominated life insurance contracts, which are the most widespread type of life insurance products in Europe, achieve large amount of intergenerational redistribution in France. Using regulatory and survey data from the national supervisor, we estimate that the average transfer across generations of investors is 1.4% of total account value per year, or 0.8% of GDP. Allen and Gale (1997)'s result that intergenerational risk sharing cannot be implemented in perfectly competitive markets does not apply, suggesting the presence of market frictions. We provide evidence of such friction in the form of exit fees, which prevent investors from exploiting the predictability of contract returns induced by return smoothing.

Intergenerational risk sharing is unique to Euro-denominated contracts, which use reserves to smooth returns across generations of investors. This is in contrast to pass-through savings products like mutual funds and unit-linked life insurance contracts. Euro-denominated contracts also stand in contrast to variable annuities with guaranteed returns sold by life insurers (Koijen and Yogo (2018)) in the US and structured savings products sold by banks in Europe and the US (Célérier and Vallée (2017)), because they generate insurance against aggregate risk through intergenerational risk sharing whereas the latter types of products implement purely cross-sectional risk sharing. This specificity of Euro-denominated contracts suggests that an aggregate shift from these contracts to unit-linked contracts would change the pattern of aggregate risk sharing in the economy, possibly to a sizeable extent given the large aggregate amount of intergenerational transfers we estimate. An additional potential benefit of intergenerational risk sharing is that it may allow insurers to hold more risky assets, as risk is better shared (Gollier (2008)). We plan to study these issues in future research.

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Figure 2: Aggregate Account Value. The solid blue line aggregate account value of Euro-denominated contracts in billion 2015 euros. The dashed red line is the number of insurers in the sample.

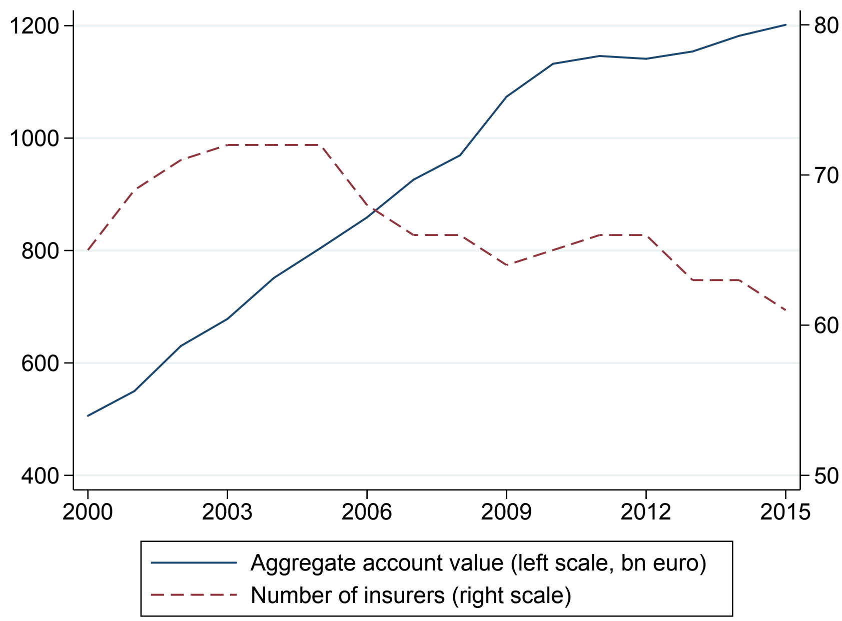


Figure 3: Fund Reserves. The figure shows aggregate fund reserves as a fraction of account value (solid blue) and the breakdown into the three components of reserves: unrealized gains (long dashed red), profit-sharing reserves (dashed green), and capitalization reserves (short dashed orange).

