Can Risk Be Shared Across Investor Cohorts? Evidence from a Popular Savings Product

Johan Hombert* Victor Lyonnet†

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Abstract

We study how retail savings products can share market risk across investor cohorts, thereby completing financial markets. Financial intermediaries smooth returns by varying reserves, which are passed on between successive investor cohorts, redistributing wealth across cohorts. Using data on euro contracts sold by life insurers in France, we estimate this redistribution to be large: 0.8% of GDP. We develop and provide evidence for a model in which low investor sophistication, while leading to individually sub-optimal decisions, improves risk sharing by allowing inter-cohort risk sharing.

*HEC Paris and CEPR, hombert@hec.fr
†The Ohio State University, lyonnet.1@osu.edu

1 Introduction

Even in well-developed financial markets, aggregate risk can only be shared among investors participating in the market when this risk is realized. This limit to risk sharing sometimes results in significant losses: In 2008, a perfectly diversified portfolio of stocks lost 40% of its value. Superior risk sharing can be achieved by diversifying risk intertemporally across investor cohorts (Gordon and Varian, 1988), but financial markets do not allow current and future investor cohorts to trade with each other (i.e., financial markets are incomplete).[1] In principle, long-lived financial intermediaries can complete the market by transferring risk between successive cohorts. However, Allen and Gale (1997) show that competition in the savings market unravels inter-cohort risk sharing implemented by an intermediary under the assumption that investors always identify and pick the best investment opportunities. This paper shows, theoretically and empirically, how inter-cohort risk sharing can be achieved when one relaxes that assumption.

Our first contribution is to show how one of the most popular savings products in Europe shares market risk across investor cohorts. These products are sold by life insurers to retail investors. Their name varies by country: "euro contracts," "participating contracts," and so on. In Europe, as of 2017, these products represent 15% of households' financial wealth, and 60% of life insurers' provisions (statistics from EIOPA and Eurostat). We focus on the 1.4-trillion-euro French market, where they are called *euro contracts* and are pure savings products (i.e., they are not traditional life insurance products). Euro contracts work as follows. When a retail investor buys a contract, an account is created, on which she can invest and withdraw cash at any time. In turn, each insurer pools the cash deposited by all its investors into a single fund invested in a portfolio of assets.

The fund holds reserves that vary to offset shocks to asset returns. Reserves increase when asset returns are high and decrease when asset returns are low, so that contract returns are an order of magnitude less volatile than funds asset returns. Reserves are pooled across investors and passed on between successive investor cohorts, causing redistribution across cohorts. Investors receive a transfer from reserves when asset returns are low, and contribute to reserves when asset returns are high. Part of these transfers net out within investors' holding period. Only the *net* transfer received from or contributed to reserves over investors' holding period represents inter-investor-cohort redistribution. Consider the following illustrative example. There are three periods. Investor A invests 100 in a euro contract in period 1 only, and investor B invests 100 in the same

[1] Gollier (2008) estimates that inter-cohort risk sharing increases the certainty equivalent of capital income by 25% relative to an economy without inter-cohort risk sharing.

contract in periods 2 and 3. The asset return is 5% in periods 1 and 2, and minus 1% in period 3. The euro contract return is 3% in every period. Therefore, 2 are contributed to reserves in periods 1 and 2, and 4 are distributed from reserves in period 3.[2] Investor A receives a net transfer of minus 2. Investor B receives a net transfer of 2 over two periods, that is, 1 per period. In this example, the average amount of inter-investor-cohort redistribution is equal to $(|-2|+|1|+|1|)/3 \simeq 1.3$ per period. Using regulatory and survey data from France, we estimate that inter-cohort redistribution amounts to 1.4% of total account value per year, which represents 17 billion euros redistributed across investor cohorts every year, or 0.8% of GDP.

These findings challenge the notion that inter-cohort risk sharing cannot be achieved in competitive markets. Allen and Gale (1997) study savings contracts that share market risk across investor cohorts through a reserve mechanism similar to that of euro contracts. They study two polar cases, showing that: (a) a financial intermediary can implement inter-cohort risk sharing if it is protected from competition, that is, if investors must invest with the intermediary regardless of the reserves level; (b) competition unravels inter-cohort risk sharing if investors are fully strategic, hence invest in contracts only when reserves are high and opt out when reserves are low, that is, if demand for contracts is infinitely elastic to reserves. In practice, (a) does not apply to euro contracts, because insurers compete with each other as well as with alternative investment options. Moreover, the large amount of inter-cohort redistribution we observe in the data rules out the assumption of infinitely elastic demand in (b). To our knowledge, no theoretical framework exists to analyze inter-cohort risk sharing in real-world euro contracts. Our second contribution is to study, theoretically and empirically, the conditions enabling inter-cohort risk sharing.

We develop a model in which long-lived intermediaries compete in selling savings products to successive cohorts of investors. We characterize how the amount of inter-cohort risk sharing depends on the elasticity of demand for contracts with respect to the expected contract return conditional on reserves. The model nests the two polar cases of perfectly inelastic demand and perfectly elastic demand that have been studied in the literature. In line with this literature, we show asset risk can perfectly be shared across investor cohorts when demand is inelastic. Instead, when demand is elastic, investors behave opportunistically and exploit the predictability of contract returns: They flow into (out of) contracts when reserves are high (low), partially unravelling risk sharing across cohorts. In the limit when demand is perfectly elastic, inter-cohort risk sharing fully unravels so that

[2] In this example, we ignore the fact that reserves are invested in assets that generate returns. We also consider non-overlapping investors. The method we use in Section 3 to measure inter-cohort redistribution accounts for these features of real-world contracts.

the savings products are akin to pass-through mutual funds, in line with Allen and Gale (1997). In a nutshell, the equilibrium level of inter-cohort risk sharing crucially (and monotonically) depends on demand elasticity.

We show the inter-cohort risk sharing achieved by the contracts cannot be replicated using market instruments. In this sense, the contracts complete markets. The reason is that contracts exploit a dimension of risk sharing— cross-cohort risk sharing — that cannot be achieved in financial markets, implying the contract has a lower risk exposure than the underlying insurers asset portfolio.

Our model shows we can estimate demand elasticity from two moments in our data. The first moment is the regression coefficient of contract return on contemporaneous asset return, conditional on the level of reserves. When demand is inelastic, contracts share risk across investor cohorts. In this case, the contract return depends on the level of reserves but not on contemporaneous asset return beyond its effect on reserves. The intuition is similar to that of the permanent income hypothesis, whereby optimal consumption does not depend on current income beyond its effect on permanent income. By contrast, when demand is elastic, little inter-cohort risk sharing occurs and the contract return depends strongly on the contemporaneous asset return. We estimate panel regressions and, controlling for the level of reserves, we show the contract return does not depend on the asset return in the current year. Therefore, the evidence is consistent with low demand elasticity.

The second moment that is informative about demand elasticity is the regression coefficient of investor flows on reserves. A high level of reserves predicts high expected contract returns, so that the sensitivity of flows to reserves is directly related to demand elasticity. We run panel regressions and find the sensitivity of flows to reserves is close to zero, again consistent with low demand elasticity. One issue when regressing flows on reserves is that reserves are potentially endogenous to unobserved demand shocks – a standard issue when one estimates demand functions by regressing quantity on price. Our model shows the past asset return is a valid instrument for reserves to estimate the sensitivity of flow to reserves. Instrumenting reserves, the sensitivity of flows to reserves remains close to zero.

Why is demand inelastic to reserves, allowing for inter-cohort risk sharing? We rule out explanations based on switching costs related to taxes or fees. In particular, we study investors buying a new contract. These new investors do not face switching costs. Despite no switching costs and although high reserves predict high contract returns, we find new investors' flows do not react to reserves.

We hypothesize that demand is inelastic to reserves because investors lack the knowledge to predict contract returns using reserves. In line with this hypothesis, we show that contracts held by investors with a small investment amount (below 250,000 euros) have a flow-reserves sensitivity indistinguishable from zero, whereas contracts with a large investment amount (above 250,000 euros) exhibit a positive and significant flow-reserves sensitivity. This result is consistent with interpreting the investment amount as a proxy for wealth and financial sophistication, whereby less sophisticated investors fail to predict contract returns using reserves.[3] Differences in demand elasticity across investors can arise if investors must incur a fixed cost to acquire the knowledge or information necessary to understand the sources of contract return predictability (Lusardi and Mitchell, 2014).

Perhaps paradoxically, the lack of household financial sophistication enables more risk sharing than would be possible if households were perfectly informed and acted accordingly. The idea that ignoring privately valuable information can be socially beneficial because it improves risk sharing goes back to Hirshleifer (1971). Our results are an illustration of this principle in the context of aggregate risk sharing: Investor inertia, while individually sub-optimal, improves (inter-cohort) risk sharing. In the context of health insurance, Handel (2013) shows that consumer health plan choice inertia reduces adverse selection, hence improves (cross-sectional) risk sharing. Hortaçsu and Syverson (2004), Drechsler, Savov, and Schnabl (2017) and Koijen and Yogo (2018) study the implications of investor inertia for competition between financial intermediaries.

A small literature studies savings products implementing cross-sectional sharing of aggregate risk between investors and the financial intermediary. Examples include variable annuities with return guarantees sold by US life insurers (Koijen and Yogo, 2018; Ellul et al., 2018) and structured products sold by European banks (Célérier and Vallée, 2017; Calvet et al., 2020). In these products, the intermediary bears part of the risk by hedging investors' returns from market risk. Such cross-sectional risk sharing is also at play in euro contracts, but we show it is an order of magnitude smaller than intertemporal risk sharing across investor cohorts. Crucially, cross-sectional risk sharing hinges on intermediaries' risk-bearing capacity.[4] By contrast, euro contracts shift most of the risk to households and share it across cohorts.

[3] Using data from a French life insurer, Bianchi (2018) studies households' portfolio allocation between mutual funds and euro contracts. He constructs a survey-based measure of financial literacy and shows this measure is highly correlated with household wealth.

[4] Life insurers' product supply shifts inwards when their capital position weakens (Koijen and Yogo, 2015, 2018; Ge, 2017; Sen and Humphry, 2018). Their capital position also affects their asset portfolio choices (Ellul et al., 2015; Becker and Ivashina, 2015; Ge and Weisbach, 2019).

Similar to euro contracts, defined benefits (DB) pension plans contain an element of inter-cohort risk sharing, because DB sponsors can spread shocks across cohorts by adjusting the contributions of futures employees, and they can also be bailed out by future taxpayers (Novy-Marx and Rauh, 2011, 2014). However, the market structure and thus the determinants of demand elasticity are different for euro contracts and DB plans. Greenwood and Vissing-Jorgensen (2018) study the implications of pension funds and insurance companies' behavior for asset prices, and Scharfstein (2018) examines their role in shaping the financial system.

We also contribute to the theoretical literature on the private implementation of inter-cohort risk sharing. The notion that financial markets cannot implement inter-cohort risk sharing because they do not allow current and future investor cohorts to trade with each other goes back at least to Stiglitz (1983) and Gordon and Varian (1988), whereas Ball and Mankiw (2007) study inter-cohort risk sharing in a hypothetical economy in which current investors can trade with future investors. Allen and Gale (1997) and Gollier (2008) study how inter-cohort risk sharing can be implemented by an intermediary having monopoly power over households' savings. Allen and Gale (1997) show inter-cohort risk sharing unravels if investor demand is infinitely elastic to reserves. We extend this literature by considering the case of finite elasticity, showing the equilibrium level of inter-cohort risk sharing decreases monotonically from perfect to nonexistent as the elasticity increases from zero to infinity.

2 Euro contracts

2.1 Institutional framework

European life insurers sell savings contracts designed to implement inter-cohort risk sharing. We study the market for these contracts in France, where they are called euro contracts. Despite being sold by life insurers, euro contracts are pure savings products which do not entail insurance against longevity or mortality risk. Life insurers selling euro contracts can be subsidiaries of insurance holding companies, subsidiaries of bank holding companies, or stand-alone life insurance companies.[5]

Investments in euro contract amount to 1.4 trillion euros as of 2015, which represent one-third of French household financial wealth (Insee, 2016). Another third of household financial wealth is invested in risky securities and investment funds, held directly or through special vehicles. The

[5]Mutual insurance companies, pension institutions, and reinsurance companies can also sell euro contracts. These institutions are subject to a different regulation and account for only 4% of aggregate provisions (ACPR, 2016). We abstract from them in the empirical analysis.

last third is invested in short-term instruments including checking accounts, savings accounts, and regulated savings products such as that analyzed at the end of Section 5.3.

When an investor buys a euro contract, the insurer creates an account on which the investor can deposit and withdraw cash at any time. We refer to the cash balance on the investor's account as the account value. The insurer pools the cash deposited by all investors in a single fund called the euro contract fund, which is invested in a portfolio of assets. The set of assets euro contract funds are allowed to hold is defined by regulation. It includes most assets from OECD countries such as sovereign and corporate bonds, loans, public and private equities, real estate, and shares in investment funds holding such assets.[6] Summary statistics on the asset composition are reported in Table 1.

At the end of each calendar year, the insurer chooses the annual contract return: Each investor's account is credited an amount equal to the account value multiplied by the contract return. The contract return chosen by the insurer generally differs from the return on the assets held by the insurer. The difference between the asset return and contract return is absorbed by two buffers: fund reserves and insurer equity. That is, the insurer chooses how the asset return in a given year is split into three parts: the contract return paid to current investors, the change in reserves, and the insurer's profit. This flexibility allows insurers to provide investors with insurance against market risk.

Reserves have two key features that jointly give rise to inter-cohort risk sharing. First, reserves are owed to investors. While the insurer can choose how to share the asset return between current contract return, change in reserves, and insurer profit, this choice is subject to the regulatory constraint that the sum of the first two components must be at least 85% of asset income. The insurer can therefore transfer funds between reserves and investors' accounts to smooth contract returns over time. However, the insurer cannot transfer funds from reserves to the insurer's equity, because the insurer's profit in any given year must be at most 15% of the asset income in that year.[7]

Second, reserves are pooled across all investors and passed on between successive investor cohorts. In particular, new investors share in reserves accumulated by previous investors, and investors redeeming their contracts give up their share of reserves. The pooling of reserves across investor cohorts happens because all investors holding the same contract offered by a given insurer receive

[6] See article R.332 of *Code des Assurances*. Asset regulation also includes diversification requirements, such as that preventing insurers to invest more than 65% of their asset portfolio in a given asset class. These diversification requirements are not binding in our sample.

[7] See Appendix B for a detailed description of the regulatory framework.

the same contract return regardless of when they entered into the contract.

Insurers often offer a range of contracts, for instance, a basic contract and a premium contract with a minimum investment amount and a lower fee rate. Insurers are allowed to pay different returns on different contracts. In principle, insurers could close existing contracts to new subscriptions when reserves are high, and create a new vintage of contracts to which they will pay different returns. Doing so would undo reserve pooling across investor cohorts. Using data at the contract level, we show in Section 5.2 that insurers do not do so; therefore, reserves are effectively pooled across investor cohorts.

The rest of this section summarizes the other main features of the institutional framework.

Minimum return guarantees. Euro contracts include a minimum guaranteed return, below which the contract return paid in any year cannot go. The minimum guaranteed return is fixed at the subscription of the contract. Against a backdrop of decreasing interest rates, French insurers have strongly reduced guaranteed rates close to zero since the 1990s (Darpeix, 2016), such that minimum return guarantees are not binding for the vast majority of contracts during the sample period (see Section 2.2).

Fees. Insurers usually charge entry fees when investors deposit cash on their account (front-end loads), and annual management fees, but are not allowed to charge exit fees (back-end loads). Regulation imposes that insurers must distribute at least 90% of their technical income to investors if it is positive, or 100% if it is negative. This amount can be paid to investors immediately by crediting investors' accounts, or later by crediting reserves. Technical income is equal to fees minus the insurer's operating costs. The implication of this regulation is that insurers cannot extract money from the reserves by raising fees on new investors, because 90% (or 100%) of these fees must eventually be returned to investors.

Taxes. Contract returns are taxed upon withdrawal at a rate that depends on the age of the contract at the time of withdrawal. The tax rate is decreasing in contract age for the first eight years of the contract. This creates a potential switching cost that we analyze in Section 6.1. The tax treatment of euro contracts is the same as that of unit-linked contracts, which are investment vehicles also sold by life insurers through which households can hold mutual funds. Therefore, household can invest in mutual funds at the same fiscal cost as in euro contracts.

Solvency regulation. Insurers are subject to Solvency I during the sample period. This regulation imposes that insurers hold a minimum amount of capital equal to 4% of total account value (article L.334 of *Code des Assurances*). These capital requirements do not depend on the portfolio asset

composition or the minimum return guarantees. Solvency II came into effect in 2016, which is after the end of the sample period but may have affected insurers because its implementation was anticipated. Solvency II did not change the regulatory framework at the basis of inter-cohort risk sharing, such as the constraint that at least 85% of asset returns must eventually be paid out to investors and how reserves are created and can be used. Under Solvency II, capital requirements depend on the portfolio asset composition and return guarantees issued. Although this could have led insurers to reduce asset risk and to lower guaranteed returns, the insurer supervisor found no significant change in asset riskiness in response to Solvency II (Baddou et al., 2016). Regarding minimum guaranteed returns, they are already at 0% during the sample period (Darpeix, 2016).

2.2 Data and summary statistics

Our main source of data comprises regulatory filings obtained from the national insurance supervisor (*Autorité de Contrôle Prudentiel et de Résolution*) for the years 1999 to 2015. The data cover all companies with life insurance operations in France and contains detailed financial statements.[8] We focus on stock insurance companies with more than 10 million euros of life insurance provisions. Because we need lagged values to calculate the change in reserves, the sample period of our analysis is 2000–2015. The final sample contains 76 insurers and 978 insurer-year observations.

Panel A of Table 1 reports summary statistics from the regulatory filings. Statistics on ratios are value-weighted by the insurer's share in aggregate account value in the current year. 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 contract termination (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 1. Aggregate account value grows from 500 billion euros in 2000 to 1,200 billion euros in 2015 (all amounts are in constant 2015 euros). Aggregate growth reflects the internal growth of existing life insurers rather than the entry of new insurers. The number of insurers in the sample is 65 at the beginning of the period and 61 at the end. Market concentration is relatively low, with a Herfindahl-Hirschman Index around 800 and total market shares of the top five insurers slightly below 50%.

[8] See Appendix C.1 for details about the data used in the paper and variable construction. The data are available through the Banque de France's open data room (click on this link).

The average reserve ratio is 10.9%. On the asset side, 80.4% of funds' portfolios are invested in sovereign and corporate bonds, 13.5% in stocks, and the rest in real estate, loans, and cash. The average asset return is 4.9% per year. The average contract return before fees is 4.0% per year.

Three factors can explain the wedge between the average asset return and the average contract return. First, as described in Section 2.1, the insurer can keep up to 15% of the asset return as profit, which represents about 75 basis points on average. Second, part of the asset return has been retained to offset the dilution of reserves induced by positive net flows over the sample period. Given the average net flow rate of 2.4% per year and the average reserve ratio of 10.9%, insurers would have had to retain $0.024 \times 0.109 \simeq 25$ basis points of asset returns per year to maintain the reserve ratio constant. Third, the average reserve ratio is actually about 3.5 percentage points higher at the end of the period than at the beginning (see Appendix Figure B.1), which implies insurers have retained over this 15-year period an additional $0.035/15 \simeq 25$ basis points per year on average.

We complement the regulatory data with contract-level information from two sources. First, we retrieve information on fees from the data provider *Profideo*, which collects information on contract characteristics from contract prospectuses. The data consists in a snapshot of contracts with positive outstanding account value in 2017, even if the contract is closed to new subscriptions at that date. The fee structure is fixed at the subscription of the contract and written in the contract prospectus. Given that for every contract, some investors hold their contract for many years, it is sufficient to have a snapshot of outstanding contracts in 2017 to retrieve a complete picture of the fee structure of all contracts sold throughout the sample period 2000–2015. The data also includes information on the time period during which contracts were open to new subscriptions. We keep contracts for which this period overlaps with the sample period. 57% percent of insurers, representing 68% of account value in the regulatory filings, can be matched with this dataset. Panel B of Table 1 shows summary statistics on fees aggregated at the level of insurer-years in which the contract is open to new subscriptions, which is the level at which we run regressions using these data. Management fees are, on average, 70 basis points of account value. Entry fees are, on average, 3.3%.[9]

Our second source of contract-level information is a survey (*Enquête Revalo*) conducted by the insurance supervisor every year from 2011 to 2015 among all the main insurers. The data covers 81% of aggregate account value in the regulatory filings. We retrieve information on net-of-fees

[9]Recall that fees do not map one-to-one into insurer profit, because insurers must return at least 90% of fees to investors (see Section 2.1).

contract returns, minimum guaranteed return, total account value, and number of investors, which allows us to calculate the average invested amount for every contract. Panel C of Table 1 presents summary statistics from this dataset at the contract-survey year level. The average net-of-fees contract return is 2.7%.[10] The average (75th percentile) minimum guaranteed return is 35 basis points (0), which is well below the average contract return of 2.7 percentage points over the same period. Thus, the minimum guaranteed rate is not binding for the vast majority of contracts: The net-of-fees contract return is strictly larger than the guaranteed return for 98% of contracts. This figure actually overstates the extent to which the minimum guaranteed return is binding, because the guaranteed return is before-fees. Assuming uniform management fees at the sample average of 70 basis points, over 99% of contracts have a non-binding minimum guaranteed return.

3 The Accounting of Inter-Cohort Risk Sharing

In this section, we quantify inter-cohort risk sharing in euro contracts based on an accounting framework which formalizes the institutional framework presented in Section 2.1.

Denote by $V_{j,t}$ the total account value with insurer j at the end of year t after payment of the annual net-of-fees return $y_{j,t}$. It evolves according to

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

where $Flow_{j,t}$ is net flow to insurer j in year t.[11] The balance sheet of the fund at the end of year t is

$$A_{j,t} = V_{j,t} + R_{j,t}, \tag{2}$$

where $A_{j,t}$ is asset value and $R_{j,t}$ is reserves at the end of year t. Assets evolve according to

$$A_{j,t} = (1 + x_{j,t})A_{j,t-1} + Flow_{j,t} - \Pi_{j,t}, \tag{3}$$

where $x_{j,t}$ is asset return and $\Pi_{j,t}$ is insurer j's profit in year t. Combining (1), (2), and (3), we

[10] It is lower than the average before-fees contract return in regulatory filings (4% in Panel A) minus average management fees (0.7% in Panel B), because the sample period is 2011–2015 for the survey data, whereas it is 2000–2015 for the regulatory filings, and contract returns are lower towards the end of the sample period (see Figure 2).

[11] We write Equation (1) assuming that flows take place at the end of the year after payment of the annual return to simplify the exposition. In the empirical analysis, we assume that flows are spread uniformly throughout the year and therefore earn half the annual contract return.

obtain

$$x_{j,t}A_{j,t-1} = y_{j,t}V_{j,t-1} + \Pi_{j,t} + \Delta R_{j,t}, \tag{4}$$

where $\Delta R_{j,t} = R_{j,t} - R_{j,t-1}$. Equation (4) describes how asset income (on the left-hand side) is split into three parts: the amount credited to current investors (first term on the right-hand side), insurer profit (second term), and change in reserves (third term). Returns paid to investors can therefore be hedged against market risk if fluctuations in asset returns are absorbed by the insurer and/or by reserves. 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 reserves represents a payoff to past and future investors and is at the root of inter-cohort risk sharing.

Contract return smoothing. Figure 2 compares the time series of asset return $x_{j,t}$ and contract return $y_{j,t}$, averaged across insurers. The key pattern is that the contract return is an order of magnitude less volatile than the return on underlying assets. Thus, euro contracts provide investors with insurance against market risk.

As shown by Equation (4), there are two potential sources of market risk sharing. Static (cross-sectional) risk sharing between investors and the insurer arises if the difference between asset income and the amount credited to current investors is absorbed by the insurer. Intertemporal risk sharing between successive cohorts of investors arises if this difference is absorbed by reserves.

To assess the contribution of reserves to the provision of insurance, Figure 3 compares two series. The solid blue line is the difference between the amount credited to current investors and asset income: $y_{j,t}V_{j,t-1} - x_{j,t}A_{j,t-1}$. It represents the total transfer to current investors, that is, the transfer from the insurer plus the transfer from reserves. The dashed red line is minus the change in reserves: $-\Delta R_{j,t}$. It represents the transfer from reserves. Both series are summed across insurers and normalized by aggregate account value. The figure shows how the two series track each other very closely; that is, variation in reserves absorbs almost all of the difference between asset return and contract return. Therefore, virtually all insurance against market risk is provided to investors through reserves.

Inter-cohort redistribution. Contract return smoothing using reserves implies that wealth is transferred across time, but it does not necessarily imply that wealth is transferred across investor cohorts because part of intertemporal transfers net out within investors' holding period. To illustrate this point with a stylized example, consider an investor holding a contract for two years during which

the asset return and contract return are as follows:

	Year 1	Year 2
Asset return	0	6
Contract return	4	4

Reserves absorb the difference between the asset return and contract return. In year 1, the investor receives a positive transfer from reserves equal to 4. In year 2, the investor makes a transfer to reserves equal to 2. Therefore, part of the year-on-year transfers net out over the investor's holding period. The net transfer to the investor is then $4 - 2 = 2$ over two years, or 1 per year. Our methodology to quantify inter-cohort redistribution follows the same logic as in this example, netting out transfers within investors' holding period in order to isolate the inter-cohort component.

To quantify inter-cohort redistribution induced by changes in reserves, we compare the actual contract return paid out to investors with the return they would obtain in a counterfactual with constant reserves, the same asset return, and the same insurer profit as in the data. Relative to the counterfactual, investors holding a contract with insurer j in year t receive a transfer from reserves equal to $-\Delta R_{j,t}$. Consider investor i holding a contract from beginning of year t_0 to end of year t_1, and denote by $V_{i,j,\tau-1}$ her account value at the beginning of year τ. She receives in year τ a transfer proportional to her weight in the insurer's total account value, equal to $\frac{V_{i,j,\tau-1}}{V_{j,\tau-1}}(-\Delta R_{j,\tau})$. Summing over her holding period as in the two-period example, we obtain investor i's holding period net transfer, which we apportion to each year in proportion to the beginning-of-year account value:[12]

$$NetTransfer_{i,j,t} = \frac{V_{i,j,t-1}}{\sum_{\tau=t_0}^{t_1} V_{i,j,\tau-1}} \sum_{\tau=t_0}^{t_1} \frac{V_{i,j,\tau-1}}{V_{j,\tau-1}}(-\Delta R_{j,\tau}). \tag{5}$$

The net transfer received by an investor depends on her holding period, that is, the year in which she starts investing and the year she redeems (and on the time profile of her investment within the holding period). Investors with the same holding period are on the same side of redistribution. By contrast, investors with different holding periods may be on opposite sides of the redistribution. Therefore, transfers across investors reflect transfers across investor cohorts.

Panel A of Table 2 shows the net transfer (5) received by an investor as a function of her holding period, for every possible holding period within the sample period. We calculate the net transfer for

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

an investor who holds the value-weighted average contract and keeps a constant investment amount of 100 by withdrawing interests paid at the end of each year.[13] The numbers in the table represent the additional annual returns of the representative euro contract relative to a counterfactual with constant reserves. For instance, an investor buying a euro contract at the beginning of 2006 and redeeming it at the end of 2011 earned an additional 1.5 percentage points per year relative to a counterfactual with no smoothing, because insurers tapped reserves during the 2008 stock market crash and the 2011 sovereign debt crisis. Conversely, transfers turn negative for holding periods spanning the end of the sample period characterized by decreasing interest rates, because insurers hoarded the high bond returns as reserves during this period.

Aggregate inter-cohort redistribution. The aggregate amount transferred across cohorts each year t is obtained by summing up the net transfers (5) across investors:

$$InterCohortTransfer_{j,t} = \sum_i |NetTransfer_{i,j,t}|. \tag{6}$$

Before calculating the aggregate inter-cohort transfer using (6), we show how the relation between variation in reserves and inter-cohort redistribution can already be quantitatively approximated using a back-of-the-envelop calculation. Suppose all investors have T-year holding periods and the annual transfer from reserves $-\Delta R_{j,t}$ is i.i.d. across time and normally distributed with zero mean. Then, the expected annualized net transfer over T years (i.e., expected $\left|\sum_{t=1}^{T} -\Delta R_{j,t}/T\right|$) is equal to $1/\sqrt{T}$ times the expected yearly transfer from reserves (i.e., expected $|-\Delta R_{j,t}|$). Intuitively, a longer holding period reduces inter-cohort transfers because a larger fraction of transfers from reserves net out over investors' holding period. The average outflow rate is 8.1% per year, which implies an average holding period of 12 years. The average absolute value of the yearly transfer from reserves is 3.7% of account value, implying an average inter-cohort transfer of the order of $3.7\%/\sqrt{12} \simeq 1.1\%$ of account value per year. Accounting for holding period heterogeneity across investors would lead to a larger inter-cohort transfer because of the convexity of $1/\sqrt{T}$.

To have an exact measure of aggregate inter-cohort transfer (6), we would need to observe the

[13] We estimate the amount of inter-cohort transfer 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 acquires another insurer, 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 scope throughout the sample period. Second, we drop a few insurers that enter or exit during the sample period or have missing data in some years. 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.

entire investment history of all investors, which is not possible, because the investment history of investors still holding a contract at the end of the sample period is not over. Two data limitations also exist. First, regulatory data start in 1999; therefore, we do not observe the entire investment history of investors who entered their contract before 1999. We can calculate the net transfer 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, which implies we know the average holding period but not its entire distribution. To calculate inter-cohort transfers, we assume the outflow rate is constant across cohorts at the insurer-year level and that investors only make one-off investments.[14] Under this assumption, we can reconstruct the investment history of all cohorts of investors and calculate the total inter-cohort transfer.

The value-weighted average amount of inter-cohort transfer is 1.4% of account value per year (Panel B of Table 2). Evaluated at the 2015 level of aggregate account value of 1,200 billion euros, it amounts to an annual 17 billion euros that shift across investor cohorts on average, or 0.8% of GDP.[15]

4 Model

The large scale inter-cohort redistribution we document in the previous section challenges the notion that inter-cohort risk sharing cannot be achieved in competitive markets. This notion follows from the assumption that investors are fully strategic, hence invest in contracts only when reserves are high and opt out when reserves are low. When the elasticity of the demand for contracts to reserves is infinitely large, inter-cohort risk sharing unravels (Allen and Gale, 1997). In this section, we relax this assumption and instead assume that the elasticity of demand is finite. The model allows us to characterize how the equilibrium amount of inter-cohort risk sharing depends on the elasticity of demand, and to derive econometric specifications to estimate this elasticity.

[14] Formally, denoting by $V_{j,t}(t_0)$ the year t-total account value of contracts sold by insurer j in year t_0, we assume $V_{j,t}(t_0) = (1-\theta_{j,t})(1+y_{j,t})V_{j,t-1}(t_0)$ for all $t_0 < t$, where the outflow rate $\theta_{j,t}$ is calculated to match observed outflows for insurer j in year t, that is, $\sum_{t_0<t} \theta_{j,t}(1+y_{j,t})V_{j,t-1}(t_0) = Outflow_{j,t}$; and account value of new contracts is calculated to match observed inflows to insurer j in year t, that is, $V_{j,t}(t) = Inflow_{j,t}$. See Appendix C.2 for details.

[15] The assumption of outflow rates independent of contract age is likely to underestimate the amount of inter-cohort transfer. Actual outflow rates are decreasing in contract age (FFSA-GEMA, 2013), implying the true dispersion of holding periods is higher than the dispersion obtained under the assumption of the age-independent outflow rate. Because expected annualized life transfer is convex in the holding period, underestimating the dispersion of holding periods leads to underestimating inter-cohort transfer.

4.1 Setup

The backbone of the model is the accounting framework presented in Section 3. Every period $t = 1, 2, \ldots, +\infty$, $J \geq 1$ long-lived intermediaries, indexed by $j = 1, \ldots, J$, sell one-period saving contracts.[16] The contract offered by intermediary j in period t promises a return $y_{j,t}$ contingent on all information observable at the end of period t. At the beginning of period t, intermediary j has reserves $R_{j,t-1}$ and collects $V_{j,t-1}$ from investors. The intermediary has total assets $V_{j,t-1} + R_{j,t-1}$, which generate an exogenous return $x_{j,t}$ with $E_{t-1}[x_{j,t}] = r$, where E_{t-1} denotes expectation conditional on information at the beginning of period t. Asset risk may include a systematic component and an idiosyncratic component determined by the covariance structure of $x_t \equiv (x_{0,t}, \ldots, x_{J,t})$, where $j = 0$ defines investors' outside option described below.

As described in Section 2.1, insurer profit is pinned down by regulation such that at most 15% of asset income goes to the insurer, because at least 85% must go to investors. Accordingly, we define the insurer profit as

$$\Pi_{j,t} = \frac{\phi}{1-\phi}\, y_{j,t}\, V_{j,t-1} \tag{7}$$

where $\phi \in (0, 1)$ is 15% in the French regulatory framework. To write insurer profit as in Equation (7), we make a couple of simplifying assumptions relative to the exact regulatory framework described in Section 2.1. First, the regulation imposes a cap on profits whereas we write the regulatory constraint with an equality. In Appendix A.2, we derive a sufficient condition for the regulatory constraint to be binding. Intuitively, the constraint is binding if demand is sufficiently inelastic, in which case equilibrium profits are high absent the regulatory constraint. We show this condition is empirically validated in Section 5. Second, as described in Appendix B, asset yield and realized capital gains in a given year are shared between investors and the insurer in that year following the 85%/15% rule, while unrealized gains are automatically assigned to reserves. The 85% share going to investors in that year can either be immediately credited to their accounts or credited to a profit-sharing reserve account for future distribution to investors' accounts. Therefore, the intermediary's profit (7) should be proportional to $y_{j,t}\, V_{j,t-1}$ plus the change in the profit-sharing reserve. Because changes in the profit-sharing reserve represent a small share of changes in total reserves empirically, this simplification is reasonable.[17]

By constraining the intermediary's profit to be proportional to the contract return, regulation

[16] In line with our empirical setup, we rule out multi-period contracts. By law, euro contracts must be demandable and insurers are not allowed to charge exit fees (back-end loads).

[17] This fact can be visualized in Appendix Figure B.1. In the insurer-year panel, the contribution of the change in the profit-sharing reserve to the variance of the change in total reserves is 1.5%.

exogenously pins down the share of asset risk borne by the intermediary, and prevents the intermediary from using its equity to provide additional insurance to investors. Even if the regulatory constraint is written with "$\leq$" instead of "$=$", transferring wealth between the intermediary and investors across states of nature is still not feasible, because doing so involves lowering the intermediary's profit below the regulatory cap in some states (which is feasible) and increasing it above the cap in other states (which would violate the regulatory constraint). Therefore, in the model, the amount of insurance provided to investors is determined by inter-cohort risk sharing, in line with the empirical evidence presented in Section 3. We can thus assume that intermediaries are risk neutral without opening the door to additional risk sharing between intermediaries and investors. Intermediaries maximize expected profit discounted at the expected rate of asset return

$$E_0 \left[\sum_{t=1}^{+\infty} \frac{\Pi_{j,t}}{(1+r)^t} \right]. \tag{8}$$

Intermediaries face the sequential budget constraint (4) for all $t \geq 1$. We normalize initial reserves $R_{j,0}$ to zero. To rule out Ponzi schemes, reserves must satisfy the transversality condition

$$\lim_{t \to +\infty} \frac{R_{j,t}}{(1+r)^t} \geq 0. \tag{9}$$

We model investor demand for contracts using a multinomial logit model. Every period a mass one of investors have one unit of wealth to invest. Each investor buys the contract that provides her with the highest expected utility. Investor i's expected utility from investing with intermediary j in period t is

$$\alpha \, E_{t-1}[u(y_{j,t})] + \xi_{j,t-1} + \psi_{i,j,t-1}. \tag{10}$$

The term $\alpha \, E_{t-1}[u(y_{j,t})]$ represents the expected indirect utility provided by contract return $y_{j,t}$, where $\alpha > 0$, $u' > 0$, $u'' < 0$, and without loss of generality we normalize $u'(r(1-\phi)) = 1$. $\xi_{j,t-1}$ is nonreturn preference for intermediary j in period t shared across all investors and $\psi_{i,j,t-1}$ is investor i's idiosyncratic preference. $\xi_{j,t-1}$ and $\psi_{i,j,t-1}$ are indexed by $t-1$ because they are realized at the end of period $t-1$. The vector of demand shocks $\xi_t \equiv (\xi_{1,t}, \ldots, \xi_{J,t})$ follows a random walk that is uncorrelated with asset returns, $E_{t-1}[\xi_t \,|\, x_t] = \xi_{t-1}$, such that in equilibrium, the asset return will affect investor demand through its effect on the contract return and through this effect only. $\psi_{i,j,t-1}$ is distributed i.i.d. extreme value across investors in cohort t.

α is the key parameter of the model. It parameterizes the elasticity of demand to expected

returns, capturing in reduced form several, non-mutually exclusive, mechanisms leading to imperfectly elastic demand, such as nonreturn product differentiation, switching costs, and information frictions (Hortaçsu and Syverson, 2004). Investors might be able to calculate expected returns yet do not necessarily buy the contract with the highest expected return, because they trade off returns against other contract attributes or because portfolio rebalancing is costly. Alternatively, information frictions might prevent investors from figuring whether certain contracts have higher expected returns than others, and which ones. We provide evidence for and against these mechanisms in Section 6.

α should be interpreted as the elasticity of demand to expected returns *conditional on reserves*. Indeed, in the model, variation in reserves is the only source of contract return predictability. In practice, there might be other sources of return predictability, such as heterogeneity in asset risk and management skills across intermediaries, which is absent from the model. Demand may also react to changes in expected returns on outside investment opportunities. The elasticity of demand to these other sources of return predictability may differ from α, for example if these other factors are more salient or easier to apprehend than reserves. We provide evidence supporting this interpretation in Section 5.3.

Investors have access to an outside investment opportunity indexed by $j = 0$, which yields expected utility given by (10) with $\xi_{0,t-1}$ normalized to zero, $\psi_{i,0,t-1}$ distributed i.i.d. extreme value, and $y_{0,t} = (1 - \phi_0)x_{0,t}$. The parameter $\phi_0 > 0$ captures the fees and other costs of investing in the outside investment opportunity. The outside investment opportunity can be thought of as other liquid saving instruments, e.g. mutual funds or direct investment in financial markets. We assume the cost of investing through the outside option is the same as the cost of investing through intermediaries, that is, $\phi_0 = \phi$.[18]

Contract return in period t is contingent on all observable information at the end of period t, which includes the history of asset returns and demand shocks. Thus, $y_{j,t}$ is a function of (x^t, ξ^t), where the t exponent denotes history up to end-of-period t. The demand for intermediary j's contract in period t is

$$V_{j,t-1} = \frac{\exp\{\alpha\, E_{t-1}[u(y_{j,t})] + \xi_{j,t-1}\}}{\sum_{k=0}^{J} \exp\{\alpha\, E_{t-1}[u(y_{k,t})] + \xi_{k,t-1}\}}. \tag{11}$$

The problem of an intermediary is to maximize profit (8) by choosing a contract return policy subject to the budget constraint (4), the profit function (7), the transversality condition (9), and

[18] In France, as in several other European countries, life insurers sell mutual funds through unit-linked contracts that are subject to the same fee structure and tax treatment as euro contracts. In such cases, $\phi_0 = \phi$ by design.

the demand function (11). Each intermediary takes other intermediaries' contract return policies as given. An equilibrium is defined as a fixed point of this problem.[19]

Finding a general analytical solution to this problem is difficult. To simplify the problem and obtain an explicit solution, we solve the model using a first-order approximation.[20] We assume shocks have bounded support, that is, there exists $\sigma > 0$ such that deviations of $x_{j,t}$ and $\xi_{j,t}$ from their $t-1$-conditional expectations lie in $[-\sigma, \sigma]$ for all j and t, and that, for some period T, these deviations are zero for $t > T$. The value of T can be any positive integer, so that our analysis covers any finite number of shocks, however large. We calculate an explicit solution that is valid as long as σ is small, that is, fluctuations in asset return and demand are not too large.

4.2 Equilibrium

Our first result characterizes equilibrium contract returns as a function of asset return and demand shocks.