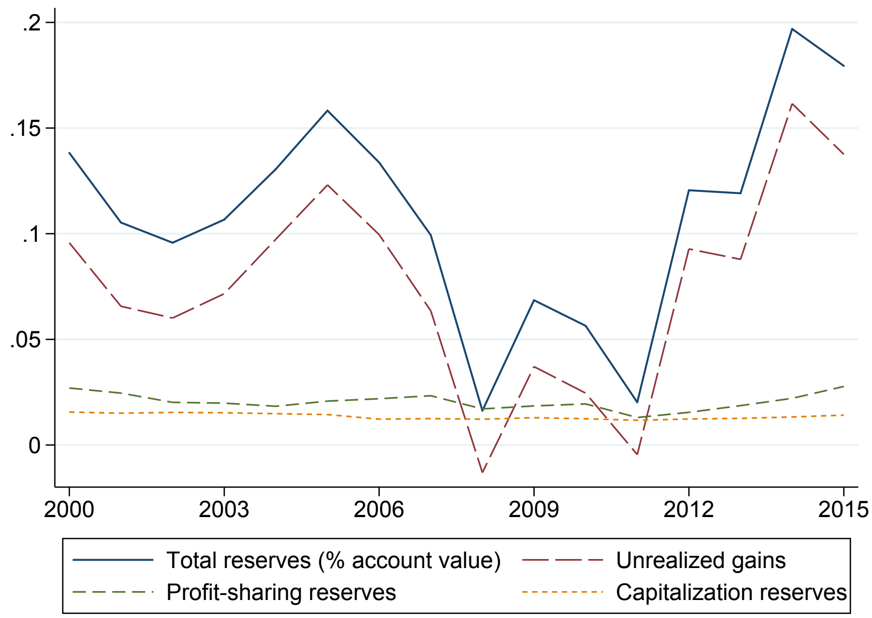


Figure 4: Fund Reserves Absorb Asset Return Fluctuations. The figure shows the difference between aggregate contract return and asset return normalized by account value $(y_t V_{t-1} - x_t A_{t-1})/V_{t-1}$ (solid blue) and aggregate transfers from reserves normalized by account value $-\Delta R_t/V_{t-1}$ (dashed red).

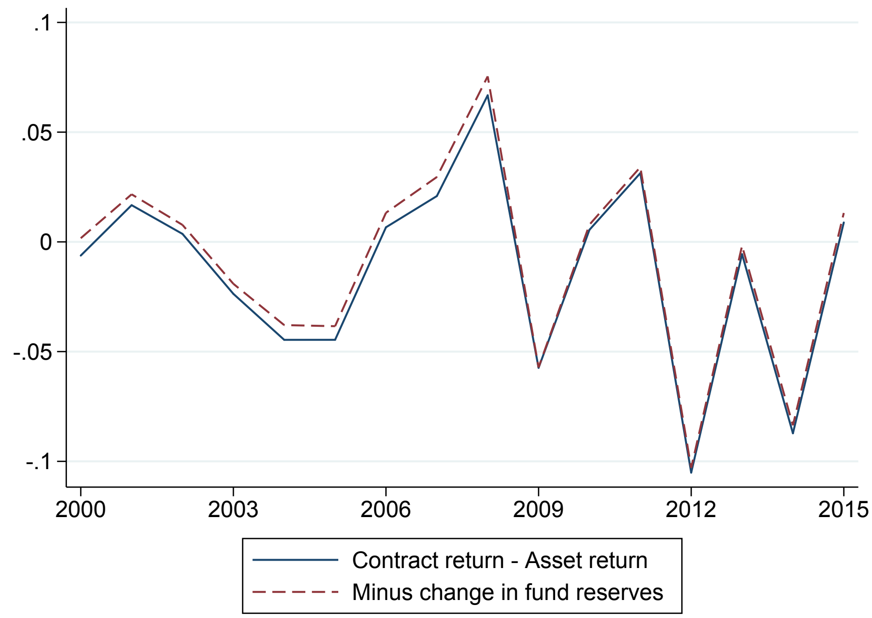


Table 1: Summary Statistics at the insurer-year level for 76 insurers over 2000–2015. All statistics (except for account value) are weighted by the insurer share in aggregate account value in the current year (see Appendix Table C.1 for unweighted summary statistics). *Account value* is total account value at year-end in constant 2015 billion euros. *Inflows* are inflows (premia) divided by beginning-of-year account value plus one-half of net flows. *Outflows* are outflows (redemptions plus payment at contract expiration) divided by beginning-of-year account value plus one-half of net flows. *Total fund reserves* is total fund reserves divided by year-end account value; it is made up of three components. *Profit-sharing reserves* is the profit-sharing reserves amount divided by year-end account value. *Capitalization reserves* is the capitalization reserves amount divided by year-end account value. *Unrealized gains* is the amount of unrealized capital gains divided by year-end account value. *Share bonds* is the share of (corporate and sovereign) bonds, held either directly or through funds, in the asset portfolio. *Share stocks* is the share of stocks, held either directly or through funds, in the asset portfolio. *Asset return* is the asset return. *Contract return* is the average contract return.

	Mean	Median	Std.Dev.	N
Account value (bn euro)	13.9	3.1	30.1	978
Inflows (% account value)	10.5	10.5	3.8	978
Outflows (% account value)	8.1	7.9	2.0	978
Total fund reserves (% account value)	10.9	10.5	6.8	978
Profit-sharing reserves (% account value)	2.1	1.7	1.3	978
Capitalization reserves (% account value)	1.4	1.1	1.0	978
Unrealized gains (% account value)	7.5	7.1	6.1	978
Share bonds (%)	80.4	81.5	8.0	978
Share stocks (%)	13.5	12.5	6.3	978
Asset return (%)	4.9	4.4	4.4	978
Contract return (%)	4.0	4.0	0.9	978

Table 2: InterTemporal Transfers and InterGenerational Transfers. *InterTemporal Transfer* is given by equation (7) and is equal to the absolute value of the change in fund reserves, divided by total account value. *InterGenerational Transfer* is given by equation (10) and is equal to the sum of lifetime net transfer across all investors, divided by total account value.