Proposition 1. *Contract return of intermediary j in period t is*

$$y_{j,t} \simeq (1-\phi)\left[r + \sum_{s=1}^{t} \beta_{j,t}(s)\,(x_{j,s} - r)\right] + f_{j,t}(\overline{x}^t - r, \xi^t), \tag{12}$$

where

$$\beta_{j,t}(s) = \frac{\gamma_j}{\alpha + \frac{1+r}{r}\gamma_j} \qquad \text{for } s < t, \tag{13}$$

$$\beta_{j,t}(t) = \frac{\alpha + \gamma_j}{\alpha + \frac{1+r}{r}\gamma_j}, \tag{14}$$

$\gamma_j > 0$ is a constant independent of α, and $f_{j,t}(.)$ is a function of the history of weighted-average asset return shocks $\overline{x}^t - r$ and the history of demand shocks ξ^t. Closed-form expressions for these variables are in Appendix A.1.

Equation (12) shows the contract return is equal to the expected asset return, r, plus a function

[19] Because we do not clear the capital market, our model is in partial equilibrium. The model is equivalent to a general equilibrium model with constant returns to capital as in Allen and Gale (1997) and Ball and Mankiw (2007). Suppose each intermediary j can lend capital to competitive firms using a linear production function $Y_{j,t} = (1 + x_{j,t})K_{j,t-1}$, where $Y_{j,t}$ is output and $K_{j,t-1}$ is capital. In such an economy, an increase in reserves leads to an increase in the aggregate capital stock. An alternative interpretation of our model is that of a small open economy, in which case an increase in reserves leads to a capital account deficit.

[20] The advantage of using a first-order approximation is that it eliminates any possible interaction between the shocks occurring in different periods. Ball and Mankiw (2007) use a similar method to solve the complete-market equilibrium in which investors are allowed to trade with future investor cohorts.

of the history of shocks to the intermediary's asset return, $x_{j,s} - r$ for $1 \leq s \leq t$, minus the compensation of the intermediary which represents a fraction ϕ of those asset returns, and a function of the history of average asset returns $\overline{x}^t$ and demand shocks ξ^t. The key coefficients in (12) are the $\beta_{j,t}(s)$, which pin down the extent of risk sharing across investor cohorts. $\beta_{j,t}(s)$ measures the sensitivity of period-t contract return, $y_{j,t}$, to period-s asset return, $x_{j,s}$. When $\beta_{j,t}(s) > 0$, the period-t investor cohort bears some of period-s asset risk.

The contract return policy (12) implies period-s asset risk is shared between the current (period-s) cohort (because $\beta_{j,s}(s) > 0$) and all future cohorts (because $\beta_{j,t}(s) > 0$ for $t > s$). In turn, Equations (13) and (14) show the extent of inter-cohort risk sharing depends on the elasticity of demand to expected contract return, α. When demand is inelastic ($\alpha \simeq 0$), $\beta_{j,s}(s) = \beta_{j,t}(s)$ for all $t > s$ so that asset risk is perfectly shared between the current and future cohorts. When demand is elastic ($\alpha > 0$), $\beta_{j,s}(s) > \beta_{j,t}(s)$ for $t > s$ such that more asset risk $x_{j,s}$ is shifted to the contemporaneous (period-s) cohort. As a result, asset risk is imperfectly shared across investor cohorts when demand is elastic.

The intuition behind Proposition 1 is that when demand is elastic, future investor cohorts behave opportunistically by investing more (less) when reserves are higher (lower). For instance, when the asset return is high, the intermediary would like to share in gains with future investor cohorts by hoarding part of the return as reserves. When demand is elastic, however, future investors flow in, diluting reserves and undoing the sharing of gains. Conversely, when the asset return is low, the intermediary would like to share in losses with future investor cohorts by tapping reserves and replenishing them in future periods. In this case, future investors flow out, preventing the intermediary from replenishing reserves and undoing the sharing of losses. In the limit when demand is perfectly elastic ($\alpha \simeq \infty$), inter-cohort risk sharing unravels completely: $\beta_{j,s}(s) = 1$ and $\beta_{j,t}(s) = 0$ for $t > s$.

We denote by R_{j,t^-} the amount of reserves at the end of period t just before distribution to investors. This amount is equal to beginning-of-period reserves plus asset income:

$$R_{j,t^-} = R_{j,t-1} + x_{j,t}(V_{j,t-1} + R_{j,t-1}). \tag{15}$$

We also denote by $\mathcal{R}_{j,t^-} \equiv R_{j,t^-}/V_{j,t-1}$ the reserve ratio to total account value. Our next result is that period-t contract return in Proposition 1 depends on the history of past asset returns, $\overline{x}^{t-1}$, *only through* its effect on the reserve ratio.

Proposition 2. *Contract return of intermediary j in period t is*

$$y_{j,t} \simeq (1-\phi)r + \frac{1-\phi}{1+r}\frac{\alpha}{\alpha + \frac{1+r}{r}\gamma_j}(x_{j,t} - r) + \frac{(1-\phi)r}{1+r}(\mathcal{R}_{j,t^-} - r) + \mu_j(\overline{x}_t - r) + \nu_j \Delta\xi_{j,t}, \quad (16)$$

where $\gamma_j > 0$ is a constant independent of α, $\mu_j < 0$ goes to zero when α goes to zero or infinity, $\overline{x}_t$ is a weighted average of $x_{k,t}$ over $k = 1, \ldots, J$, $\nu_j > 0$ goes to zero when α goes to infinity, and $\Delta\xi_{j,t}$ is a demand shock. Closed-form expressions for these variables are in Appendix A.3.

Proposition 2 shows how the share of asset risk borne by current investors depends on the elasticity of demand. When demand is inelastic ($\alpha \simeq 0$), the coefficient in front of $x_{j,t}$ in (16) is equal to zero. The contract return then does not depend on the current asset return beyond its effect on the reserve ratio; that is, asset risk is perfectly shared across investor cohorts. When demand is elastic ($\alpha > 0$), the coefficient in front of $x_{j,t}$ is strictly positive. The intermediary then shifts more asset risk to the current cohort. In this case, the contract return depends on the current asset return above and beyond its effect on the end-of-period reserve ratio; that is, asset risk is imperfectly shared across investor cohorts.

An implication of Proposition 2 is that the reserve ratio $\mathcal{R}_{j,t^-}$ is a sufficient statistic for the history of shocks. All that matters for setting the contract return is the intermediary's current reserve ratio, not the path leading to that ratio. Indeed, in (16), the contract return does not depend on past shocks beyond their effect on the reserve ratio. The sensitivity of the contract return to the reserve ratio results from the following tradeoff faced by the intermediary. On the one hand, paying out a larger fraction of reserves to current investors leads to higher demand and thus higher profit in the current period. On the other hand, tapping reserves today implies paying lower returns to future investors, lowering future demand and hence future profit. The optimal choice is to pay out in the current period a fraction of reserves equal to the weight of current investors in intertemporal profit, equal to $\frac{r}{1+r}$, a fraction $1-\phi$ of which accrues to investors.

Proposition 2 also implies an intermediary's contract return depends negatively on other intermediaries' asset returns, because $\mu_j < 0$. Intuitively, when other intermediaries have high asset returns they increase contract returns both in the current period and in future periods, which reduces intermediary j's future demand, but not its current-period demand which is realized before asset returns. Intermediary j's optimal response is then to increase future contract returns by lowering the current contract return so as to avoid losing too large future market shares.[21] This effect

[21] This best-response reflects the strategic complementarity property of logit demand, that is, the property whereby contract return best-response functions are increasing in other intermediaries' contract returns.

vanishes when demand is perfectly inelastic ($\alpha \simeq 0$), because intermediary j then has no incentive to react; and it vanishes when demand is infinitely elastic ($\alpha \simeq \infty$), because other intermediaries then do not change the future contract return in response to asset return shocks. Finally, the contract return depends on the demand shock $\Delta\xi_{j,t}$ realized at the end of the period. Intuitively, the intermediary has incentives to lean against a negative shock to future demand, by lowering the contract return in the current period and increasing reserves to promise higher returns in the future.

4.3 Contracts complete markets

A crucial implication of Proposition 2 is that the contract return cannot be replicated using existing market instruments. A first, mundane reason is that the contract return (16) includes an error term that depends on the realized demand shock, which may not be tradable. Let us exclude this reason by focusing on the case without demand shocks, that is, $\Delta\xi_{j,t} = 0$. The contract return can then be replicated *up to a constant* by positions in (i) the assets held by insurer j, generating the return $x_{j,t}$; (ii) a weighted portfolio of assets held by all insurers, generating the return $\overline{x}_t$; and (iii) the risk-free asset, generating the return $r_f < r$. We show in Proposition 3 that this constant is nonzero.

Proposition 3. *In the absence of demand shocks, the contract return can be replicated up to a constant by the assets held by insurers and the risk-free asset. The return difference between the contract and the replicating portfolio is*

$$\left[1 - (1-\phi)\frac{\alpha + \gamma_j}{\alpha + \frac{1+r}{r}\gamma_j} - \mu_j\right](r - r_f) + (1-\phi)\, r\, \mathcal{R}_{j,t-1} - \phi\, r, \tag{17}$$

where $\mathcal{R}_{j,t-1} \equiv R_{j,t-1}/V_{j,t-1}$ is the beginning-of-period reserve ratio.

The first term in (17) is positive and proportional to the risk premium on the assets held by insurers, $r - r_f > 0$. It reflects the fact that the contract earns the risk premium without bearing all the associated risk (and almost none of it when $\alpha \simeq 0$), because some of this risk is diversified across investor cohorts. That is, the replicating portfolio with the same risk exposure as the contract return must have a lower risk exposure than the insurer's asset portfolio. Therefore, the replicating portfolio earns a lower risk premium than the contract. Correspondingly, the term in large brackets which multiplies the risk premium in (17) is positive and equal to the difference between the risk exposure of the insurer's portfolio and that of the contract return. The second term is proportional to the reserve ratio and arises from the predictable distribution of reserves in the contract return. The third term is negative and equal to the fees.

When reserves are equal to their unconditional mean (normalized to zero) and fees are not too high, Proposition 3 implies that the contract strictly dominates the replicating portfolio. The contract reaches a point beyond the efficient frontier based on market instruments, because the contract shares asset risk with future cohorts of investors who do not yet participate in the market. By contrast, inter-cohort risk sharing cannot be achieved using market instruments. In this sense, the contract completes financial markets.

Proposition 3 could imply that there exists an arbitrage opportunity consisting in buying the contract and shorting the replicating portfolio. We analyze this possibility in more depth in Section 6.3 and show that, in practice, arbitrage is made unprofitable by the non-deductibility of interest expenses on levered financial investments by households.

4.4 Empirical implications

We now derive two relations that can be estimated in the data to back out the elasticity of demand, which is the key determinant of equilibrium risk sharing.

The first relation is the contract return policy. The coefficients γ_j, μ_j, and ν_j from Proposition 2, are intermediary-specific, because the optimal contract return depends on the elasticity of demand, itself a function of the intermediary's market share due to logit demand. A closer inspection of these coefficients (reported in Appendix A.3) reveals they only depend on market shares up to second-order terms. When market shares are not too large, equilibrium contract returns can be approximated as follows:

Relation 1 (contract return policy). *For small market shares, the period-t contract return of intermediary j is*

$$y_{j,t} \simeq cste_t + \frac{1-\phi}{1+r}\frac{\alpha}{\alpha+\frac{1+r}{r}\gamma}x_{j,t} + \frac{(1-\phi)r}{1+r}\mathcal{R}_{j,t^-} + \varepsilon_{j,t}, \tag{18}$$

where $cste_t$ is a period-specific constant, $\gamma = \frac{-u''((1-\phi)r)}{u'((1-\phi)r)} > 0$ is the coefficient of absolute risk aversion, and $Cov\big((x_{j,t}, \mathcal{R}_{j,t^-}), \varepsilon_{j,t}\big) \simeq 0$.

Relation 1 implies the coefficients in the equilibrium contract return policy (18) can be estimated by running a linear regression with time fixed effects in a panel of intermediaries. Relation 1 also implies the model can be easily rejected, because it predicts the coefficient in front of the reserve ratio should be commensurate with the expected asset return. The coefficient in front of the current

asset return is informative about the elasticity of demand: it varies monotonically from zero to one as α varies from zero to infinity.

The second relation is that between flows and reserves:

Relation 2 (**flow-reserves relation**). *Net flows to intermediary j in period t are given by*

$$\log(V_{j,t-1}) \quad \simeq \quad cste_j + cste_{t-1} + \alpha\,(1-\phi)\,r\,\mathcal{R}_{j,t-1} + \xi_{j,t-1}, \tag{19}$$

where $cste_j$ and $cste_{t-1}$ are intermediary-specific and period-specific constants, respectively, $\mathcal{R}_{j,t-1}$ is the beginning-of-period reserve ratio, and $Cov(\mathcal{R}_{j,t-1}, \xi_{j,t-1}) < 0$. Moreover, lagged asset return $x_{j,t-1}$ is a valid instrument for $\mathcal{R}_{j,t-1}$.

We know from Proposition 2 that the contract return paid at the end of period t depends on the end-of-period reserve ratio, itself determined by the beginning-of-period reserve ratio. Correspondingly, Relation 2 states that investor demand depends on the reserve ratio at the beginning of the period. The sensitivity of investor demand to the reserve ratio is equal to the product of the sensitivity of investor demand to expected contract return, α, and the sensitivity of expected contract return to the beginning-of-period reserve ratio, $(1-\phi)r$.

The coefficient $\alpha\,(1-\phi)\,r$ in the flow-reserves relation can be estimated by running a linear regression with time and intermediary fixed effects. The OLS estimate is unbiased if intermediary-specific demand shocks are zero, or if they are observable to the econometrician and can be controlled for. In the presence of unobservable demand shocks, however, the error term is negatively correlated with reserves. Intuitively, when the intermediary anticipates a negative demand shock, it optimally increases reserves to increase future contract returns and lean against the demand shock, generating a spurious negative correlation between reserves and demand. This correlation creates a downward bias in the OLS estimate. The bias can be corrected by instrumenting reserves using lagged asset returns. Indeed, lagged asset returns affect reserves because a fraction of asset returns are hoarded as reserves (relevance condition), but they are not directly correlated with demand shocks beyond their effect on reserves (exclusion restriction).

5 Demand (In)Elasticity to Reserves

The key insight from the model is that the equilibrium level of inter-cohort risk sharing depends on the elasticity of demand to expected returns conditional on reserves, that is, on the value of

α. Specifically, a demand that is inelastic to reserves ($\alpha \simeq 0$) allows for perfect inter-cohort risk sharing, whereas a demand that is perfectly elastic to reserves ($\alpha \simeq \infty$) unravels inter-cohort risk sharing. The model shows that α can be identified from two moments given by Relations 1 and 2. Guided by the results in Section 4.4, we estimate each of these moments in turn, by running panel regressions.

5.1 Relation 1: Contract return policy

The first implication of the model is that after controlling for the current reserve ratio, equilibrium contract returns depend positively on current asset returns if $\alpha > 0$, and do not depend on current asset returns if $\alpha \simeq 0$. We estimate the contract return policy given by Relation 1 by running a panel regression with year fixed effects. According to our model, insurer fixed effects are not necessary, because the model assumes no heterogeneity in expected asset return across insurers. Yet, our preferred specification does include insurer fixed effects to account for such heterogeneity in the data.[22] We estimate weighted regressions using the insurer share of account value in aggregate account value as weights.[23] We calculate standard errors two-way clustered by insurer and by year.

Results are reported in Table 3. In line with the model, the coefficient on the reserve ratio is positive and statistically significant at the 1% level, in both specifications. In our preferred specification with insurer fixed effects (Column 2), the point estimate implies a one-percentage-point increase in the reserve ratio is associated with a 3.5-basis-point increase in the annual contract return. That is, out of each additional euro of reserves, 3.5 cents are credited to investor accounts per year. The model predicts a regression coefficient equal to $(1-\phi)r/(1+r)$. Thus, the estimate of 0.035 and $\phi = 0.15$ imply $r = 4.3\%$, consistent with the average asset return observed during the period.[24]

The coefficient on the asset return is not statistically different from zero when insurer fixed effects are not included (Column 1). In other words, the contract return does not depend on the contemporaneous asset return beyond its effect on the reserve ratio, which is consistent with $\alpha \simeq 0$. The coefficient on the asset return is slightly negative and even becomes statistically significant when

[22] In the model, including insurer fixed effects does not lead to a misspecified regression, because it only adds regressors that are uncorrelated with the dependent variable and with the other explanatory variables. In the data, insurer fixed effects in contract return regressions are always jointly significant at statistical levels below 1%.

[23] We obtain similar results when we estimate non-weighted regressions (untabulated).

[24] The sample average asset return is 4.9% (Table 1), perhaps because realized asset returns have been above expected returns during the sample period. As discussed in Section 2.2, the reserve ratio rose by 25 basis points per year, while positive net flows should have diluted reserves at a rate of 25 basis points per year. Therefore, insurers have retained approximately 50 basis points of realized asset returns in reserves, consistent with an ex-ante expected return of approximately 4.4%.

insurer fixed effects are included (Column 2). Now, recall that the contemporaneous asset return enters positively into the reserve ratio (Equation (15)). Therefore, the contract return depends positively on the contemporaneous asset return because the sum of the coefficients on the reserve ratio and on the contemporaneous return is positive (equal to 0.17 with p-value at 0.15). The negative coefficient implies the contract return in year t is more sensitive to lagged asset returns (in years $s < t$) than to the contemporaneous asset return (in year t). Two institutional factors can explain this seemingly surprising result. First, amounts withdrawn through the calendar year are usually credited a pro rata return calculated based on the lagged contract return. Second, insurers sometimes guarantee new clients a higher return in the first year of the contract for marketing purposes. As a result, contract returns associated with these inflows and outflows do not depend on the current year asset return, which weakens the relation between the contract return and the contemporaneous asset return.

In conclusion, the empirical contract return policy rejects $\alpha > 0$ and is instead consistent with $\alpha \simeq 0$.

5.2 Are reserves really pooled across investor cohorts?

Inter-cohort risk sharing arises to the extent that reserves are pooled across investor cohorts. As discussed in Section 2.1, in principle, insurers could undo reserves pooling by closing existing contracts to new subscriptions when reserves are high, and creating a new vintage of contracts to price in the high level of reserves for new investors. Pricing of reserves could be done by creating new contracts with (a) higher entry fees, (b) higher management fees, (c) lower before-fees contracts return, or any combination of (a), (b), and (c), when reserves are higher.

We use two different sources of contract-level information to test whether insurers follow any of the (a), (b), or (c) strategies. First, we use data on fees to test for (a) and (b). The data is a snapshot of contracts with positive outstanding account value in 2017 (even if the contract is no longer commercialized in 2017). The fee structure is fixed at the subscription of the contract and written in the contract prospectus. Because, for a given contract, some investors hold their contract for many years, it is sufficient to have a snapshot of outstanding contracts in 2017 to retrieve the fee structure of all contracts sold throughout the sample period 2000–2015. The data also reports the time period during which each contract was open to new subscriptions. For each insurer j and each year t over 2000–2015, we calculate the average entry fee and average management fee across all contracts offered by insurer j and open to new subscriptions in year t. We regress the average fee on

the insurer's beginning-of-year reserve ratio. If insurers price reserves into fees, the coefficient on the reserve ratio would be positive. Results in Table 4 show that insurers neither follow strategy (a) by adjusting entry fees (Column 1) to the level of reserves, nor strategy (b) by adjusting management fees (Column 2) to the level of reserves.

Second, we use data on net-of-(management-)fees returns at the contract level to test whether insurers do a combination of (b) and (c). The data is from a survey conducted by the insurance supervisor since 2011. Each survey is a snapshot of contracts with positive outstanding contract value (even if the contract is no longer commercialized in the survey year) with information on the net-of-fees contract return. The data reports the first year in which the contract was commercialized. For each contract c of vintage s, we retrieve the insurer's reserve ratio at the beginning of year s from the regulatory filings. We obtain a panel at the contract (c) $\times$ vintage year (s) $\times$ return year (t) level, where vintage years run throughout the sample period 2000–2015 and return years are from 2011 to 2015. We regress the net-of-fees return (of contract c in year t) on the reserve ratio in the contracts' vintage year (at beginning of year s) with insurer and vintage year fixed effects.[25] If insurers followed strategies (b) or (c) of pricing reserves by adjusting future net-of-fees contract returns, the coefficient on the reserve ratio in the contract's vintage year would be negative. Column 3 of Table 4 shows this is not the case. Insurers do not discriminate across investor cohorts based on the level of reserves when investors enter into the contract.

In conclusion, reserves are indeed pooled across investor cohorts.