	Value-weighted average	Equal-weighted average
InterTemporal Transfer (% account value)	3.7	4.2
InterGenerational Transfer (% account value)	1.4	1.5

Table 3: Annualized Lifetime Transfer as Function of Holding Period. The table reports $\mathcal{ALT}_{i,t}$ given by equation (9) for an investor buying the representative contract at the beginning of year t^0 (rows) and redeeming it at the end of year t^1 (columns). Reading: An investor buying a contract at the beginning of 2006 and redeeming it at the end of 2011 has received an additional 1.5 percentage points per year relative to an investment in a fund or a unit-linked contract that would be invested in the same portfolio of assets but would not smooth investor returns with reserves.

entry year \ exit year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2000	0.2	1.1	0.6	0	−0.7	−1.2	−0.9	−0.5	0.4	−0.2	−0.2	0.1	−0.7	−0.6	−1.1	−1
2001		2	0.8	−0.1	−0.9	−1.5	−1.1	−0.6	0.4	−0.3	−0.2	0.1	−0.7	−0.7	−1.2	−1.1
2002			−0.4	−1.2	−1.9	−2.4	−1.7	−1.1	0.2	−0.6	−0.4	0	−1	−0.9	−1.5	−1.3
2003				−2	−2.6	−3	−2	−1.2	0.2	−0.6	−0.4	0	−1.1	−1	−1.6	−1.4
2004					−3.2	−3.5	−2	−1	0.7	−0.4	−0.2	0.2	−1	−0.9	−1.5	−1.3
2005						−3.8	−1.4	−0.2	1.7	0.2	0.3	0.7	−0.7	−0.6	−1.4	−1.1
2006							0.9	1.6	3.5	1.2	1.1	1.5	−0.2	−0.2	−1.1	−0.8
2007								2.2	4.8	1.3	1.1	1.6	−0.4	−0.4	−1.4	−1.1
2008									7.5	0.9	0.8	1.4	−0.9	−0.8	−1.9	−1.5
2009										−5.7	−2.6	−0.6	−3	−2.5	−3.4	−2.7
2010											0.6	2	−2.1	−1.6	−3	−2.2
2011												3.4	−3.5	−2.4	−3.8	−2.8
2012													−10.4	−5.3	−6.3	−4.3
2013														−0.2	−4.2	−2.4
2014															−8.2	−3.4
2015																1.4

Table 4: Contract Returns. Panel regressions at the insurer-year level weighted by insurer share in aggregate account value in the current year. *Contract return* is the annual before-fees contract return chosen at the end of the calendar year. *Lagged reserves* is the beginning-of-year level of reserves normalized by total account value. *Asset return* is annual asset return. Standard errors double-clustered by insurer and year are reported in parenthesis. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

	Contract return			
	(1)	(2)	(3)	(4)
Lagged reserves + Asset return	.029***			
	(.008)			
Lagged reserves		.035***	.03***	.026***
		(.0077)	(.0064)	(.0075)
Asset return		.017		
		(.011)		
Insurer FE	✓	✓	✓	
Year FE	✓	✓	✓	✓
Adjusted-R2	.8	.81	.8	.69
Observations	978	978	978	978

Table 5: Long/Short Portfolio Returns. Panel A shows the performance of a portfolio long all contracts with beginning-of-year reserves above median and short all contracts with beginning-of-year reserves below median with portfolio weights proportional to the contract rank rescaled between minus one and one times the contract's total account value. Panel B shows the weighted average and standard deviation of portfolio-year-level returns for all portfolios long one contract with beginning-of-year reserves above median and short one contract with beginning-of-year reserves below median, where the weights are equal to the product of the absolute value of both contracts' ranks times the products of their total account value.

Panel A: Portfolio long all contracts with above-median reserves/
short all contracts with below-median reserves

Mean return	S.d. return	Sharpe ratio	Market model	
			α	β
.0034	.0013	2.6	.0033	.0025
(.00032)			(.0003)	(.0013)

Panel B: All portfolios long one contract with above-median reserves/
short one contract with below-median reserves

Mean return	S.d. return	Sharpe ratio
.0034	.0070	.49
(.00032)		

Panel C: Contracts with above-median reserves
vs. contracts with below-median reserves

	Mean return	S.d. return
Above-median reserves	.042	.0087
Below-median reserves	.039	.0091
Difference	.0034	−.0004

Table 6: Investor Flows. Panel regressions at the insurer-year level weighted by insurer share in aggregate account value in the current year. In Panel A, all insurers are included. In Panel B, only insurers already active in 1999 are included. *Inflows* is total premia normalized by total account value. *Redemptions* is voluntary redemptions normalized by total account value. *Expiration* is involuntary redemptions at contract expiration (investor death) normalized by total account value. *Net flows* is Inflows − Redemptions − Expiration. *Lagged reserves* is the beginning-of-year level of reserves normalized by total account value. Standard errors double-clustered by insurer and year are reported in parenthesis. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

Panel A: All insurers

	Inflows (1)	Redemptions (2)	Expiration (3)	Net flow (4)
Lagged reserves	.037	-.014	.012	.043
	(.035)	(.019)	(.0096)	(.036)
Insurer FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Adjusted-R2	.75	.77	.84	.65
Observations	978	978	978	978

Panel B: Excluding entrants

	Inflows (1)	Redemptions (2)	Expiration (3)	Net flow (4)
Lagged reserves	.063*	.0082	.0036	.058
	(.036)	(.013)	(.0091)	(.041)
Insurer FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Adjusted-R2	.76	.75	.84	.67
Observations	839	839	839	839

Table 7: Term Structure of Contract Returns. Panel regressions at the insurer-year level weighted by insurer share in aggregate account value in the current year. *Contract return* is the annual before-fees contract return chosen at the end of calendar years t (column 1), $t+1$ (column 2), ..., $t+4$ (column 5). *Reserves* is the level of reserves at the beginning-of-year t normalized by total account value. Standard errors double-clustered by insurer and year are reported in parenthesis. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

	Contract return				
	year t (1)	year $t+1$ (2)	year $t+2$ (3)	year $t+3$ (4)	year $t+4$ (5)
Reserves beginning of year t	.026***	.024***	.023**	.02**	.019*
	(.0075)	(.0073)	(.0078)	(.0087)	(.0089)
Insurer FE					
Year FE	✓	✓	✓	✓	✓
Adjusted-R2	.69	.71	.62	.61	.57
Observations	978	859	783	717	645

A Additional Material on Institutional Framework

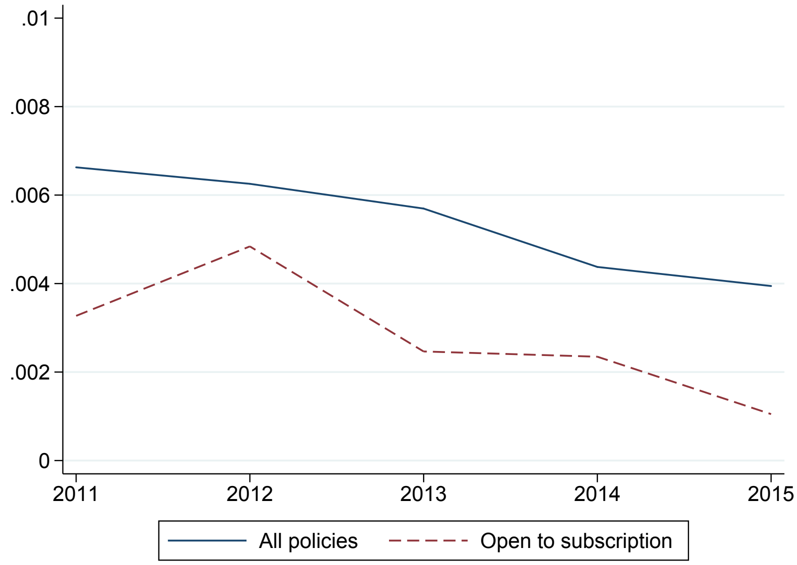
A.1 Minimum Guaranteed Returns

This appendix present summary statistics on minimum guaranteed returns and the fraction of contracts whose returns is at the guaranteed minimum. We use data from a survey of contract returns (*Enquête Revalo*) run by the insurance supervisor that collects information at the product level. Insurers are required to report for every life insurance product they have sold in the past and that still has in-force contracts the following information: product name, contract category, date of first commercialization, minimum guaranteed rate, a dummy variable indicating whether the product is open to new subscriptions; and the value at the end of the survey year and of the previous year of the following variables: number of in-force contracts, total account value, and contract return. The survey has been run for all the years from 2011 to 2015.

Panel A of Figure A.1 plots the average minimum guaranteed rate (weighted by contract account value) for each survey year for all the contracts (solid blue line) as well as for the subset of contracts still open to new subscriptions (dashed red line). Panel B of Figure A.1 plots the fraction of contracts with a return strictly above the minimum guaranteed rate (weighted by contract account value).

Figure A.1: Minimum guaranteed returns. Panel A shows the weighted average minimum guaranteed return for all in-force contracts (solid blue) and for the subset of contracts still open to new subscriptions (dashed red). Panel B shows the fraction of contracts with a return strictly above the minimum guaranteed return.