5.3 Relation 2: Flow-reserves relation

The second implication of the model is that investor flows depend positively on the reserve ratio if $\alpha > 0$, whereas flows are insensitive to reserves if $\alpha = 0$. In the model, the dependent variable in the flow-reserves relation given by Equation (19) is the log level of the invested amount, rather than the usual definition of flows as the change in the invested amount. The reason is that investments are assumed to be one-period in the model, so that the outflow rate is 100% at the end of each period. Instead, real-world contracts are automatically renewed from year to year unless the investor redeems shares. Accordingly, we estimate the flow-reserves relation using the usual concept of net flows, defined as inflows minus outflows divided by beginning-of-year account value. We estimate panel regressions with insurer and year fixed effects. We run separate regressions for net flows and for the three components of net flows: (plus) inflows, that is, premia, which come either from

[25] Because we stack the five snapshots of return data, we interact the fixed effects with return-year dummies.

investors already holding a contract and adding money to their account or from new investors; (minus) redemptions, which are voluntary outflows; and (minus) payments at contract termination, which are involuntary outflows (due to investor death). One should expect the former two to respond to the level of reserves if $\alpha > 0$, but not the latter. One might also expect inflows to be more sensitive to reserves than redemptions, because redemptions are more likely to be driven by liquidity motives.

Table 5 contains the results. The sensitivity of net flows to the beginning-of-year reserve ratio is not significantly different from zero (Column 1). The net-flow decomposition yields similar results: Neither inflows (Column 2) nor outflows (Columns 3 and 4) are sensitive to reserves. We can reject at the 5% level that the regression coefficient of net flow on the reserve ratio is larger than 0.12. Combined with our estimate of the predictive power of reserves for future contract returns, a coefficient of 0.12 implies a semi-elasticity of demand to expected returns conditional on reserves of 4.6; that is, a change in reserves implying a one percentage point increase in future contract returns increases net flow by 4.6 percentage points.[26] In comparison, Drechsler, Savov, and Schnabl (2017) estimate the semi-elasticity of bank deposits to the spread between interest rates on deposits and the Fed Fund rate to be 5.3.[27] We conjecture demand for euro contracts is inelastic to reserves whereas the demand for deposits is elastic to deposit spreads, because the predictive power of reserves for contract returns is not easily comprehensible whereas the deposit spread is readily observable and easy to understand. We provide evidence consistent with this interpretation at the end of this section and in Section 6.2.

Relation 2 implies that the OLS estimate of the flow-reserves relation has a downward bias if insurers face flow shocks anticipated by insurers but unobservable to the econometrician.[28] The bias caused by unobservable demand shocks can be corrected by instrumenting reserves using past asset returns. The first stage is strongly significant (F-stat equal to 29 with standard errors two-way

[26]The semi-elasticity is computed as the regression coefficient of net flows on reserves rejected at 5% (0.12 in Column 1 of Table 5) divided by the regression coefficient of the contract return on reserves (0.026 in Column 1 of Table 3).

[27]The semi-elasticity of the demand for S&P 500 index funds to the fee estimated by Hortaçsu and Syverson (2004) and that for variable annuities estimated by Koijen and Yogo (2018) are not directly comparable to our estimate for euro contracts. The reason is that euro contracts are demandable, so we measure demand in terms of net flows divided by account value, which can be positive or negative and is similar to a growth rate of account value. This is in line with Drechsler, Savov, and Schnabl (2017), who measure demand for deposits in terms of growth rate of deposits. By contrast, Hortaçsu and Syverson (2004) and Koijen and Yogo (2018) measure demand in terms of log purchase flows. In Appendix D.1, we suggest an adjustment to our estimate to make it comparable to theirs, and find the elasticity of demand for euro contracts to expected returns conditional on reserves to be significantly lower than the elasticity of demand to fees, both for index funds and variable annuities.

[28]To account for observable demand shocks, in Appendix Table D.2, we estimate the flow regressions controlling for potential determinants of demand, and find that the coefficient on reserves remains small and insignificant.

clustered by insurer and year). The second stage regressions are presented in Panel B of Table 5. In Column 1, the IV estimate of the net flow-reserves sensitivity is slightly higher than the OLS estimate, but it remains small and statistically insignificant. In Column 3, the redemption-reserves sensitivity is negative (i.e., investors redeem less when reserves are higher) and significant at 10%, but the economic magnitude is small (the semi-elasticity is 3). Overall, the IV regressions confirm that flows are at most barely elastic to reserves. To conclude, the empirical flow-reserves relationship rejects $\alpha > 0$ and is instead consistent with $\alpha \simeq 0$.

The fact that flows are inelastic to reserves even though reserves predict returns does not imply that investors do no care about returns. Investors may fail to predict returns using reserves (see Section 6.2), but they react to more transparent sources of predictability. In Appendix D.3, we study how flows to euro contracts react to changes in the interest rate on a regulated savings product which competes with euro contracts. This product's regulated interest rate is readily observable and regularly discussed in the press, so that even unsophisticated investors are aware of its evolution. Consistent with flows reacting to more salient sources of predictability, we find that flows to euro contracts decrease when the regulated interest rate on the competing savings product increases.

5.4 Reserves predict contract returns

Because reserves are not diluted by investor flows (as shown in the previous section) and are owed to investors (by regulation), the reserve ratio should predict future contract returns. We verify this prediction in Table 6. In Column 1, we regress the contract return paid at the end of year t on the reserve ratio at the beginning of year t in the insurer-year panel with year fixed effects.[29] The coefficient on the beginning-of-year reserve ratio is positive and statistically significant at the 1% level. Therefore, the reserve ratio predicts the expected contract return at a one-year horizon: Contracts with higher reserves have higher expected returns.

Higher reserves predict higher expected contract return because reserves are eventually distributed to investors—not because higher reserves are associated with higher risk. To show this, we consider a zero-cost portfolio that is invested long in contracts with high reserves and short in contracts with low reserves. At the beginning of each year, we rank insurers on the $[0, 1]$ interval based on the beginning-of-year reserve ratio, and use portfolio weights proportional to insurers' rank minus one-half. Columns 1 and 2 of Table 7 show the performance of each leg of the portfolio, and

[29] We do not include insurer fixed effects because we are running a predictive regression, which would estimate insurer fixed effects on the entire sample period. In the (untabulated) regression with insurer fixed effects, the coefficient on the lagged reserve ratio is 0.03 and significant at the 1% level.

Column 3 that of the long-short portfolio. The first row confirms that higher reserves predict higher expected returns: Average returns are 34 basis points per year higher for high-reserves contracts than for low-reserves contracts.

The second and third rows of Table 7 report the estimates of a market model. The difference in market beta between high-reserves and low-reserves contracts is a precisely estimated zero (a difference in beta larger than 0.01 is rejected at the 1% level), implying alpha is 34 basis points higher for high-reserves contracts than for low-reserves contracts, on average.[30] Therefore, the predictability of expected contract returns does not reflect a compensation for market risk.

The fourth row reports the cross-sectional standard deviations of high- and low-reserves contracts returns, averaged over time. We find the difference between the two groups is a precisely estimated zero. Therefore, the predictability of expected contract returns does not reflect a compensation for idiosyncratic risk either.

Reserves should predict contract returns not only at one year but also at longer horizons, because reserves are only progressively distributed to investors. We show in Appendix E that the predictive power of reserves for future contract returns should decay at the same rate as the one at which the reserve ratio mean reverts. The reserve ratio mean reverts for two reasons. First, reserves are progressively credited to investors' accounts (at a rate of 3% per year in Columns 1–2 of Table 3). Second, inflows dilute reserves at a rate equal to the unconditional net flow rate (2.4% per year in Table 1) plus a term that depends on the sensitivity of flows to reserves (equal to zero in Table 5). Thus, the reserve ratio should mean revert at a rate of 5.4% per year. The predictive power of reserves for future contract returns should also decay at a rate of 5.4% per year.

In Columns 2–5 of Table 6, we check that the data is consistent with the above calculation. We regress contract return in years t, $t+1$, $\ldots$, $t+4$, on the reserve ratio at the beginning of year t. The regression coefficient on the initial reserve ratio decays at a rate of about 7%, which is close to the predicted rate of 5.4%. In conclusion, reserves predict future contract returns over many years.

[30] The large t-stat of the alpha estimate reflects the fact that the predictive power of reserves is almost mechanical. Because reserves must eventually be distributed to investors, they must predict future contract returns. The null hypothesis rejected by the non-zero alpha is merely that insurers do not divert reserves.

6 Why Is Demand Inelastic to Reserves?

6.1 Switching costs

We test whether the low elasticity of flows to reserves is explained by switching costs created by the tax treatment of euro contracts. As described in Section 2.1, contract returns are taxed upon withdrawal at a rate that depends on the age of the contract at the time of withdrawal: the tax rate is 35% if contract age is less than four years, 15% between four and eight years, and 7.5% after eight years.[31] Therefore, an investor owning a contract and willing to increase her investment in euro contracts faces a tax incentive to add cash on her existing contract rather than buying a new contract.

In contrast to other investors, new investors are not subject to the tax-induced switching cost. Therefore, if the low elasticity of flows to reserves is explained by switching costs, purchases of new contracts should react to reserves. Instead, if the low elasticity is explained by something else, then purchases of new contracts should be as inelastic to reserves as total flows are. We test whether purchases of new contracts react to reserves using information on the number of new contracts purchased from each insurer in each year. Insurers have been required to report this information since 2006, therefore, the sample period for this test is restricted to 2006–2015. We regress the number of new contracts purchased divided by the number of outstanding contracts on the beginning-of-year reserve ratio. Table 8 shows that both in our OLS and IV estimations, new investors' inflows are not sensitive to the level of reserves. We conclude that switching costs induced by taxes cannot explain the low elasticity of inflows to reserves.

Another switching cost stems from entry fees that investors incur when they add cash to their contract, creating a disincentive to move cash from one contract to another. However, entry fees do not distort the choice of contract for newly invested money, because entry fees are incurred regardless of the contract chosen, and we have shown insurers do not adjust entry fees to the level of reserves (Table 4). Therefore, entry fees cannot explain the low elasticity of total inflow to reserves (Column 2 of Table 5) nor the low elasticity of new investors' inflow (Table 8).

6.2 Investor sophistication

We test whether flows are inelastic to reserves because investors lack the knowledge to predict contract returns using reserves. This lack of knowledge could be due to investors simply not under-

[31] See Appendix F for an estimate of the tax-induced switching cost.

standing that reserves predict returns, or perhaps investors not being able to obtain information on the level of reserves.[32] To test that hypothesis, we study whether the flow-reserves sensitivity varies across investors with different levels of financial sophistication. We proxy for investor sophistication using the investment amount, the idea being that financial sophistication is correlated with wealth, for instance, if investors must incur a fixed cost to acquire the knowledge necessary to predict returns (Lusardi and Mitchell, 2014).

We construct the proxy for investor sophistication using contract-level data collected by the insurance supervisor for the years 2011 to 2015. The data contains information on the number of investors, the total account value, and the net-of-fees return for every contract. We calculate the average individual account value as the total account value divided by the number of investors. We classify contracts into three size bins according to the average account value: below 50,000 euros, 50,000–250,000 euros, and above 250,000 euros. We also construct net flows at the contract level.

We exploit cross-sectional variation in investor sophistication along two dimensions. First, we exploit variation across insurers. Some insurers cater to wealthier, hence more sophisticated, clienteles. Second, we exploit variation across contracts within a given insurer. As described in Section 2.1, insurers often offer different contracts with different minimum investment amounts that target different clienteles. A crucial feature of the institutional framework is that reserves are pooled across all contracts of a given insurer, so that reserves predict returns for all contracts. Therefore, we can exploit cross-contract variation in investor sophistication to test whether the flow-reserves sensitivity varies within a given insurer-year. We regress net flows at the contract level on the beginning-of-year reserve ratio interacted with dummy variables for each bin of average account value (and on the non-interacted dummy variables).

The first specification (Column 1 of Table 9) does not include insurer-year fixed effects and thus exploits cross-insurer variation in investor sophistication. The flow-reserves sensitivity is small and statistically insignificant both for contracts with small and intermediate average account value (below 250,000 euros per investor). By contrast, the flow-reserves sensitivity is positive and statistically significant at the 10% level for contracts with larger average account value (above 250,000 euros per investor). Combined with our estimate of the predictive power of reserves for future contract returns, the point estimate implies a semi-elasticity of sophisticated net flows to expected returns conditional on reserves of 14; that is, a change in reserves implying a one percentage point increase

[32] Although insurers' annual reports contain information on the level of reserves, it often is incomplete or consolidated at the group level.

in future contract returns increases sophisticated net flow by 14 percentage points.[33]

The second specification (Column 2 of Table 9) includes insurer-year fixed effects and thus isolates cross-contract variation in investor sophistication within insurer-years. In that case, the absolute level of the flow-reserves sensitivity is no longer identified, because it is defined at the insurer-year level. We use the small-average-account-value category as the reference group. The results are consistent with those obtained in the first specification: The flow-reserves sensitivity is larger for contracts with large account values than for contracts with smaller account values. The difference is significant at the 1% level. The IV estimates yield similar results (Columns 3 and 4).

These results are consistent with low financial sophistication explaining the low elasticity of flows to reserves. Only investors with large investments time reserves, because they are more likely sophisticated and have incentives to understand the mechanics of inter-cohort redistribution through reserves. Therefore, perhaps surprisingly, the lack of household financial sophistication enables more risk sharing than would be possible if households were perfectly informed and acted accordingly.

6.3 Do arbitrage opportunities exist?

Does the predictability of contract returns generate an arbitrage opportunity that an investor who perfectly understands euro contracts could trade on? If this was the case, a single arbitrageur would unravel the inter-cohort risk sharing equilibrium. In this section, we show the role of the capital income tax is crucial to prevent this from happening.

Proposition 3 implies contract returns can be replicated up to a constant by a portfolio composed of the assets held by insurers and the risk-free asset. Because euro contracts cannot be sold short, if an arbitrage strategy exists, it consists in long positions in euro contracts and short positions in the assets held by insurers and the risk-free asset. In France, as in many other countries, households interest expenses in levered financial investments are not tax deductible.[34] Therefore, the return on the long leg of the arbitrage strategy is taxable, whereas the return on the short leg is not tax deductible. We denote the capital income tax rate by τ and the risk-free rate by r_f. We show in Appendix A.7 that one euro invested long in contract j hedged with short positions in the replicating

[33] The semi-elasticity is computed as the regression coefficient of net flows on reserves in contracts with average account value above 250,000 euros (0.36 in Column 1 of Table 9) divided by the regression coefficient of contract return on reserves (0.026 in Column 1 of Table 3).

[34] In some countries, including France and the US, interest paid on mortgages, student loans and business loans often are tax deductible, but interest expenses in levered financial investments typically are not. Since euro contracts can only be purchased by households, the relevant tax regime is that of households.

portfolio generates a risk-free profit

$$\pi_{j,t}^{arb} \simeq \left[1 - \frac{(1-\tau)(1-\phi)r}{1+r}\right](r - r_f) + (1 - \tau)(1 - \phi)r\,\mathcal{R}_{j,t-1} - \tau r - (1 - \tau)\phi r \quad (20)$$

when $\alpha \simeq 0$.

Equation (20) highlights the two sources of arbitrage profits and the two arbitrage costs. First, contract returns are hedged against asset risk, yet they earn the risk premium on the risky assets held by insurers. An arbitrageur going long the contract and short the underlying assets earns the risk premium without bearing the associated risk. This source of arbitrage profits is reflected in the first term of $\pi_{j,t}^{arb}$: $r - r_f > 0$ is the risk premium, and the term in brackets is equal to one minus the exposure of the after-tax contract return to asset risk. This term is close to one because contract returns are almost perfectly hedged against asset risk. The second source of arbitrage profits comes from the predictable distribution of reserves to contract holders. It is reflected in the second term of $\pi_{j,t}^{arb}$, which is proportional to the reserve ratio. The costs of the arbitrage strategy are the tax on the expected asset return (third term of $\pi_{j,t}^{arb}$) and the insurer compensation (fourth term).

The key insight from (20) is that a capital income tax is sufficient to eliminate arbitrage opportunities; that is, $\pi_{j,t}^{arb} < 0$ if τ is large enough. This result does not rely on euro contracts benefiting from a tax advantage, because it assumes the returns on all long positions are taxed at a uniform rate τ. Neither does this result rely on euro contracts being expensive, because it holds even when ϕ is arbitrarily close to zero.

We calibrate the terms in (20) in Appendix A.7 and show that arbitrage opportunities are eliminated if the capital income tax rate is greater than 26%. In reality, the applicable tax rate depends on the contract holding period. At the end of the sample period, the lowest possible tax rate is 23% (15.5% of social security contributions plus 7.5% of capital income tax). Hence, the actual minimum tax rate is close to our estimate of the minimum tax rate necessary to eliminate arbitrage opportunities.

Note the absence of arbitrage opportunities is not contradictory with our finding in Section 6.2 that the flow-reserves relation is statistically significant among investors with large invested amounts. Indeed, conditionally on saving a positive amount, sophisticated households always should buy those contracts with high reserves rather than those with low reserves, even in the presence of a capital income tax. Yet, buying euro contracts and shorting the underlying assets and the risk-free asset is not profitable in the presence of a large enough capital income tax.

7 Conclusion

We provide the first evidence of a large scale, and private, implementation of inter-cohort risk sharing. The evidence implies that financial intermediaries can complete markets, by allowing different investor cohorts to share risk, which they cannot achieve even in fully developed financial markets. Such inter-cohort risk sharing is desirable from an *ex-ante* welfare perspective, that is, under the Rawlsian veil of ignorance (Gordon and Varian, 1988; Ball and Mankiw, 2007).

Private implementation of inter-cohort risk sharing requires a two-sided commitment problem be overcome (Allen and Gale, 1997). First, investors must remain invested in contracts even when reserves are low. We show that investment flows are inelastic to reserves, and do not tumble when reserves are low. The demand elasticity is lower among investors who are expected to have lower financial sophistication. Therefore, perhaps paradoxically, lower investor sophistication enables a better sharing of risk— across investor cohorts —than what would be possible if investors were perfectly informed.

Second, insurers must credibly commit not to run away with reserves, which they might be tempted to do when reserves are high. Regulation solves this side of the commitment problem, ensuring reserves are eventually returned to investors. This suggests a reason why inter-cohort risk-sharing savings products exist in several European countries, where such regulation exists, but not in the US, where it does not.

These results have implications for real investment, which we leave for future research. First, spreading aggregate risk across cohorts implies that aggregate consumption is smoothed over time, which requires the capital stock to increase in good time and to decrease in bad time. Hence, inter-cohort risk sharing has implications for the cyclicality of aggregate investment. Second, as Gollier (2008) theoretically shows, intermediaries can invest in more risky assets when risk is shared across cohorts. Therefore, inter-cohort risk sharing has implications for the composition of aggregate investment.

References

ACPR. 2016. "Les chiffres du marché français de la banque et de l'assurance."

Allen, Franklin and Douglas Gale. 1997. "Financial markets, intermediaries, and intertemporal smoothing." *Journal of Political Economy* 105 (3):523–546.

Baddou, S, C-H Huynh, F Malgras, D Marionnet, S Slama et al. 2016. "La situation des assureurs en France au regard des premières remises Solvabilité II en 2016." .

Ball, Laurence and N Gregory Mankiw. 2007. "Intergenerational risk sharing in the spirit of arrow, debreu, and rawls, with applications to social security design." *Journal of Political Economy* 115 (4):523–547.

Becker, Bo and Victoria Ivashina. 2015. "Reaching for yield in the bond market." *Journal of finance* 70 (5):1863–1902.

Bianchi, Milo. 2018. "Financial literacy and portfolio dynamics." *Journal of Finance* 73 (2):831–859.

Calvet, Laurent E, Claire Célérier, Paolo Sodini, and Boris Vallee. 2020. "Can Security Design Foster Household Risk-Taking?" .

Célérier, Claire and Boris Vallée. 2017. "Catering to investors through security design: Headline rate and complexity." *Quarterly Journal of Economics* 132 (3):1469–1508.

Darpeix, Pierre-Emmanuel. 2016. "Le taux technique en assurance vie (code des assurances)." *Analyses et Synthèses (Banque de France)* .

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl. 2017. "The deposits channel of monetary policy." *Quarterly Journal of Economics* 132 (4):1819–1876.

Ellul, Andrew, Chotibhak Jotikasthira, Anastasia V Kartasheva, Christian T Lundblad, and Wolf Wagner. 2018. "Insurers as asset managers and systemic risk." *Kelley School of Business Research Paper* (18-4):18–18.