Panel A: Average guaranteed return



Panel B: Fraction of contracts with non-binding minimum return

A.2 Return Dispersion Across Contracts

In this appendix, we study the dispersion of contract return across contracts sold by the same insurer. In particular, we want to assess whether one of the following describes the data accurately: (a) contract return is constant across all contracts sold by the same insurer; (b) contract return is constant up to a contract-specific fixed effect. The goal of this test is to determine whether assuming a constant return across contracts (up to a constant in case (b)) is a good approximation of the extent of intertemporal return smoothing experienced by investors. The answer is yes if fluctuations in contract return is the same across all contracts of the same insurer (i.e., (a) or (b) hold) whereas the answer is no if there is significant idiosyncratic fluctuations in contract returns. To test (a), we study whether the dispersion of contract returns in the cross-section of contracts is small relative to the time-series dispersion of contract returns. To test (b), we calculate the cross-sectional dispersion after controlling for a product-specific fixed effect.

To compute the time-series dispersion, we use the regulatory data from 1999 to 2015 and we restrict the sample to insurers that we observe throughout the sample period. First, we calculate the average contract return at the insurer-year level. Then, we compute the time-series standard deviation of this variable at the insurer level. Finally, we take the average across all insurers. The time-series standard deviation of annual contract returns is 0.97 percentage points.

To compute the cross-contract dispersion, we use data from the contract return survey described in Appendix A.1, which contains return information at the product level. The data does not include a unique product identifier to track a given product across survey years, which we will need to test whether contract return is well explained by a product fixed effect. We construct a unique product identifier using the following procedure:

- We match contracts on name, contract category, date of first commercialization, and minimum guaranteed rate across the five waves of the survey. We refer to the resulting level of observation as a product.

- If a product has several observations in a given year, we check whether they all have the same contract return. If not, we drop all the observations associated with this product-year. If yes, we collapse them into a single product-year observation by summing account values across observations.

- We drop products with gaps in their time-series.

- For each pair of subsequent years of a product, we check whether the lagged values of account value and contract return reported in the survey for year t match the current values reported in the survey for year $t-1$. When the discrepancy is larger than 1% for at least one of the two variables, we drop all the years associated with the product.

This procedure allows us to assign a unique product identifier for 71% of account value.

To test for condition (a), we calculate the value-weighted standard deviation of contract return across products at the insurer-year level. Then, we take the average over all insurer-year observations. The cross-contract standard deviation of annual contract returns is 0.30 percentage points. The dispersion of returns across contracts is thus three times smaller than the time-series dispersion. Therefore, although condition (a) of no return dispersion across contracts does not perfectly hold, it would still be a reasonable approximation of the data relative to the large time-series variations.

In fact, we only need condition (b) that the dispersion in contract returns reflects a contract fixed effects. To test for it, we restrict the sample to products that we observe in every survey year and we compute the residual of a panel regression of annual product return on product fixed effect. Then, we calculate the value-weighted standard deviation of the residual across products at the insurer-year level. Finally, we take the average over all insurer-year observations. The cross-sectional standard deviation after absorbing product fixed effects drops to 0.10 percentage points, that is, 10 times less than the time-series dispersion. We conclude that condition (b) that contract return is constant across all contracts up to a product fixed effect is a good approximation of the data.

A.3 Deviations From Historical Cost Accounting

There are two deviations from historical cost accounting principles to force insurers to recognize large unrealized losses. First, when an asset has "lasting and significant" unrealized capital losses, its book value is partially adjusted downwards through the creation of a provision on the asset side of the balance sheet (*provision pour dépréciation durable*) to reflect the paper loss. This adjustment is booked as a realized loss. It thus increases unrealized gains (makes them less negative). If the return credited to contracts and to the insurer are held constant, this realized loss reduces the profit-sharing reserve account, and total fund reserves are not affected. However, the goal of this provision is to induce the insurer to reduce the return credited to investor accounts and thus reduce profit-sharing reserves by less than the realized loss, which increases total fund reserves.

The second deviation from historical cost accounting is that, when the market value of the fund portfolio of non-fixed income securities is less than the book value, the overall paper loss is recognized through a provision on the liability side of the balance sheet (*provision pour risque d'exigibilité*). This is booked as a loss. Therefore, if the return credited to contracts and to the insurer are held constant, this reduces the profit-sharing reserve account and thus total fund reserves. However, the goal of this provision is to induce the insurer to reduce the return credited to investor accounts and thus offset the reduction in the amount of fund reserves.

B Additional Material on Variables Construction

B.1 Basic Variables

The raw data are from the annual regulatory filings (*Dossiers Annuels*) from 1999 to 2015.

Account value `Provisions d'assurance vie à l'ouverture` (beginning-of-year account value) and `Provisions d'assurance vie à la clôture` (end-of-year account value) in C1V1–C1V3 statements summed over contract categories 1, 2, 4, 5, and 7, which is the set of contracts backed by the same pool of underlying assets and associated to the same pool of reserves. The main excluded contract categories are 8 and 9, which are unit-linked contracts.

Profit-sharing reserves `Provisions pour participations aux bénéfices et ristournes` in BILPV statement.

Capitalization reserves `Réserve de capitalisation` in C5P1 statement.

Unrealized gains Book value (`Valeur nette`) minus market value (`Valeur de réalisation`) of assets underlying life insurance contracts measured as `Placements représentatifs des provisions techniques` minus `Actifs représentatifs des unités de compte` in N3BJ statement.

Inflows `Sous-total primes nettes` in C1V1–C1V3 statements summed over contract categories 1, 2, 4, 5, and 7. It includes initial cash deposits at subscription and subsequent cash deposits in existing contracts. The inflow rate is calculated as inflow amount divided by beginning-of-year account value plus one half of net flows.

Outflows `Sinistres et capitaux payés` plus `Rachats payés` in C1V1–C1V3 statements summed over contract categories 1, 2, 4, 5, and 7. It includes partial and full redemptions, either voluntary or at death of investor. The outflow rate is calculated as outflow amount divided by beginning-of-year account value plus one half of net flows.

Contract return We calculate the value-weighted average contract return as the amount credited to investor accounts divided by beginning-of-year account value plus one half of net flows (i.e., we assume that flows are uniformly distributed throughout the year and thus receive on average one half of the annual contract return). The amount credited to investor accounts is measured as `Intérêts techniques incorporés aux provisions d'assurance vie` plus `Participations aux bénéfices` plus `Intérêts techniques inclus dans exercice prestations` plus `Participations aux bénéfices incorporées dans exercice prestations` in C1V1–C1V3 statements summed over contract categories 1, 2, 4, 5, and 7.

Asset return We sum the three components of asset returns, which are reported separately in insurers' financial statement. First, `Produits des placements nets de charges` in C1V1–C1V3 statements summed over contract categories 1, 2, 4, 5, and 7, measures asset yield (dividends on non-fixed income securities plus yield on fixed income securities) and realized gains and losses on non-fixed income securities, net of operating costs. Second, the change in capitalization reserves account value reflects realized gains and losses on fixed income securities. Third, the change in unrealized gains captures measures unrealized gains. We calculate asset return as the sum of these three components divided by account value plus fund reserves.

B.2 Account Value by Generation

We describe in this appendix how we estimate account value by generation from insurer-level account value, inflows, and outflows, under parametric assumptions on the inflow rate and the outflow rate.

Regarding inflows, we assume that investors only make one-off investments. They make an initial deposit when they buy a contract and never deposit additional funds at subsequent dates. Regarding outflows, we assume that investors only proceed to full redemptions and that the redemption rate does not depend on contract age for a given insurer in a given year.

We call generation (t^0, t^1) the set of investors who buy their contract in year t^0 and redeem it in year t^1, for $t^0 < t^1$. We denote $V_t(t^0, t^1)$ the account value of generation (t^0, t^1) at the end of year t and by $V_t^+(t^0, t^1)$ and $V_t^-(t^0, t^1)$ their inflows and outflows, respectively, during year t. Under the maintained assumption that inflows and outflows are uniformly distributed throughout the year and are entitled to one half of the annual contract return, account value of generation (t^0, t^1) evolves according to

$$V_{t^0-1}(t^0, t^1) = 0, \tag{B.1}$$

$$V_t(t^0, t^1) = (1 + y_t)V_{t-1}(t^0, t^1) + (1 + \frac{y_t}{2})(V_t^+(t^0, t^1) - V_t^-(t^0, t^1)), \quad t = t^0, ..., t^1 - 1, \tag{B.2}$$

$$V_{t^1}(t^0, t^1) = 0, \tag{B.3}$$

where y_t is the net-of-fees contract return. The assumption of no inflow after initial subscription writes

$$V_t^+(t^0, t^1) = 0, \qquad t > t^0. \tag{B.4}$$

The assumption of no partial redemption before exit writes

$$V_t^-(t^0, t^1) = 0, \qquad t < t^1. \tag{B.5}$$

The assumption of outflow rate independent of contract age at the insurer-year level writes

$$\frac{V_t^-(t^0,t)}{V_{t-1}(t^0)} = \frac{V_t^-}{V_{t-1}}, \qquad t > t^0. \tag{B.6}$$

We now describe the procedure to calculate account value by generation.

Net-of-fees returns The data only reports gross-of-fees contract return. Since we observe beginning-of-year account value V_{t-1}, inflows V_t^+, outflows V_t^-, and end-of-year account value V_t, we back out the net-of-fees contract return y_t from the law of motion of total account value

$$V_t = (1+y_t)V_{t-1}(1+\frac{y_t}{2})(V_t^+ - V_t^-). \tag{B.7}$$

Cohort-level account value Define a cohort t^0 as the set of generations $\{(t^0,t^1) : t^1 > t^0\}$. Denoting by $T^0 = 1999$ and $T^1 = 2015$ the first year and last year when account value data are available, we redefine cohort T^0-1 as the set of cohorts $\{t^0 : t^0 \leq T^0-1\}$. We denote by $V_t(t^0)$, $V_t^+(t^0)$, and $V_t^-(t^0)$ the end-of-year, inflows, and outflows, respectively, of cohort t^0.