Ellul, Andrew, Chotibhak Jotikasthira, Christian T Lundblad, and Yihui Wang. 2015. "Is historical cost accounting a panacea? Market stress, incentive distortions, and gains trading." *Journal of Finance* 70 (6):2489–2538.

FFSA-GEMA. 2013. "Les rachats des contrats d'assurance vie après 60 ans." *Document de travail* Conseil d'Orientation des Retraites (8).

Ge, Shan. 2017. "How Do Financial Constraints Affect Product Pricing? Evidence from Weather and Life Insurance Premiums." .

Ge, Shan and Michael S Weisbach. 2019. "The Role of Financial Conditions in Portfolio Choices: The Case of Insurers." .

Gollier, Christian. 2008. "Intergenerational risk-sharing and risk-taking of a pension fund." *Journal of Public Economics* 92 (5):1463–1485.

Gordon, Roger H and Hal R Varian. 1988. "Intergenerational risk sharing." *Journal of Public Economics* 37 (2):185–202.

Greenwood, Robin M and Annette Vissing-Jorgensen. 2018. "The impact of pensions and insurance on global yield curves." .

Handel, Benjamin R. 2013. "Adverse selection and inertia in health insurance markets: When nudging hurts." *American Economic Review* 103 (7):2643–82.

Hirshleifer, Jack. 1971. "The private and social value of information and the reward to inventive activity." *American Economic Review* 61 (4):561–574.

Hortaçsu, Ali and Chad Syverson. 2004. "Product differentiation, search costs, and competition in the mutual fund industry: A case study of S&P 500 index funds." *Quarterly journal of economics* 119 (2):403–456.

Insee. 2016. "Les revenus et le patrimoine des ménages." *Insee Références* édition 2016.

Koijen, Ralph and Motohiro Yogo. 2015. "The cost of financial frictions for life insurers." *American Economic Review* 105 (1):445–475.

———. 2018. "The fragility of market risk insurance." .

Lusardi, Annamaria and Olivia S Mitchell. 2014. "The economic importance of financial literacy: Theory and evidence." *Journal of economic literature* 52 (1):5–44.

Novy-Marx, Robert and Joshua Rauh. 2011. "Public pension promises: how big are they and what are they worth?" *Journal of Finance* 66 (4):1211–1249.

———. 2014. “Linking benefits to investment performance in US public pension systems.” *Journal of Public Economics* 116:47–61.

Scharfstein, David S. 2018. “Presidential address: Pension policy and the financial system.” *Journal of Finance* 73 (4):1463–1512.

Sen, Ishita and David Humphry. 2018. “Capital regulation and product market outcomes.” .

Stiglitz, J. 1983. “On the relevance of public financial policy: indexation, price rigidities and optimal monetary policies.”

Tables and Figures

Figure 1: Aggregate Account Value. The figure shows aggregate account value of euro contracts in billion 2015 (solid blue) euros and the number of insurers in the sample (dashed red).

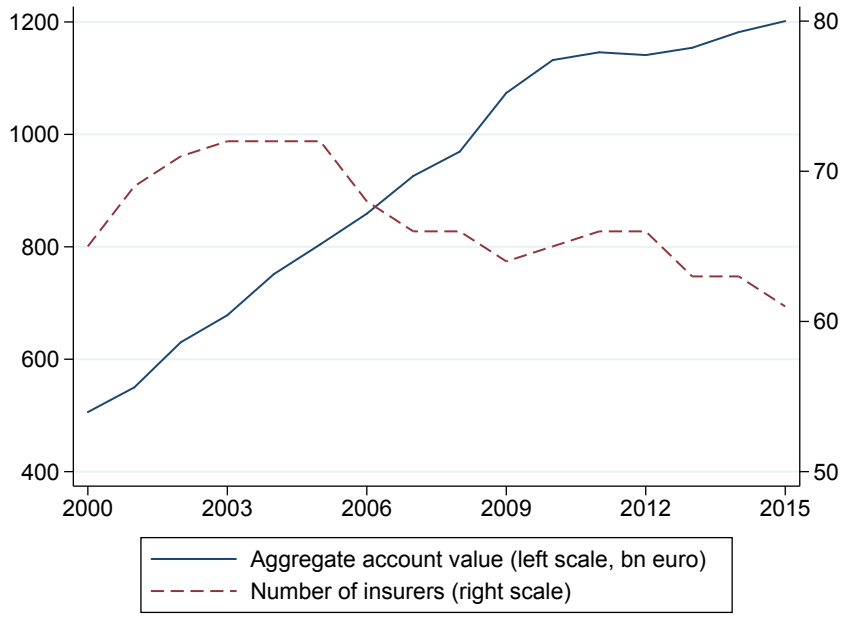


Figure 2: Asset Return vs. Contract Return. The figure shows value-weighted average contract return (solid blue) and value-weighted average asset return (dashed red).

Figure 3: 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 transfer from reserves normalized by account value $-\Delta R_t/V_{t-1}$ (dashed red).

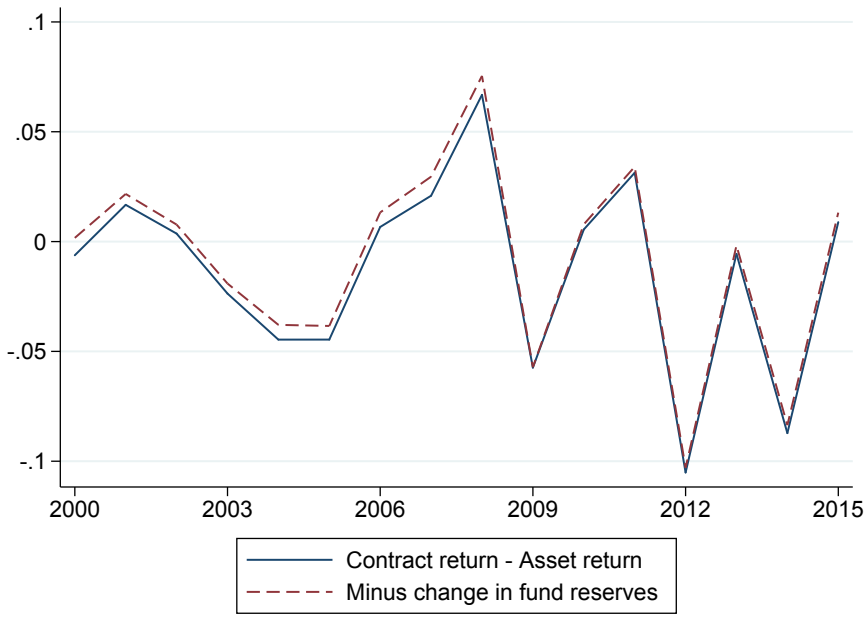


Table 1: Summary Statistics Panel A presents regulatory filings data at the insurer-year level for 76 insurers over 2000–2015. All statistics (except for account value) are weighted by the insurer share in aggregate account value in the current year. *Account value* is total account value at year-end 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 termination) divided by beginning-of-year account value plus one-half of net flows. *Reserves* is total reserves divided by year-end account value. *Portfolio share: bonds* is the share of (corporate and sovereign) bonds, held either directly or through funds, in the asset portfolio. *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 before-fees contract return. Panel B presents prospectus data on fees at the insurer-year level for 48 insurers over 2000–2015. *Management fees* is the average management fees across contracts offered by the insurer and open to new subscriptions in the current year. *Entry fees* is the average entry fees across contracts offered by the insurer and open to new subscriptions in the current year. Panel C presents survey data at the contract-year level for about 2,700 outstanding contracts per year from 56 insurers over 2011–2015. *Net-of-fees return* is the contract net-of-fees return. *Minimum guaranteed return* is the before-fees minimum return guaranteed by the insurer.

	Mean	S.D.	P25	P50	P75	N
Panel A: Regulatory Filings						
Account value (bn euro)	13.9	30.1	0.9	3.1	11.9	978
Inflows (% account value)	10.5	3.8	7.8	10.5	12.3	978
Outflows (% account value)	8.1	2.0	7.1	7.9	8.8	978
Reserves (% account value)	10.9	6.8	6.7	10.5	14.3	978
Portfolio share: bonds (%)	80.4	8.0	75.4	81.5	85.6	978
Portfolio share: stocks (%)	13.5	6.3	10.0	12.5	15.7	978
Asset return (%)	4.9	4.4	2.1	4.4	7.5	978
Contract return (%)	4.0	0.9	3.3	4.0	4.5	978
Panel B: Prospectus Data						
Management fee (%)	.7	.13	.64	.73	.77	578
Entry fee (%)	3.3	.87	3	3.5	3.8	578
Panel C: Survey Data						
Net-of-fees return (%)	2.7	.45	2.4	2.8	3	13,672
Minimum guaranteed return (%)	.35	.73	0	0	0	13,672

Table 2: Inter-Cohort Redistribution. In Panel A, *Net transfer* is defined in (5) for an investor buying a 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 received an additional 1.5 percentage points per year relative to a counterfactual with constant reserves. In Panel B, *Inter-cohort transfer* is defined in (6) and equal to the sum of lifetime net transfer across investors divided by total account value.

Panel A: Net transfer by investor cohort

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

Panel B: Aggregate inter-cohort redistribution

Inter-cohort transfer	
in % account value/year	1.4
in 2015 euros/year	17 billion
in % GDP	0.8

Table 3: Contract Returns. Panel regressions at the insurer-year level for 76 insurers over 2000–2015. *Contract return* is the annual before-fees contract return paid at the end of year t. *Reserve ratio* is total reserves at the end of year t just before annual distribution normalized by total account value. *Asset return* is asset return in year t. All regressions are weighted by the insurer share in aggregate account value in the current year. Standard errors two-way clustered by insurer and year are reported in parenthesis. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

	Contract return ($y_{j,t}$)	
	(1)	(2)
Reserve ratio (R_{j,t^-})	.026***	.035***
	(.0078)	(.0081)
Asset return ($x_{j,t}$)	-.017	-.018**
	(.011)	(.0079)
Year FE	✓	✓
Insurer FE		✓
R^2	.69	.81
Observations	978	978

Table 4: Fees. Columns 1 and 2 present panel regressions at the insurer-year level for 48 insurers over 2000–2015. The dependent variable in Column 1 is *Entry fee* constructed as the average entry fee (frond-end load) of contracts sold by the insurer j in year t. The dependent variable in Column 2 is *Management fee* constructed as the average management fee of contracts sold by insurer j in year t. The independent variable in Columns 1 and 2 is *Lagged reserves* constructed as insurer j's reserves at beginning-of-year t normalized by total account value. The regressions in Columns 1 and 2 include insurer and year fixed effects and are weighted by the insurer share in aggregate account value in the current year. Column 3 presents a panel regression at the contract-vintage year-return year level for about 2,700 outstanding contracts per year from 56 insurers over 2011–2015. The dependent variable in Column 3 is contract return in year t of contract c of vintage year s offered by insurer j. The independent variable in Column 3 is *Lagged reserves* constructed as insurer j's reserves at beginning-of-year s normalized by total account value. The regression in Column 3 includes insurer-return year and vintage year-return year fixed effects and are weighted by the contract share in aggregate account value in the current return year. Standard errors two-way clustered by insurer and year (return year for Column 3) are reported in parenthesis. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

	Entry fee	Management fee	Net-of-fee contract return
	(1)	(2)	(3)
Lagged reserves	-.016	.000054	-.005
	(.011)	(.0011)	(.0056)
Year FE	✓	✓	✓
Insurer FE	✓	✓	✓
R^2	.92	.95	.72
Observations	578	578	13,659

Table 5: Investor Flows. Panel regressions at the insurer-year level for 76 insurers over 2000–2015. *Inflows* is total premia normalized by total account value. *Redemptions* is voluntary redemptions normalized by total account value. *Termination* is involuntary redemptions at contract termination (investor death) normalized by total account value. *Net flows* is Inflows minus Redemptions minus Termination. *Lagged reserves* is the beginning-of-year level of reserves normalized by total account value. Panel A shows OLS regressions. Panel B shows IV regressions in which the insurer's beginning-of-year reserve ratio is instrumented using the insurer's asset return in the previous year (the first year of data for each insurer is therefore dropped from the second stage). All regressions are weighted by the insurer share in aggregate account value in the current year. Standard errors two-way clustered by insurer and year are reported in parenthesis. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

	Panel A: OLS Regressions			
	Net flows	Inflows	Redemptions	Termination
	(1)	(2)	(3)	(4)
Lagged reserves	.035	.031	-.013	.012
	(.038)	(.037)	(.019)	(.0097)
Year FE	✓	✓	✓	✓
Insurer FE	✓	✓	✓	✓
R^2	.63	.73	.74	.79
Observations	978	978	978	978

	Panel B: IV Regressions			
	Net flows	Inflows	Redemptions	Termination
	(1)	(2)	(3)	(4)
Lagged reserves	.086	-.02	-.078*	-.025
	(.098)	(.091)	(.041)	(.02)
Year FE	✓	✓	✓	✓
Insurer FE	✓	✓	✓	✓
R^2	.66	.77	.75	.8
Observations	859	859	859	859

Table 6: Contract Return Predictability. Panel regressions at the insurer-year level for 76 insurers over 2000–2015. *Contract return* is the annual before-fees contract return the end of years t (Column 1), $t+1$ (Column 2), $\ldots$, $t+4$ (Column 5). *Reserves at beginning of year* t is total reserves at the beginning-of-year t normalized by total account value. All regressions include year fixed effects and are weighted by the insurer share in aggregate account value in the current year. Standard errors two-way clustered by insurer and year are reported in parenthesis. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

	Contract return in year				
	t	$t+1$	$t+2$	$t+3$	$t+4$
	(1)	(2)	(3)	(4)	(5)
Reserves at beginning of year t	.025***	.024***	.023**	.019**	.019*
	(.0074)	(.0073)	(.0078)	(.0087)	(.0088)
Year FE	✓	✓	✓	✓	✓
R^2	.69	.71	.62	.61	.57
Observations	978	859	783	717	645

Table 7: High-Reserves Contracts Are Not Riskier. Performance of a portfolio long contracts with beginning-of-year reserves above median and short 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. Column 1 shows the performance of the short leg, Column 2 of the long leg, and Column 3 the performance of the long-short portfolio. *Mean return* is the average return of the leg/portfolio. *Alpha* and *Beta* are the intercept and loading on the market in the market model. *S.D. return* is the time-series average of the cross-sectional standard deviation of contract return within the leg in Columns 1 and 2, and it is the difference between that of the long leg and that of the short leg in Column 3. Newey-West standard errors with two lags are reported in parenthesis. In Column 3, ***, **, and * mean that the difference between the long leg and the short leg is statistically significant at the 1%, 5%, and 10% levels, respectively.

	Low-reserves contracts	High-reserves contracts	Difference High minus Low
	(1)	(2)	(3)
Mean return	.039	.042	.0034***
	(.0029)	(.0030)	(.00035)
Alpha	.039	.042	.0034***
	(.0027)	(.0029)	(.00032)
Beta	-.012	-.0092	.0027*
	(.0070)	(.0075)	(.00092)
S.D. return	.0051	.0042	-.00091
	(.00034)	(.00049)	(.00069)

Table 8: Inflows From New Investors. Panel regressions at the insurer-year level for 67 insurers over 2006–2015 *Purchases of new contracts* is the number of new contracts purchased in the current year divided by the beginning-of-year outstanding number of contracts. *Lagged reserves* is the beginning-of-year level of reserves normalized by total account value. Column 1 shows the OLS regression. Column 2 shows the IV regression in which the insurer's beginning-of-year reserve ratio is instrumented using the insurer's asset return in the previous year. All regressions include insurer and year fixed effects and are weighted by the insurer share in aggregate account value in the current year. Standard errors two-way clustered by insurer and year are reported in parenthesis. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

	Purchases of new contracts	
	OLS	IV
	(1)	(1)
Lagged reserves	.029	-.053
	(.047)	(.14)
Year FE	✓	✓
Insurer FE	✓	✓
R^2	.49	.49
Observations	581	548

Table 9: Financial Sophistication. Panel regressions at the contract-year level *Contract-level net flows* is contract net flows normalized by contract total account value. *Lagged reserves* is insurer beginning-of-year level of reserves normalized by insurer total account value. *Avg account value RANGE* is a dummy variable equal to one if the contract average account value (calculated as contract total account value divided by number of investors) lies in *RANGE*. All regressions include these non-interacted dummy variables in addition to their interaction with lagged reserves. Colums 1 and 3 include insurer and year fixed effects. Colums 2 and 4 include insurer-year fixed effects. Columns 1 and 2 show OLS regressions. Columns 3 and 4 show IV regressions in which the insurer's beginning-of-year reserve ratio is instrumented using the insurer's asset return in the previous year. All regressions are weighted by the contract share in aggregate account value in the current year. Standard errors two-way clustered by insurer and year are reported in parenthesis. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

	Contract-level net flows			
	OLS	OLS	IV	IV
	(1)	(2)	(3)	(4)
Lagged reserves x (Avg account value 0–50 k€)	-.059		-.29	
	(.17)		(.4)	
Lagged reserves x (Avg account value 50–250 k€)	.014	.13	-.13	.25*
	(.17)	(.076)	(.29)	(.15)
Lagged reserves x (Avg account value 250+ k€)	.36*	.41***	.43	.76***
	(.13)	(.0031)	(.26)	(.22)
Avg account value bin FE	✓	✓	✓	✓
Year FE	✓		✓	
Insurer FE	✓		✓	
Insurer-Year FE		✓		✓
R^2	.13	.16	.13	.16
Observations	7,272	7,272	7,268	7,268

Appendix (For Online Publication)

A Proofs

A.1 Proof of Proposition 1

We denote by $\mathcal{H}^t = (x^t, \xi^t)$ the history of shocks up to time t. Intermediary j chooses the contract return policy $\{y_{j,t}(\mathcal{H}^t)\}_{t\geq 1}$ to maximize expected discounted profit

$$E_0\left[\sum_{t=1}^{+\infty}\frac{1}{(1+r)^t}\frac{\phi}{1-\phi}y_{j,t}V_{j,t-1}\big(\{E_{t-1}[u(y_{k,t})]\}_{k=0,\ldots,J}\big)\right], \tag{A.1}$$

where we omit argument $\mathcal{H}^t$ in $y_{j,t}$, and demand for contract j in period t is the function of the collection of expected utility of all contracts' returns

$$V_{j,t-1}\big(\{U_k\}_{k=0,\ldots,J}\big) = \frac{\exp\{\alpha\, U_j + \xi_{j,t-1}\}}{\sum_{k=0}^{J}\exp\{\alpha\, U_k + \xi_{k,t-1}\}}. \tag{A.2}$$

This maximization problem is subject to the intertemporal budget constraint

$$\sum_{t=1}^{+\infty}\frac{1}{(1+r)^t}\left[\left(x_{j,t} - \frac{1}{1-\phi}y_{j,t}\right)V_{j,t-1}\big(\{E_{t-1}[u(y_{k,t})]\}_{k=0,\ldots,J}\big)\prod_{s=t+1}^{+\infty}\frac{1+x_{j,s}}{1+r}\right] \geq 0, \quad \forall\, \mathcal{H}^t, \tag{A.3}$$

(A.1) is obtained by plugging per-period profit (7) into intertemporal profit (8). (A.3) is obtained by plugging profit (7) into the sequential budget constraint (4), consolidating the budget constraint intertemporally, and using the transversality condition (9). (A.3) must hold for all histories $\mathcal{H}^T$.

We denote by $\lambda_j(\mathcal{H}^T)$ the Lagrange multiplier of (A.3) divided by the probability of history $\mathcal{H}^T$. Therefore, the Lagrangian associated with intermediary j's problem is equal to (A.1) plus the time-0 expectation of $\lambda_j(\mathcal{H}^T)$ times the LHS of (A.3). The first-order condition with respect to $y_{j,t}(\mathcal{H}^t)$ is

$$\begin{aligned} E_{t-1}&\left[\frac{\phi}{1-\phi}y_{j,t} + \lambda_j\left(x_{j,t} - \frac{1}{1-\phi}y_{j,t}\right)\prod_{s=t+1}^{+\infty}\frac{1+x_{j,s}}{1+r}\right]V^{(j)}_{j,t-1}\big(\{E_{t-1}[u(y_{k,t})]\}_{k=0,\ldots,J}\big)u'(y_{j,t}) \\ &+\left(\frac{\phi}{1-\phi} - \frac{1}{1-\phi}E_t\left[\lambda_j\prod_{s=t+1}^{+\infty}\frac{1+x_{j,s}}{1+r}\right]\right)V_{j,t-1}\big(\{E_{t-1}[u(y_{k,t})]\}_{k=0,\ldots,J}\big) = 0, \end{aligned} \tag{A.4}$$

where we continue to omit argument $\mathcal{H}^t$ in $y_{j,t}$ and argument $\mathcal{H}^T$ in λ_j, $V^{(k)}_{j,t-1} = \partial V_{j,t-1}/\partial U_k$ denotes

the partial derivative of demand, and $V_{j,t-1}^{(k\ell)} = \partial^2 V_{j,t-1}/(\partial U_k \partial U_\ell)$ the cross-derivative.