$V_{T^0-1}(T^0-1)$ is observed in the data as beginning-of-year account value in year T^0. (B.4) implies that, for all $t^0 \geq T^0$, inflows of cohort t^0 in year t^0 is $V_{t^0}^+(t^0) = V_{t^0}^+$, which is observed in the data as total outflow in year t^0.

Then, we compute cohort-level end-of-year account value and outflows in all years $t \in [T^0, T^1]$ by forward iteration. Once we have computed cohort-level end-of-year account value in year $t-1$, (B.5) and (B.6) imply that outflows of cohort $t^0 < t$ in year t is $V_t^-(t^0) = \frac{V_{t-1}(t^0)}{V_{t-1}}V_t^-$, where the last term is total outflows in year t, which is observed in the data. End-of-year account value of cohort $t^0 < t$ in year t is $V_t(t^0) = (1+y_t)V_{t-1}(t^0) - (1+\frac{y_t}{2})V_t^-(t^0)$. End-of-year account value of cohort t in year t is $V_t(t) = (1+\frac{y_t}{2})V_t^+(t)$.

Generation-level account value For $t^1 \in [T^0, T^1]$, we redefine generation (T^0-1, t^1) as the set of generations $\{(t^0,t^1) : t^0 \leq T^0-1\}$. For $t^0 \in [T^0, T^1]$, we redefine generation (t^0, T^1+1) as the set of generations $\{(t^0,t^1) : t^1 \geq T^1+1\}$.

(B.5) implies that generation-level outflows is $V_{t^1}^-(t^0,t^1) = V_{t^1}^-(t^0)$ for all $T^0-1 \leq t^0 < t^1 \leq T^1$. Then, we compute end-of-year account value for each generation (t^0,t^1) in all year $t \in [t^0, t^1-1]$ by backward iteration. If $t^1 \leq T^1$, it follows from (B.2) and (B.3) that $V_{t^1-1}(t^0,t^1) = (1+\frac{y_{t1}}{2})V_{t^1}^-(t^0)/(1+y_{t^1})$. If $t^1 = T^1+1$, $V_{T^1}(t^0, T^1+1) = V_{T^1}(t^0)$. Once we have computed the end-of-year account value of generation (t^0,t^1) in year t, we use (B.3) to calculate it in year $t-1$: $V_{t-1}(t^0,t^1) = V_t(t^0,t^1)/(1+y_t)$ for all $t \in [t^0+1, t^1-1]$. Finally, for $t^0 \geq T^0$, it follows from (B.1) and (B.2) that inflows of generation (t^0,t^1) in year t^0 is $V_{t^0}^+(t^0,t^1) = V_{t^0}(t^0,t^1)/(1+\frac{y_{t^0}}{2})$.

C Equal-Weighted Results

This appendix reports unweighted summary statistics and regression results.

Table C.1: Unweighted Summary Statistics. Same as Table 1 with equal weights.

	Mean	Median	Std.Dev.	N
Account value (bn euro)	13.9	3.1	30.1	978
Inflows (% account value)	10.8	9.9	6.5	978
Outflows (% account value)	8.5	8.0	3.6	978
Total fund reserves (% account value)	11.9	11.0	8.8	978
Profit-sharing reserves (% account value)	2.5	1.9	2.1	978
Capitalization reserves (% account value)	1.9	1.3	2.1	978
Unrealized gains (% account value)	7.5	6.4	7.6	978
Share bonds (%)	81.2	83.3	11.6	978
Share stocks (%)	12.4	11.0	8.4	978
Asset return (%)	5.0	4.4	5.4	978
Contract return (%)	4.0	4.0	1.0	978

Table C.2: Contract Returns: Unweighted Regressions. Same as Table 4 with equal weights.

	Contract return			
	(1)	(2)	(3)	(4)
Lagged reserves + Asset return	.029**			
	(.013)			
Lagged reserves		.031**	.023***	.016**
		(.012)	(.0074)	(.006)
Asset return		.025		
		(.017)		
Insurer FE	✓	✓	✓	
Year FE	✓	✓	✓	✓
Adjusted-R2	.53	.53	.52	.41
Observations	978	978	978	978

Table C.3: Long/Short Portfolio Returns: Unweighted Regressions. Same as Table 5 with equal weights.

Panel A: Portfolio long all contracts with above-median reserves/
short all contracts with below-median reserves

Mean return	S.d. return	Sharpe ratio	Market model	
			α	β
.0029	.0015	2.0	.0028	.0014
(.00036)			(.00037)	(.0016)

Panel B: Average across all portfolios long one contract with above-median reserves/
short one contract with below-median reserves

Mean return	S.d. return	Sharpe ratio
.0029	.0098	.30
(.00036)		

Panel C: Contracts with above-median reserves
vs. contracts with below-median reserves

	Mean return	S.d. return
Above-median reserves	.042	.0095
Below-median reserves	.039	.0098
Difference	.0029	−.00037

Table C.4: Investor Flows: Unweighted Regressions. Same as Table 6 with equal weights.

Panel A: All insurers

	Inflows (1)	Redemptions (2)	Expiration (3)	Net flow (4)
Lagged reserves	.0085	.023*	.024**	-.03
	(.039)	(.012)	(.0087)	(.038)
Insurer FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Adjusted-R2	.67	.77	.76	.58
Observations	978	978	978	978

Panel B: Excluding entrants

	Inflows (1)	Redemptions (2)	Expiration (3)	Net flow (4)
Lagged reserves	.042	.029**	.025**	.0028
	(.039)	(.013)	(.01)	(.035)
Insurer FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Adjusted-R2	.66	.75	.73	.59
Observations	839	839	839	839
Lagged reserves	.063*	.0082	.0036	.058
	(.036)	(.013)	(.0091)	(.041)
Insurer FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Adjusted-R2	.76	.75	.84	.67
Observations	839	839	839	839

Table C.5: Term Structure of Contract Returns: Unweighted Regressions. Same as Table 7 with equal weights.

	Contract return				
	year t (1)	year $t+1$ (2)	year $t+2$ (3)	year $t+3$ (4)	year $t+4$ (5)
Reserves beginning of year t	.016**	.016**	.015**	.012*	.011
	(.006)	(.0068)	(.0067)	(.0068)	(.0068)
Insurer FE					
Year FE	✓	✓	✓	✓	✓
Adjusted-R2	.41	.49	.34	.42	.38
Observations	978	859	783	717	645

D Reserves Dilution

This appendix presents the calculation of the mean reversion rate of the reserves ratio. The laws of motion of total account value and of total assets follow, respectively, from equations (1) and (3) and from equation (5):

$$V_t = (1 + y_t)V_{t-1} + Flow_t, \tag{D.1}$$

$$A_t = (1 + x_t)A_{t-1} + Flow_t - \Pi_t. \tag{D.2}$$

Assume that contract return is an affine function of the end-of-year level of reserves just before distribution:

$$y_t = y_0 + y_r \frac{R_{t-1} + x_t A_{t-1}}{V_{t-1}}, \tag{D.3}$$

where y_0 and y_r are constant terms; that flows are a affine function of the beginning-of-year level of reserves:

$$\frac{Flow_t}{V_{t-1}} = f_0 + f_r \frac{R_{t-1}}{V_{t-1}}, \tag{D.4}$$

where f_0 and f_r are constant terms; that insurer profit is a constant fraction of total asset returns:

$$\Pi_t = \pi x_t A_{t-1}, \tag{D.5}$$

where $\pi \leq 0.15$ is a constant term; and that asset return x_t is i.i.d. and independent from $\{y_s, Flow_s\}_{s<t}$.

We denote by $r_t = R_t/V_t$ the reserves ratio and linearize the equations for small deviations of (x_t, r_t) around its unconditional mean $(\overline{x}, \overline{r})$, where $\overline{x} = E[x_t]$ and $\overline{r}$ is such that $(x_t, r_{t-1}) = (\overline{x}, \overline{r})$ implies $r_t = \overline{r}$. Solving, we obtain the steady-state contract return $\overline{y} = y_0 + y_r(\overline{r} + \overline{x}(1 + \overline{r})) = (1 - \pi)\overline{x} - \frac{\overline{f}\overline{r}}{1+\overline{r}}$, where $\overline{f} = f_0 + f_r\overline{r}$ is steady-state net flows. Finally, linearizing r_t yields

$$r_t - \overline{r} = (1 - \delta)(r_{t-1} - \overline{r}) + \epsilon_t, \tag{D.6}$$

where

$$\delta = \frac{(1 + \overline{r})(1 + \overline{x})y_r + \overline{f}/(1 + \overline{r}) + f_r\overline{r}}{1 + (1 - \pi)\overline{x} + \overline{f}/(1 + \overline{r})} \tag{D.7}$$

and

$$\epsilon_t = \frac{(1 + \overline{r})(1 - \pi - (1 + \overline{r})y_r)}{1 + (1 - \pi)\overline{x} + \overline{f}/(1 + \overline{r})}(x_t - \overline{x}). \tag{D.8}$$

A first order approximation of (D.7) for small values of y_r, $\overline{f}$, $\overline{x}$ and $\overline{r}$ implies

$$\delta \approx y_r + \overline{f} + f_r\overline{r}. \tag{D.9}$$