We write asset returns and demand shocks, as follows:

$$x_{j,t} = r + \sigma\, \epsilon_{j,t}^{x} \tag{A.5}$$

$$\xi_{j,t} = \xi_j + \sigma\, \zeta_{j,t} = \xi_j + \sigma \sum_{s=1}^{t} \epsilon_{j,s}^{\xi} \tag{A.6}$$

for $j = 0, \ldots, J$ and $t \geq 1$, where $\sigma > 0$, $\epsilon_{j,t}^{x}$ and $\epsilon_{j,t}^{\xi}$ are realized at the end of period t, have bounded support, zero mean, and are equal to zero for $t > T$.

We solve the model using a first-order approximation for small shocks. We guess that, when σ goes to zero,

$$y_{j,t} = y_{j,t}^{0} + \sigma\, y_{j,t}' + O(\sigma^2), \tag{A.7}$$

$$\lambda_j = \lambda_j^0 + \sigma\, \lambda_j' + O(\sigma^2), \tag{A.8}$$

where $y_{j,t}^0$ and λ_j^0 are deterministic, $y_{j,t}'$ and $\lambda_j^{'}$ are functions of $\mathcal{H}^T$, and $O(\sigma^2)$ denote functions of $(\mathcal{H}^T, \sigma)$ at the order of σ^2, that is, there exist $K > 0$ and $\overline{\sigma} > 0$ such that $O(\sigma^2) \leq K\sigma^2$ for all $\mathcal{H}^T$ and $\sigma < \overline{\sigma}$.

We determine $y_{j,t}^0$ and λ_j^0 by letting σ go to zero in the intertemporal budget constraint (A.3) and first-order condition (A.4). The latter yields

$$\Big(\phi y_{j,t}^0 + \lambda_j^0\big((1-\phi)r - y_{j,t}^0\big)\Big) V_j^{(j)}\big(\{u(y_{k,t}^0)\}_{k=0,\ldots,J}\big) u'(y_{j,t}^0) + \big(\phi - \lambda_j^0\big) V_j\big(\{u(y_{k,t}^0)\}_{k=0,\ldots,J}\big) = 0, \tag{A.9}$$

where $V_j(.) \equiv V_{j,0}(.)$ denotes the demand function when demand shocks $\zeta_{k,t}$ are set to zero for all k. Since (A.9) does not depend on t, $y_{k,t}^0$ does not depend on t, and we denote it by y_k^0. Letting σ go to zero in (A.3), we obtain

$$\sum_{t=1}^{+\infty} \frac{1}{(1+r)^t} \left(r - \frac{1}{1-\phi} y_j^0 \right) V_j\big(\{u(y_k^0)\}_{k=0,\ldots,J}\big) = 0. \tag{A.10}$$

The solution to (A.10) is symmetric across intermediaries, and is given by

$$y_j^0 = (1-\phi)r. \tag{A.11}$$

Substituting y_j^0 into (A.9), we obtain

$$\lambda_j^0 = \phi + \phi(1-\phi) r \frac{V_j^{(j)}}{V_j} u', \tag{A.12}$$

where we omit argument y_j^0 in $u(.)$ and its derivatives, and we omit argument $\{u(y_k^0)\}_{k=0,\ldots,J}$ in $V_j(.)$ and its derivatives.

We determine $y'_{j,t}$ and λ'_j by calculating first-order approximations of the intertemporal budget constraint (A.3) and first-order condition (A.4). Let us first write down a first-order approximation of the demand function (A.2):

$$\begin{aligned} V_{j,t-1}\big(\{E_{t-1}[u(y_{k,t})]\}_{k=0,\ldots,J}\big) &= V_j\big(\{u(y_k^0)\}_{k=0,\ldots,J}\big) \\ &+ \sigma \sum_{k=0}^{J} V_j^{(k)}\big(\{u(y_k^0)\}_{k=0,\ldots,J}\big) u'(y_k^0) \Big(E_{t-1}[y'_{k,t}] + \frac{\zeta_{k,t-1}}{\alpha u'(y_k^0)}\Big) + O(\sigma^2). \end{aligned} \tag{A.13}$$

The analogous approximation holds for $V_{j,t-1}^{(j)}$. A first-order approximation of the budget constraint (A.3) gives

$$\sum_{t=1}^{+\infty} \frac{1}{(1+r)^t} \left(\epsilon_{j,t}^x - \frac{1}{1-\phi} y'_{j,t}\right) V_j = 0. \tag{A.14}$$

We denote $y_{j,t}^s = E_s[y'_{j,t}] - E_{s-1}[y'_{j,t}]$ as the time-s innovation of $y'_{j,t}$ for all $1 \leq s \leq t$. Calculating $E_s[.]$ of (A.14) minus $E_{s-1}[.]$ of (A.14), we obtain

$$\sum_{t=s}^{+\infty} \frac{y_{j,t}^s}{(1+r)^{t-s}} = (1-\phi)\epsilon_{j,s}^x, \qquad s \leq t. \tag{A.15}$$

A first-order approximation of the first-order condition (A.4) gives

$$\begin{aligned} \frac{\phi}{1-\phi} E_{t-1}[y'_{j,t}] V_j^{(j)} u' - \lambda_j^0 \frac{1}{1-\phi} E_{t-1}[y'_{j,t}] V_j^{(j)} u' + \phi r \sum_{k=0}^{J} V_j^{(jk)} (u')^2 \left(E_{t-1}[y'_{k,t}] + \frac{\zeta_{k,t-1}}{\alpha u'}\right) + \phi r V_j^{(j)} u'' y'_{j,t} \\ - \frac{1}{1-\phi} E_t[\lambda'_j] V_j + \left(\frac{\phi}{1-\phi} - \frac{1}{1-\phi}\lambda_j^0\right) \sum_{k=0}^{J} V_j^{(k)} u' \left(E_{t-1}[y'_{k,t}] + \frac{\zeta_{k,t-1}}{\alpha u'}\right) = 0, \end{aligned} \tag{A.16}$$

where we have multiplied the first-order condition by $(1+r)^t$ and we have used $y_j^0 = (1-\phi)r$. Using

(A.12), we substitute λ_j^0 into (A.16). We then divide by $\phi r V_j^{(j)} u''$, to obtain

$$y'_{j,t} + \frac{V_j^{(j)}}{V_j}\frac{(u')^2}{-u''}E_{t-1}[y'_{j,t}] + \sum_{k=0}^{J}\left(\frac{V_j^{(k)}}{V_j} - \frac{V_j^{(jk)}}{V_j^{(j)}}\right)\frac{(u')^2}{-u''}\left(E_{t-1}[y'_{k,t}] + \frac{\zeta_{k,t-1}}{\alpha u'}\right) = \frac{V_j}{(1-\phi)\phi r V_j^{(j)} u''}E_t[\lambda'_j]. \quad \text{(A.17)}$$

We denote $\lambda_j^s = E_s[\lambda'_j] - E_{s-1}[\lambda'_j]$ the time-s innovation of λ'_j for all $1 \leq s \leq T$. Calculating (A.17) minus $E_{t-1}[.]$ of (A.17), we obtain

$$y_{j,t}^t = \frac{V_j}{(1-\phi)\phi r V_j^{(j)} u''}\lambda_j^t. \quad \text{(A.18)}$$

Calculating $E_s[.]$ of (A.17) minus $E_{s-1}[.]$ of (A.17) for $s < t$, we obtain

$$\left(1 + \frac{V_j^{(j)}}{V_j}\frac{(u')^2}{-u''}\right)y_{j,t}^s + \sum_{k=0}^{J}\left(\frac{V_j^{(k)}}{V_j} - \frac{V_j^{(jk)}}{V_j^{(j)}}\right)\frac{(u')^2}{-u''}\left(y_{k,t}^s + \frac{\epsilon_{k,s}^{\xi}}{\alpha u'}\right) = \frac{V_j}{(1-\phi)\phi r V_j^{(j)} u''}\lambda_j^s, \qquad s < t. \quad \text{(A.19)}$$

The derivatives of the logit demand function are

$$\frac{V_j^{(j)}}{V_j} = \alpha(1-s_j), \qquad \frac{V_j^{(jj)}}{V_j^{(j)}} = \alpha(1-2s_j), \qquad \frac{V_j^{(k)}}{V_j} = -\alpha s_k, \qquad \frac{V_j^{(jk)}}{V_j^{(j)}} = -\alpha s_k\left(1 - \frac{s_j}{1-s_j}\right), \qquad k \neq j,$$

where

$$s_j \equiv V_j = \frac{\exp\{\xi_j\}}{\sum_{k=0}^{J}\exp\{\xi_k\}} \quad \text{(A.20)}$$

is intermediary j's market share when all intermediaries offer the same contract return and all demand shocks are set to zero. We use these expressions, and (A.18) to substitute λ_j^s on the right-hand side of (A.19). We obtain

$$y_{j,t}^s = \frac{\gamma_j}{\alpha+\gamma_j}y_{j,s}^s + \frac{\alpha\delta_j}{\alpha+\gamma_j}\sum_{k=0}^{J}s_k y_{k,t}^s - \frac{\frac{1}{u'}\delta_j}{\alpha+\gamma_j}\left(\epsilon_{j,s}^{\xi} - \sum_{k=1}^{J}s_k\epsilon_{k,s}^{\xi}\right), \qquad s < t, \quad \text{(A.21)}$$

where

$$\gamma_j = \frac{1}{1+\frac{s_j^2}{1-s_j}} \frac{-u''[(1-\phi)r]}{\big(u'[(1-\phi)r]\big)^2}, \tag{A.22}$$

$$\delta_j = \frac{1}{1+\frac{s_j^2}{1-s_j}} \frac{s_j}{1-s_j}. \tag{A.23}$$

To determine $\sum_{k=0}^{J} s_k y_{k,t}^s$, we first note that $y_{0,t}^s = 0$ for $s < t$. Then, multiplying (A.21) by s_j, and summing over $j = 1, \ldots, J$, we obtain

$$(1-A)\sum_{k=0}^{J} s_k y_{k,t}^s = \sum_{k=1}^{J} \frac{\gamma_k s_k}{\alpha+\gamma_k} y_{k,s}^s - \sum_{k=1}^{J} \frac{\frac{1}{u'}\delta_k s_k}{\alpha+\gamma_k}\left(\epsilon_{k,s}^{\xi} - \sum_{\ell=1}^{J} s_\ell \epsilon_{\ell,s}^{\xi}\right), \qquad s < t. \tag{A.24}$$

where $A = \sum_{k=1}^{J} \frac{\alpha\delta_k s_k}{\alpha+\gamma_k}$. Substituting the expression of $\sum_{k=0}^{J} s_k y_{k,t}^s$ given by (A.24) into (A.21), and collecting the terms $\epsilon_{k,s}^{\xi}$, we obtain

$$y_{j,t}^s = \frac{\gamma_j}{\alpha+\gamma_j} y_{j,s}^s + \frac{1}{1-A}\frac{\alpha\delta_j}{\alpha+\gamma_j}\sum_{k=1}^{J}\frac{\gamma_k s_k}{\alpha+\gamma_k} y_{k,s}^s - \frac{\frac{1}{u'}\delta_j}{\alpha+\gamma_j}\big(\epsilon_{j,s}^{\xi} - \overline{\epsilon}_s^{\xi}\big), \qquad s < t, \tag{A.25}$$

where

$$\overline{\epsilon}_s^{\xi} = \frac{1}{1-A}\sum_{k=1}^{J}\left(1 - \frac{\alpha\delta_k}{\alpha+\gamma_k}\right) s_k \epsilon_{k,s}^{\xi}. \tag{A.26}$$

Substituting the expression of $y_{j,t}^s$ given by (A.25) into the budget constraint (A.15), we obtain

$$\frac{\alpha + \frac{1+r}{r}\gamma_j}{\alpha+\gamma_j} y_{j,s}^s + \frac{1}{1-A}\frac{\frac{1}{r}\alpha\delta_j}{\alpha+\gamma_j}\sum_{k=1}^{J}\frac{\gamma_k s_k}{\alpha+\gamma_k} y_{k,s}^s = (1-\phi)\epsilon_{j,s}^{x} + \frac{\frac{1}{ru'}\delta_j}{\alpha+\gamma_j}\big(\epsilon_{j,s}^{\xi} - \overline{\epsilon}_s^{\xi}\big). \tag{A.27}$$

To determine $\sum_{k=1}^{J} \frac{\gamma_k s_k}{\alpha+\gamma_k} y_{k,s}^s$, we multiply both sides of (A.27) by $\frac{\gamma_j s_j}{\alpha+\frac{1+r}{r}\gamma_j}$, sum over $j = 1, \ldots, J$, and rearrange terms, to obtain

$$\frac{1-B}{1-A}\sum_{k=1}^{J}\frac{\gamma_k s_k}{\alpha+\gamma_k} y_{k,s}^s = (1-\phi)\widehat{\epsilon}_s^{x} + \frac{1}{\alpha u'}\widehat{\epsilon}_s^{\xi}, \tag{A.28}$$

where $B = \sum_{k=1}^{J} \frac{\alpha\delta_k s_k}{\alpha+\frac{1+r}{r}\gamma_k}$, and

$$\widehat{\epsilon}_s^x = \sum_{k=1}^{J} \frac{\gamma_k s_k}{\alpha + \frac{1+r}{r}\gamma_k} \epsilon_{k,s}^x, \tag{A.29}$$

$$\widehat{\epsilon}_s^\xi = \sum_{k=1}^{J} \frac{\gamma_k s_k}{\alpha + \frac{1+r}{r}\gamma_k} \frac{\frac{\alpha}{r}\delta_k}{\alpha + \gamma_k} \left(\epsilon_{k,s}^\xi - \overline{\epsilon}_s^\xi\right). \tag{A.30}$$

Substituting (A.28) back into (A.27), we obtain

$$y_{j,s}^s = \frac{\alpha + \gamma_j}{\alpha + \frac{1+r}{r}\gamma_j}(1-\phi)\epsilon_{j,s}^x - \frac{\frac{1}{r}\alpha\delta_j}{\alpha + \frac{1+r}{r}\gamma_j}\frac{1}{1-B}(1-\phi)\widehat{\epsilon}_s^x + \frac{\frac{1}{ru'}\delta_j}{\alpha + \frac{1+r}{r}\gamma_j}\left(\epsilon_{j,s}^\xi - \overline{\epsilon}_s^\xi - \frac{1}{1-B}\widehat{\epsilon}_s^\xi\right). \tag{A.31}$$

Substituting the expression of $y_{j,s}^s$ given by (A.31) into (A.25) we obtain

$$y_{j,t}^s = \frac{\gamma_j}{\alpha + \frac{1+r}{r}\gamma_j}(1-\phi)\epsilon_{j,s}^x + \frac{\alpha\delta_j}{\alpha + \frac{1+r}{r}\gamma_j}\frac{1}{1-B}(1-\phi)\widehat{\epsilon}_s^x - \frac{\frac{1}{u'}\delta_j}{\alpha + \frac{1+r}{r}\gamma_j}\left(\epsilon_{j,s}^\xi - \overline{\epsilon}_s^\xi - \frac{1}{1-B}\widehat{\epsilon}_s^\xi\right), \qquad s < t. \tag{A.32}$$

Finally, we use (A.11), (A.31), and (A.32) to calculate $y_{j,t} = y_{j,t}^0 + \sigma\sum_{s=1}^{t} y_{j,t}^s + O(\sigma^2)$. We obtain:

$$y_{j,t} = (1-\phi)\left[r + \sum_{s=1}^{t-1}\frac{\gamma_j}{\alpha + \frac{1+r}{r}\gamma_j}(x_{j,s} - r) + \frac{\alpha + \gamma_j}{\alpha + \frac{1+r}{r}\gamma_j}(x_{j,t} - r)\right] + f_{j,t}(\overline{x}^t - r, \xi^t) + O(\sigma^2), \tag{A.33}$$

where $f_{j,t}(.)$ is a function of the history of average asset return shocks $\overline{x}^t - r$ and demand shocks ξ^t:

$$f_{j,t}(\overline{x}^t - r, \xi^t) = \frac{\alpha\delta_j}{\alpha + \frac{1+r}{r}\gamma_j}\frac{\sum_{k=1}^{J}\frac{\gamma_k s_k}{\alpha+\frac{1+r}{r}\gamma_k}}{1 - \sum_{k=1}^{J}\frac{\alpha\delta_k s_k}{\alpha+\frac{1+r}{r}\gamma_k}}(1-\phi)\left(\sum_{s=1}^{t-1}(\overline{x}_s - r) - \frac{1}{r}(\overline{x}_t - r)\right) + g_{j,t}(\xi^t), \tag{A.34}$$

$$\overline{x}_t = \sum_{k=1}^{J}\frac{\frac{\gamma_k s_k}{\alpha+\frac{1+r}{r}\gamma_k}}{\sum_{\ell=1}^{J}\frac{\gamma_\ell s_\ell}{\alpha+\frac{1+r}{r}\gamma_\ell}} x_{k,t}, \tag{A.35}$$

and s_j, γ_j, and δ_j are given by (A.20), (A.22), and (A.23), respectively.

A.2 Sufficient condition for binding regulatory constraint

Suppose that instead of modeling the regulatory constraint (7) as an equality (with "="), we model it as an inequality (with "$\leq$") as in the actual regulation of euro contracts described in Appendix B. In this case, we show that a sufficient condition for this constraint to be binding, and therefore

equivalent to the constraint modeled with an equality, is:

$$\frac{\phi\,\alpha}{1-\phi} < 1. \tag{A.36}$$

Suppose (A.36) holds. Let $\kappa \in (1, \frac{1-\phi}{\phi\,\alpha})$. To show that the regulatory constraint is binding, we need to show that intermediaries can increase their intertemporal profit by violating the constraint. Consider a marginal increase $d\pi_{j,t} > 0$ in the fraction of account value that goes to intermediary j in period t and a reduction in contract return $dy_{j,t} = -\kappa\, d\pi_{j,t}$. Investor demand in period t changes by $-\kappa\, d\pi_{j,t}[V_j^{(j)} + O(\sigma)]$. The budget constraint (A.3) is strictly relaxed because $\kappa > 1$ and $x_{j,t} - \frac{1}{1-\phi} y_{j,t} = O(\sigma)$. The intermediary's intertemporal profit (A.1) changes by

$$\frac{1}{(1+r)^t}\left[d\pi_{j,t}V_j - \frac{\phi}{1-\phi}\kappa\, d\pi_{j,t}V_j^{(j)}\right] = \frac{1}{(1+r)^t}\left[1 - \frac{\phi}{1-\phi}\kappa\,\alpha\,(1-s_j)\right]d\pi_{j,t}V_j,$$

which is positive, because $\kappa < \frac{1-\phi}{\phi\,\alpha}$ and $1 - s_j < 1$. Therefore, the regulatory constraint is binding.

(A.36) is arguably satisfied in our empirical setup since we estimate $\alpha \simeq 0$.

A.3 Proof of Proposition 2

Reserves evolve according to $R_{j,t} = (1+x_{j,t})R_{j,t-1} + \left(x_{j,t} - \frac{1}{1-\phi}y_{j,t}\right)V_{j,t-1}$ with $R_{j,0} = 0$. Therefore, a first-order approximation of $R_{j,t}$ is

$$R_{j,t} = \sigma\, h_{j,t}V_j + O(\sigma^2), \tag{A.37}$$

where

$$
\begin{aligned}
h_{j,t} &= \sum_{s=1}^{t}(1+r)^{t-s}\left(\epsilon^x_{j,s} - \frac{y'_{j,s}}{1-\phi}\right) \\
&= \sum_{s=1}^{t}(1+r)^{t-s}\left(\epsilon^x_{j,s} - \frac{y^s_{j,s}}{1-\phi}\right) - \sum_{s=1}^{t}(1+r)^{t-s}\sum_{\tau=1}^{s-1}\frac{y^\tau_{j,s}}{1-\phi} \\
&= \sum_{s=1}^{t}(1+r)^{t-s}\left(\epsilon^x_{j,s} - y^s_{j,s}\right) - \sum_{s=1}^{t}\sum_{\tau=s+1}^{t}(1+r)^{t-\tau}\frac{y^s_{j,\tau}}{1-\phi} \\
&= \sum_{s=1}^{t}(1+r)^{t-s}\left(\epsilon^x_{j,s} - \sum_{\tau=s}^{t}(1+r)^{s-\tau}\frac{y^s_{j,\tau}}{1-\phi}\right) \\
&= \sum_{s=1}^{t}(1+r)^{t-s}\sum_{\tau=t+1}^{+\infty}(1+r)^{s-\tau}\frac{y^s_{j,\tau}}{1-\phi} \\
h_{j,t} &= \frac{1}{r}\sum_{s=1}^{t}\frac{y^s_{j,t+1}}{1-\phi}, \qquad \text{(A.38)}
\end{aligned}
$$

where we move from the first line to the second line using $y'_{j,s} = \sum_{\tau=1}^{s} y^\tau_{j,s}$, to the third line by switching indices s and τ, to the fourth line by putting the two sums over s together, to the fifth line using the budget constraint (A.15), and to the sixth line using that $y^s_{j,\tau}$ does not depend on τ for all $\tau > s$, so $y^s_{j,\tau}$ can be replaced by $y^s_{j,t+1}$.

We have

$$
\begin{aligned}
y_{j,t} - (1-\phi)r &= \sigma y'_{j,t} + O(\sigma^2) = \sigma\sum_{s=1}^{t-1} y^s_{j,t} + \sigma y^t_{j,t} + O(\sigma^2) \\
&= \frac{(1-\phi)r}{1+r}\left((1+r)\frac{R_{j,t-1}}{V_j} + \sigma\epsilon^x_{j,t}\right) + \frac{1-\phi}{1+r}\frac{\alpha}{\alpha + \frac{1+r}{r}\gamma_j}\sigma\epsilon^x_{j,t} \\
&\quad -(1-\phi)\frac{\frac{1}{r}\alpha\delta_j}{\alpha + \frac{1+r}{r}\gamma_j}\frac{1}{1-B}\sigma\widehat{\epsilon}^x_t + \frac{\frac{1}{r}\delta_j}{\alpha + \frac{1+r}{r}\gamma_j}\sigma\left(\epsilon^\xi_{j,t} - \overline{\epsilon}^\xi_t - \frac{1}{1-B}\widehat{\epsilon}^\xi_t\right) + O(\sigma^2)
\end{aligned}
$$

where we move from the first line to the second line using (A.37) and (A.38) to substitute $\sum_{s=1}^{t-1} y^s_{j,t}$, and using (A.31) to substitute $y^t_{j,t}$. Thus:

$$
\begin{aligned}
y_{j,t} = (1-\phi)r + \frac{1-\phi}{1+r}\frac{\alpha}{\alpha + \frac{1+r}{r}\gamma_j}(x_{j,t} - r) + \frac{(1-\phi)r}{1+r}\left(\frac{R_{j,t^-}}{V_{j,t-1}} - r\right) \\
+ \mu_j(\overline{x}_t - r) + \nu_j\Delta\xi_{j,t} + O(\sigma^2), \qquad \text{(A.39)}
\end{aligned}
$$

where

$$\mu_j \quad = \quad -(1-\phi)\frac{\frac{1}{r}\alpha\delta_j}{\alpha+\frac{1+r}{r}\gamma_j}\frac{\sum_{k=1}^{J}\frac{\gamma_k s_k}{\alpha+\frac{1+r}{r}\gamma_k}}{1-\sum_{k=1}^{J}\frac{\delta_k s_k}{\alpha+\frac{1+r}{r}\gamma_k}}, \tag{A.40}$$

s_j, γ_j, and δ_j are given by (A.20), (A.22), and (A.23), respectively, $\overline{x}_t$ is a weighted average of asset returns $x_{k,t}$ over $k = 1, \ldots, J$ defined in (A.35), $\nu_j = \frac{1}{r}\delta_j/\Big(\alpha + \frac{1+r}{r}\gamma_j\Big)$, $\Delta\xi_{j,t} = \epsilon^{\xi}_{j,t} - \overline{\epsilon}^{\xi}_t - \frac{1}{1-B}\widehat{\epsilon}^{\xi}_t$, and $\overline{\epsilon}^{\xi}_t$ and $\widehat{\epsilon}^{\xi}_t$ are weighted averages of demand shocks $\epsilon^{\xi}_{k,t}$ over $k = 1, \ldots, J$ defined in (A.26) and (A.30), respectively.

A.4 Proof of Proposition 3

(16) implies that the contract return can be written as

$$y_{j,t} \quad = \quad a + b\,x_{j,t} + c\,\overline{x}_t + O(\sigma^2), \tag{A.41}$$

where

$$a \quad = \quad (1-\phi)r - (1-\phi)\frac{\alpha+\gamma_j}{\alpha+\frac{1+r}{r}\gamma_j}\,r + (1-\phi)r\,\mathcal{R}_{j,t-1} - \mu_j\,r \tag{A.42}$$

$$b \quad = \quad (1-\phi)\,\frac{\alpha+\gamma_j}{\alpha+\frac{1+r}{r}\gamma_j} \tag{A.43}$$

$$c \quad = \quad \mu_j \tag{A.44}$$

and $\mathcal{R}_{j,t-1} = R_{j,t-1}/V_{j,t-1}$. Therefore, the contract return can be replicated up to a constant with a portfolio with weight b in the insurer's assets generating return $x_{j,t}$, weight c in the average insurer portfolio generating return $\overline{x}_t$, and weight $1-b-c$ in the risk-free asset generating return r_f. The return difference between the contract and the replicating portfolio is the constant $a-(1-b-c)\,r_f$, which is equal to

$$\left[1-(1-\phi)\frac{\alpha+\gamma_j}{\alpha+\frac{1+r}{r}\gamma_j} - \mu_j\right](r-r_f) + (1-\phi)\,r\,\mathcal{R}_{j,t-1} - \phi\,r. \tag{A.45}$$

A.5 Proof of Relation 1

We consider the case where the number of intermediaries, J, is large, so that market shares, s_j, are small. Formally, we assume there exists $\overline{s} > 0$ such that $s_j < \overline{s}J^{-1}$ for all $J > 1$. Let $O(J^{-1})$ denote functions of the order of J^{-1}, that is, there exist $K > 0$ and $\overline{J}$ such that $O(J^{-1}) \leq KJ^{-1}$

for all $J > \overline{J}$. It follows from (A.22) that $\gamma_j = -u''/(u')^2 + O(J^{-2})$, from (A.23) that $\delta_j = O(J^{-1})$, and from (A.40) that $\mu_j = \mu + O(J^{-1})$. Therefore, (A.39) can be rewritten as:

$$y_{j,t} = cste + \frac{1-\phi}{1+r}\frac{\alpha}{\alpha + \frac{1+r}{r}\gamma}x_{j,t} + \frac{(1-\phi)r}{1+r}\mathcal{R}_{j,t^-} + \mu\,\overline{\epsilon}_t^x + \varepsilon_{j,t} + O(\sigma^2), \tag{A.46}$$

where $\gamma \equiv -u''/(u')^2 = -u''/u'$ using the normalization $u'(r-\phi) = 1$, and

$$\varepsilon_{j,t} = \nu_j \Delta\xi_{j,t} + O(J^{-1})x_{j,t} + O(J^{-1})(\overline{x}_t - r). \tag{A.47}$$

Since demand shocks entering into the expression of $\Delta\xi_{j,t}$ are uncorrelated with asset return $x_{j,t}$, the covariance between $x_{j,t}$ and $\varepsilon_{j,t}$ is $O(J^{-1})$. Since $\mathcal{R}_{j,t^-} = \mathcal{R}_{j,t-1} + x_{j,t}(1+\mathcal{R}_{j,t-1})$ and $\mathcal{R}_{j,t-1}$ is uncorrelated with $\varepsilon_{j,t}$, the covariance between $\mathcal{R}_{j,t^-}$ and $\varepsilon_{j,t}$ is also $O(J^{-1})$.

A.6 Proof of Relation 2

A first-order approximation of log demand of intermediary j in period t is

$$\log(V_{j,t-1}) = \log(V_j) + \sum_{k=1}^{J}\frac{V_j^{(k)}}{V_j}\left(E_{t-1}[y_{k,t}] - (1-\phi)r + \frac{\xi_{k,t-1}}{\alpha u'}\right)u' + O(\sigma^2). \tag{A.48}$$

The expectation of contract return (A.39) is equal to

$$E_{t-1}[y_{k,t}] = (1-\phi)r + (1-\phi)r\,\mathcal{R}_{k,t-1} + O(\sigma^2), \tag{A.49}$$

where we have used $\mathcal{R}_{k,t^-} = (1+x_{k,t})\mathcal{R}_{k,t-1} + x_{k,t}$ and $E_{t-1}[x_{k,t}] = r$. Plugging (A.49) into (A.48), substituting the derivative of logit demand, and using the normalization $u'((1-\phi)r) = 1$, we obtain

$$\log(V_{j,t-1}) = \log(V_j) + \psi_{t-1} + \alpha(1-\phi)r\,\mathcal{R}_{j,t-1} + \xi_{j,t-1} + O(\sigma^2), \tag{A.50}$$

where $\psi_{t-1} = -\sum_{k=1}^{J}\big(\alpha(1-\phi)r\,\mathcal{R}_{k,t-1} + \xi_{k,t-1}\big)s_k$.

To calculate the covariance between $\mathcal{R}_{j,t-1}$ and $\xi_{j,t-1}$, we use (A.37) and (A.38) to write

$$\mathcal{R}_{j,t-1} = \sigma\frac{1}{r}\sum_{s=1}^{t-1}\frac{y_{j,t}^s}{1-\phi} + O(\sigma^2). \tag{A.51}$$

Substituting $y^s_{j,t}$ using (A.32), and focusing on terms $\epsilon^{\xi}_{j,s}$, we obtain

$$\mathcal{R}_{j,t-1} = \ldots - \sigma \frac{1}{r} \sum_{s=1}^{t-1} \frac{1}{1-\phi} \frac{\frac{1}{u'}\delta_j}{\alpha + \frac{1+r}{r}\gamma_j} \epsilon^{\xi}_{j,s} + O(\sigma^2) = \ldots - \frac{1}{(1-\phi)r} \frac{\frac{1}{u'}\delta_j}{\alpha + \frac{1+r}{r}\gamma_j} \xi_{j,t-1} + O(\sigma^2).$$

Therefore

$$Cov(\mathcal{R}_{j,t-1}, \xi_{j,t-1}) \simeq -\frac{1}{(1-\phi)r} \frac{\frac{1}{u'}\delta_j}{\alpha + \frac{1+r}{r}\gamma_j} < 0. \tag{A.52}$$

Finally, let us now show that $x_{j,t-1}$ is a valid instrument for $\mathcal{R}_{j,t-1}$. The relevance condition is satisfied, because it follows from the budget constraint (4) that $Cov(x_{j,t-1}, \mathcal{R}_{j,t-1}) > 0$. The exclusion restriction is satisfied, because $Cov(\epsilon^x_{j,t-1}, \epsilon^{\xi}_{j,t-1}) = 0$. Thus, the IV estimate of the flow-reserves relation (A.50) using lagged asset return to instrument for reserves is unbiased.

A.7 Is arbitrage profitable?

In this appendix, we calculate arbitrage profits from buying euro contracts and shorting the replicating portfolio, for any value of α. We then calibrate it in the relevant case $\alpha \simeq 0$.

Following the proof of Proposition 3 in Appendix A.4, the contract return can be written as

$$y_{j,t} \quad = \quad a + b\, x_{j,t} + c\, \overline{x}_t + O(\sigma^2), \tag{A.53}$$

where a, $b > 0$, and $c < 0$ are given by (A.42), (A.43), and (A.44), respectively. Consider the hedged, zero-cost portfolio that goes long one euro in contract j, short $(1-\tau)b$ euros in intermediary j's asset portfolio, long $(1-\tau)|c|$ euros in the weighted-average intermediary portfolio, and borrows $1-(1-\tau)b+(1-\tau)|c|$ at the risk-free rate. The return on the long position in the euro contract is taxed at rate τ. The return on the long position in the weighted-average intermediary portfolio is taxed if the position cannot be netted against the short position in intermediary j's asset, but the part of the long position that can be netted is not taxed. We make the conservative assumption (in the sense that it maximizes the profitability of the arbitrage strategy) that the long position in the weighted-average intermediary portfolio can be fully netted against the short position in

intermediary j's asset, and thus is not taxed. The arbitrage profit is equal to

$$\pi_{j,t}^{arb} = (1-\tau)y_{j,t} - (1-\tau)b\,x_{j,t} + (1-\tau)|c|\,\overline{x}_t - (1-(1-\tau)b + (1-\tau)|c|)r_f$$
$$= \left[1-(1-\tau)(1-\phi)\frac{\alpha+\gamma_j}{\alpha+\frac{1+r}{r}\gamma_j} + (1-\tau)|\mu_j|\right](r-r_f) + (1-\tau)(1-\phi)r\,\mathcal{R}_{j,t-1} - \tau r - (1-\tau)\phi r. \tag{A.54}$$

When $\alpha \simeq 0$, (A.40) implies $\mu_j \simeq 0$, and

$$\pi_{j,t}^{arb} \simeq \left[1-\frac{(1-\tau)(1-\phi)r}{1+r}\right](r - r_f) + (1-\tau)(1-\phi)r\,\mathcal{R}_{j,t-1} - \tau r - (1-\tau)\phi r, \tag{A.55}$$

We calibrate the expected asset return using the sample average asset return (4.9% in Table 1), and noting that it is likely realized asset returns have been above expected returns during the sample period. As discussed in Section 2.2, the reserve ratio rose by 25 basis points per year, while positive net flows should have diluted reserves at a rate of 25 basis points per year. Therefore, insurers have retained in reserves approximately 50 basis points of the realized asset returns in excess of expected returns. Thus, we set $r = 4.4\%$. Using $r_f = 3\%$, the risk premium is 1.4%.

We set $\phi = 0.15$ based on the regulatory framework described in Section 2.1.

To focus on a situation that makes the arbitrage most profitable, we assume the reserve ratio is 10 percentage points above target. This represents 1.5 standard deviations of the reserve ratio (Table 1). It also amounts to the difference between the highest point of the aggregate reserve ratio (reached in 2014, see Appendix Figure B.1) and its sample average. Thus, we set $\mathcal{R}_{j,t-1} = 0.1$.

Substituting these calibrated values in (A.55), arbitrage opportunities are eliminated for $\tau > 0.26$.

B Regulatory Framework

Reserves of euro contract funds represent the difference between the value of assets held by the fund and total account value. Reserves have three components, whose creation and use is determined by the regulation guiding how asset income can be split between investors and the insurer.

At least 85% of financial income plus 90% of technical income (or 100% if it is negative) must be distributed to investors. 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 amount distributed to investors is split into two parts: one part credited immediately to investors' accounts and another part credited to, or debited from, a reserve account called the profit-sharing reserve (*provision pour participation aux bénéfices*). This profit-sharing account is the first component of reserves. We have:

$$\text{Contract return} + \Delta\text{Profit-sharing reserve} \geq 85\% \,\text{Financial income} + 90\% \,\text{Technical income}. \quad \text{(B.1)}$$

The profit-sharing reserve account can only be used for future distribution to investor accounts. Therefore, the profit-sharing reserve effectively belongs to (current and future) investors. The profit-sharing reserve is pooled across all contracts. When an investor redeems her contract, she gives up her right to future distribution of the profit-sharing reserve. Conversely, when a new investor buys a contract, she shares in the outstanding profit-sharing reserve. Therefore, the profit-sharing reserve is passed on between successive cohorts of contract holders.[35]

The second component of reserves is called the capitalization reserve account (*réserve de capitalisation*). It is made of realized gains and losses on fixed income securities, which are not booked as financial income but are credited to, or debited from, this account. The capitalization reserve account can only be used to offset future losses on fixed income securities and cannot be credited to investors' accounts or to insurer income. The third component of reserves is made of the unrealized capital gains on the funds' assets, which are not booked as financial income.[36] Both the capitaliza-

[35] Another regulation imposes that insurers must distribute the funds credited to the profit-sharing reserve to investors within eight years. This implies that insurers can hoard up to eight years worth of contract returns in the profit-sharing reserve. In practice, this constraint is never binding. The profit-sharing reserve represents less than one year of contract returns on average, and two years and a half at the 99th percentile.

[36] While unrealized capital gains are not booked as financial income, there exist two deviations from historical cost accounting principles that 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

tion reserve and unrealized capital gains represent deferred financial income. Since at least 85% of the financial income must be distributed to investors, at least 85% of the capitalization reserve and unrealized capital gains effectively belong to (current and future) investors.

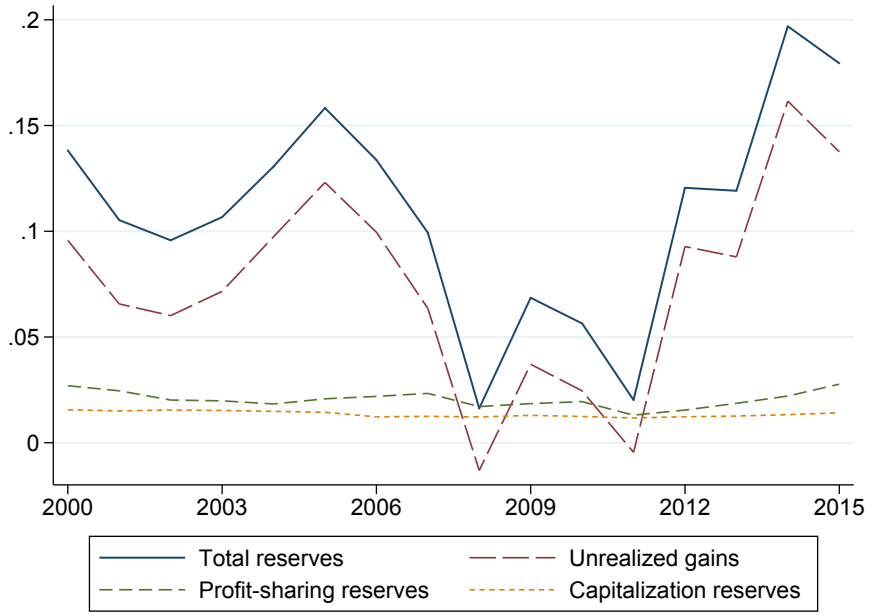
Since all three components of reserves are eventually owed to investors and are pooled across investor cohorts, the composition of reserves is immaterial for inter-cohort risk sharing. For this reason, our empirical analysis focuses on total reserves.

Summary statistics Reserves represent on average 10.9% of account value, of which 7.5% are unrealized capital gains, 2.1% are profit-sharing reserves, and 1.4% are capitalization reserves. Figure B.1 plots the time-series of aggregate reserves and its three sub-components as a fraction of account value.

investors' accounts and to the insurer's profit are held constant, this realized loss reduces the profit-sharing reserve, and total reserves are not affected. The goal of this provision is to induce the insurer to reduce the return credited to investors' accounts and thus to reduce the profit-sharing reserve by less than the realized loss, increasing total reserves.

The second deviation from historical cost accounting is that, when the market value of the 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 investors' accounts and to the insurer's profit are held constant, this reduces the profit-sharing reserve and thus total reserves. The goal of this provision is to induce the insurer to reduce the return credited to investors' accounts and thus to offset the reduction in the amount of reserves.

Figure B.1: Reserves. The figure shows total 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).



C Variables Construction

C.1 Regulatory filings

This section describes how we construct variables at the insurer-year level using 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 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 reserves.

C.2 Account value by cohort

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

Regarding inflows, we assume 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 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 omit the insurer index j to simplify the formulas. We call cohort (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 cohort (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 cohort (t_0, t_1) evolves according to

$$V_{t_0-1}(t_0, t_1) = 0, \tag{C.2}$$

$$V_t(t_0, t_1) = (1 + y_t)V_{t-1}(t_0, t_1) + (1 + \frac{y_t}{2})(V_t^+(t_0, t_1) - V_t^-(t_0, t_1)), \quad t = t_0, ..., t_1 - 1, \tag{C.3}$$

$$V_{t_1}(t_0, t_1) = 0, \tag{C.4}$$

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

$$V_t^+(t_0, t_1) = 0, \qquad t > t_0. \tag{C.5}$$

The assumption of no partial redemption before exit writes

$$V_t^-(t_0, t_1) = 0, \qquad t < t_1. \tag{C.6}$$

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

$$\frac{V_t^-(t_0, t)}{V_{t-1}(t_0)} = \frac{V_t^-}{V_{t-1}}, \qquad t > t_0. \tag{C.7}$$

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

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

$$V_t = (1 + y_t)V_{t-1}(1 + \frac{y_t}{2})(V_t^+ - V_t^-). \tag{C.8}$$

Birth-cohort-level account value Define a birth-cohort t_0 as the set of cohorts $\{(t_0, t_1) : t_1 > t_0\}$. Denoting by $T_0 = 1999$ and $T_1 = 2015$ the first year and last year when account value data are available, we redefine birth-cohort $T_0 - 1$ as the set of birth-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 birth-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. (C.5) implies that, for all $t_0 \geq T_0$, inflows of birth-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 birth-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 birth-cohort-level end-of-year account value in year $t-1$, (C.6) and (C.7) imply that outflows of birth-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 birth-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 birth-cohort t in year t is $V_t(t) = (1 + \frac{y_t}{2})V_t^+(t)$.

Cohort-level account value For $t_1 \in [T_0, T_1]$, we redefine cohort $(T_0 - 1, t_1)$ as the set of cohorts $\{(t_0, t_1) : t_0 \leq T_0 - 1\}$. For $t_0 \in [T_0, T_1]$, we redefine cohort $(t_0, T_1 + 1)$ as the set of cohorts $\{(t_0, t_1) : t_1 \geq T_1 + 1\}$.

(C.6) implies that cohort-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 cohort (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 (C.3) and (C.4) that $V_{t_1-1}(t_0, t_1) = (1 + \frac{y_{t_1}}{2})V_{t_1}^-(t_0)/(1 + y_{t_1})$. 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 cohort (t_0, t_1) in year t, we use (C.4) 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 (C.2) and (C.3) that inflows of cohort (t_0, t_1) in year t_0 is $V_{t_0}^+(t_0, t_1) = V_{t_0}(t_0, t_1)/(1 + \frac{y_{t_0}}{2})$.

D Additional Analysis of Demand for Euro Contracts

D.1 Comparison of estimated semi-elasticity with the literature

In Hortaçsu and Syverson (2004) and Koijen and Yogo (2018), demand is measured in terms of log purchase flow, and the semi-elasticity of demand to the fee is defined as

$$\epsilon^{log\,purchase} = -\frac{dQ/Q}{dP}, \tag{D.1}$$

where Q are sales of the investment product and P is the fee.

In our paper, demand is measured in net flow divided by account value, and the semi-elasticity of demand to the return is defined as

$$\epsilon^{flow\,rate} = \frac{dF/V}{dER}, \tag{D.2}$$

where F is net flow, V is total account value, and ER is expected contract return conditional on reserves. The semi-elasticity in Drechsler, Savov, and Schnabl (2017) is also defined as (D.2) with F change in deposits, V stock of deposits, and ER spread between deposits interest rate and Fed Fund rate.

We suggest two adjustments to make $\epsilon^{flow\,rate}$ comparable to $\epsilon^{log\,purchase}$. First, we use inflow instead net flow in $\epsilon^{flow\,rate}$ to have a positive quantity which is homogeneous to a purchase flow. Let us denote inflow by Q. Dividing $\epsilon^{flow\,rate}$ by Q/V, we obtain

$$\epsilon^{flow\,rate} \times \left(\frac{Q}{V}\right)^{-1} = \frac{dQ/Q}{dER}, \tag{D.3}$$

where $\epsilon^{flow\,rate}$ is now the semi-elasticity estimated using inflow. We reject that $\epsilon^{flow\,rate}$ is 4.2 (equal to the regression coefficient of inflow on reserves 0.12 in Column 1 of Table 5 divided by the regression coefficient of contract return on reserves 0.026 in Column 1 of Table 3). V/Q is the average inflow rate equal to 10.5% (Table 1).

Second, the fee in $\epsilon^{log\,purchase}$ is paid every year throughout the holding period. By contrast, the expected return in $\epsilon^{flow\,rate}$ is for next year and decays in subsequent years, because the predictive power of reserves for contract returns decays with horizon. We calculate in Appendix E that the predictive power of reserves decays at a rate of 5.4% per year. Using an outflow rate of 8.1% per year (Table 1) and a discount rate of 3% per year, we find that an expected return of one percentage

point next year that decays at 5.4% per year has the same present value as an expected return of $(8.1 + 3)/(8.1 + 3 + 5.4) = 0.67$ percentage points that is constant through time. Hence, we must multiply dER by a factor of 0.67 to make to it comparable to a constant return. Hortaçsu and Syverson (2004) and Koijen and Yogo (2018) measure fees in percentage points ($P = 1$ is a fee of one percentage point) whereas we measure contract return in percent ($ER = 0.01$ is a return of one percentage point), so we multiply dER by 67 to make it comparable to P. We obtain that

$$\epsilon^{flow\,rate} \times \left(\frac{Q}{V}\right)^{-1} \times 67^{-1} \simeq 0.6 \tag{D.4}$$

is comparable to $\epsilon^{log\,purchase}$.

Koijen and Yogo (2018) estimate $\epsilon^{log\,purchase} = 16$, that is, sales of variable annuities decrease by 16% when the fee increases by one basis point. Hortaçsu and Syverson (2004) do not report the estimate of the semi-elasticity but it can be inferred from the average fee (30 basis points in their Table II) and the estimated average marginal cost (15 basis points in their Table III) using $\epsilon^{purchase} = 1/(P - MC) = 7$. We conjecture that these authors find higher semi-elasticity to the fee than our semi-elasticity to reserves because fees are more transparent and salient than returns predicted by reserves.

D.2 Additional covariates in flow regressions

Table D.2 reports the same flow regressions as in Table 5 with additional control variables. We include the capital ratio of the insurer measured at the end of the previous year. We find that its effect on flows is insignificant.In odd-numbered columns, we also include the lagged contract return. We note, however, that the regression coefficient on lagged contract return is a biased estimate of the sensitivity of demand to lagged contract return because contract return is a choice variable of the insurer. Proposition 2 show that insurers increase the contract return (for a given asset return) when demand is higher. Therefore, the relation between flows and contract returns suffers from reverse causality. This in contrast to the flow-performance relation studied in the mutual fund literature, because mutual funds have no flexibility to adjust the return paid to investors: the contract return is pinned down by the realized asset return. By contrast, euro contract returns are disconnected to the current asset return (as shown by Figure 2 and Table 3) and chosen by the insurer.

Table D.2: Investor Flows with Additional Covariates. Panel regressions at the insurer-year level for 76 insurers over 2000–2015. *Inflows* is total premia normalized by total account value. *Redemptions* is voluntary redemptions normalized by total account value. *Termination* is involuntary redemptions at contract termination (investor death) normalized by total account value. *Net flows* is Inflows minus Redemptions minus Termination. *Lagged reserves* is the beginning-of-year level of reserves normalized by total account value. *Capital* is the lagged capital normalized by total account value. *Lagged contract return* in contract return in previous year. Panel A shows OLS regressions. Panel B shows IV regressions in which the insurer's beginning-of-year reserve ratio is instrumented using the insurer's asset return in the previous year (the first year of data for each insurer is therefore dropped from the second stage). All regressions are weighted by the insurer share in aggregate account value in the current year. Standard errors two-way clustered by insurer and year are reported in parenthesis. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

	Panel A: OLS Regressions							
	Net flows		Inflows		Redemptions		Termination	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged reserves	.042	.043	.036	.038	-.015	-.013	.011	.011
	(.039)	(.041)	(.038)	(.039)	(.019)	(.02)	(.0095)	(.0094)
Capital ratio	-.15	-.15	-.087	-.088	.038	.037	.019	.019
	(.15)	(.15)	(.12)	(.12)	(.047)	(.047)	(.025)	(.025)
Lagged contract return		-.037		-.13		-.11		.012
		(.51)		(.41)		(.16)		(.065)
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Insurer FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	.63	.63	.73	.73	.75	.75	.8	.8
Observations	978	978	978	978	978	978	978	978

	Panel B: IV Regressions							
	Net flows		Inflows		Redemptions		Termination	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged reserves	.089	.089	-.019	-.02	-.08*	-.08*	-.026	-.026
	(.099)	(.098)	(.093)	(.093)	(.041)	(.041)	(.02)	(.02)
Capital ratio	-.13	-.13	-.034	-.034	.064	.064	.034	.033
	(.17)	(.17)	(.12)	(.12)	(.057)	(.057)	(.027)	(.027)
Lagged contract return		-.16		-.17		.022		-.026
		(.62)		(.44)		(.23)		(.073)
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Insurer FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	.66	.66	.77	.77	.75	.75	.8	.8
Observations	859	859	859	859	859	859	859	859

D.3 Regulated interest rate

In this appendix, we show that flows to euro contracts decrease when the interest rate on a regulated savings product which competes with euro contracts increases. The regulated savings product is called Livret A. It has an investment limit of 23,000 euros per household member including children and is demandable on short notice. Interests are tax free. In 2015, there were 60 million Livret A accounts for a population of 66 million, representing an outstanding investment of 250 billion euros.

Livret A accounts are distributed by banks but the interest rate is fixed by the Ministry of Finance. The rate is revised twice a year based on the short-term interest rate and the inflation rate. Changes in the regulated rate are discussed in the press, making them salient events. Since euro contract returns are smooth and the regulated rate tracks the short-term rate, there is time-series variation in the difference between euro contract returns and the regulated rate.

Figure D.2 suggests that aggregate inflow into euro contracts decreases when the regulated rate increases relative to euro contract returns.[37] We confirm the graphical analysis by regressions Table D.3. We use two different approaches to control for time trends. In Panel A, we work with variables in first difference. In Panel B, we work with variables in level and include a quadratic time trend. Both approaches yield consistent results. Inflows to euro contract increase when the return differential between euro contract and regulated savings increases (i.e., when the regulated rate decreases), whereas the opposite holds for outflows.

[37] The regulated rate plotted on Figure D.2 is free of fees and taxes, whereas the contract return is before fees and taxes, so the level of the return differential between euro contracts and Livret A is smaller than suggested by the figure.

Figure D.2: Flows and Regulated Interest Rate. Aggregate inflow to euro contracts normalized by aggregate account value (solid blue), weighted-average euro contract return (dashed red), and yearly average interest rate of regulated savings product Livret A (dashed green).

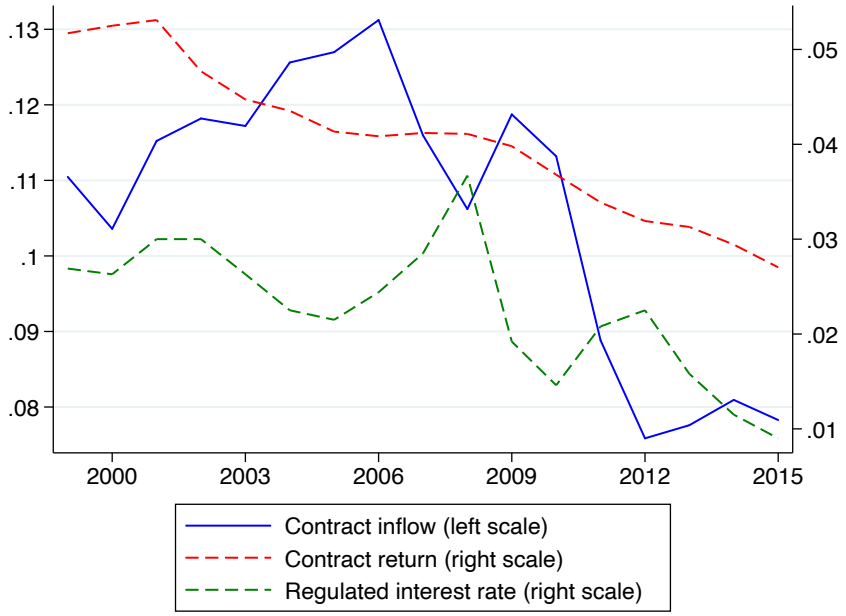


Table D.3: Flows and Regulated Interest Rate. Time-series regressions over 2000–2015. Regressions in Panel A are in first difference. Regressions in Panel B are in level and include a quadratic time trend. *Inflows* is aggregate premia normalized by aggregate account value. *Redemptions* is aggregate voluntary redemptions normalized by aggregate account value. *Termination* is aggregate involuntary redemptions at contract termination (investor death) normalized by aggregate account value. *Net flows* is Inflows minus Redemptions minus Termination. *Contract return minus Regulated rate* is contract return averaged across insurers minus regulated interest rate averaged over the year. Newey-West standard errors with two lags are reported in parenthesis. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

	Panel A: First difference			
	Net flows	Inflows	Redemptions	Termination
	(1)	(2)	(3)	(4)
Return spread	-1.6***	-1***	.65**	-.011
	(.47)	(.29)	(.23)	(.019)
Observations	16	16	16	16
	Panel B: Level with quadratic time trend			
	Net flows	Inflows	Redemptions	Termination
	(1)	(2)	(3)	(4)
Return spread	-1.9***	-1.2***	.69***	-.031
	(.52)	(.32)	(.22)	(.039)
Observations	17	17	17	17

E Mean Reversion of Reserves

This appendix presents the calculation of the mean reversion rate of the reserve ratio that we use in Section 5.4. Using (7) to substitute insurer profit in the sequential budget constraint (4), the evolution of reserves is given by

$$(1 + y_{j,t} + \mathcal{F}_{j,t})\,\mathcal{R}_{j,t} = x_{j,t} + (1 + x_{j,t})\mathcal{R}_{j,t-1} - \frac{1}{1-\phi} y_{j,t} \tag{E.1}$$

where $\mathcal{R}_{j,t} = R_{j,t}/V_{j,t}$ is the reserve ratio and $\mathcal{F}_{j,t} = (V_{j,t} - (1+y_{j,t})V_{j,t-1})/V_{j,t-1}$ is net flow. Taking the conditional expectation $E_{t-1}[.]$ of (E.1) and linearizing (E.1) around the steady state, we obtain

$$\mathcal{R}_{j,t} - \overline{\mathcal{R}} = \frac{1+\overline{x}}{1+\overline{y}+\overline{\mathcal{F}}}\left(\mathcal{R}_{j,t-1} - \overline{\mathcal{R}}\right) - \frac{\frac{1}{1-\phi} + \overline{\mathcal{R}}}{1+\overline{y}+\overline{\mathcal{F}}}\left(y_{j,t} - \overline{y}\right) - \frac{\overline{\mathcal{R}}}{1+\overline{y}+\overline{\mathcal{F}}}\left(\mathcal{F}_{j,t} - \overline{\mathcal{F}}\right), \tag{E.2}$$

where upper bars denotes steady state values.

The empirical estimate of the contract return policy in Table 3 implies

$$E_{t-1}\left[y_{j,t}\right] = \overline{y} + \frac{\partial y}{\partial \mathcal{R}} \times \left(\mathcal{R}_{j,t-1} - \overline{\mathcal{R}}\right), \quad \text{where } \frac{\partial y}{\partial \mathcal{R}} \simeq 0.03. \tag{E.3}$$

The empirical estimate of the flow-reserves relation in Table 5 implies

$$E_{t-1}\left[\mathcal{F}_{j,t}\right] = \overline{\mathcal{F}} + \frac{\partial \mathcal{F}}{\partial \mathcal{R}} \times \left(\mathcal{R}_{j,t-1} - \overline{\mathcal{R}}\right), \quad \text{where } \frac{\partial \mathcal{F}}{\partial \mathcal{R}} \simeq 0. \tag{E.4}$$

Using (E.3) and (E.4) to substitute $E_{t-1}[y_{j,t}]$ and $E_{t-1}[\mathcal{F}_{j,t}]$, respectively, in (E.2), we obtain

$$\begin{aligned}\mathcal{R}_{j,t} - \overline{\mathcal{R}} &= \left(\frac{1+\overline{x}}{1+\overline{y}+\overline{\mathcal{F}}} - \frac{\frac{1}{1-\phi} + \overline{\mathcal{R}}}{1+\overline{y}+\overline{\mathcal{F}}}\frac{\partial y}{\partial \mathcal{R}} - \frac{\overline{\mathcal{R}}}{1+\overline{y}+\overline{\mathcal{F}}}\frac{\partial \mathcal{F}}{\partial \mathcal{R}}\right)\left(\mathcal{R}_{j,t-1} - \overline{\mathcal{R}}\right) \\ &\equiv (1-\delta)\left(\mathcal{R}_{j,t-1} - \overline{\mathcal{R}}\right). \end{aligned} \tag{E.5}$$

(E.1) implies that the steady-state contract return $\overline{y}$ must satisfy $\left(1+\overline{y}+\overline{\mathcal{F}}\right)\overline{\mathcal{R}} = \overline{x} + (1+\overline{x})\,\overline{\mathcal{R}} - \overline{y}/(1-\phi)$. A first order approximation of (E.5) for small values of $\frac{\partial y}{\partial \mathcal{R}}$, ϕ, $\overline{\mathcal{F}}$, $\overline{x}$, and $\overline{\mathcal{R}}$, implies that the reserve ratio mean reverts at rate

$$\delta \;\simeq\; \frac{\partial y}{\partial \mathcal{R}} + \overline{\mathcal{F}} + \frac{\partial \mathcal{F}}{\partial \mathcal{R}}\overline{\mathcal{R}}. \tag{E.6}$$

The first term of (E.6) arises because the fraction $\frac{\partial y}{\partial \mathcal{R}}$ of reserves are distributed to investors.

The second and third terms reflect reserve dilution by flows. The second term arises because unconditional flows dilute reserves at a rate equal to the unconditional net flow rate $\overline{\mathcal{F}}$. The third term arises because conditional flows dilute reserves at a rate equal to the sensitivity of flows to reserves $\frac{\partial \mathcal{F}}{\partial \mathcal{R}}$ times the unconditional reserve ratio $\overline{\mathcal{R}}$. Using $\frac{\partial y}{\partial \mathcal{R}} = 0.03$ (Table 3), $\overline{\mathcal{F}} = 0.024$ (Table 1), and $\frac{\partial \mathcal{F}}{\partial \mathcal{R}} = 0$ (Table 5), the reserve ratio mean reverts at a rate of $\delta \simeq 5.4\%$ per year.

F Taxes

Tax treatment of euro contracts Contract returns are automatically reinvested in the contract and are not taxable until cash is withdrawn. When an individual withdraws cash, contract returns associated with the withdrawal are taxable as capital income.

The French tax system for capital income has a two-tier structure. The first tier is social security contributions, which is a flat tax on capital income whose rate has progressively increased from 10% in 1999 to 15.5% in 2015. The second tier is the income tax. Households can either 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. The withholding tax rate has been in the range 16%–19% for directly held stocks and mutual funds over 2004–2015. For euro contracts and 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 if more than eight years. The withholding tax is the most favorable option for the majority of households (at least in value-weighted terms).

Tax cost of switching insurer The tax system creates a tax cost of switching insurer for two reasons. First, contract returns are taxed upon withdrawals. Therefore, switching contracts moves the tax bill forward in time, which increases the present value of the tax bill. Second, the tax rate is a (non-continuously) decreasing function of contract age upon withdrawal. Therefore, switching contract increases the applicable tax rate by resetting the tax clock. The total tax loss of switching contract depends on how long the investor has held the initial contract and how long she will hold the new contract.

To quantify the tax cost of switching insurer, consider an investor who has been holding a contract for m years and has a contract value of one euro in year t, i.e., she invested $(1+y)^{-m}$ euro in year $t-m$. We calculate the year t-present value of the tax bill in the following two scenarios: (1) she holds the contract for another n years; (2) she switches to another insurer and holds the new contract for n years. Returns are taxed upon withdrawals and the tax rate depends on the age of the contract at the time of withdrawals. During the sample period, the tax rate for a k year old contract is $\tau(k) = 35\%$ if k is less than four years; $\tau(k) = 15\%$ if k is between four and eight years;

and $\tau(k) = 7.5\%$ if k is more than eight years. In scenario (1), the tax bill is

$$\tau(m+n)\big[(1+y)^n - (1+y)^{-m}\big] \quad \text{in year } t+n. \tag{F.1}$$

In scenario (2), the tax bill is

$$\begin{cases} \tau(m)\big[1-(1+y)^{-m}\big] & \text{in year } t, \\ \tau(n)\big[(1+y)^n - 1\big] & \text{in year } t+n. \end{cases} \tag{F.2}$$

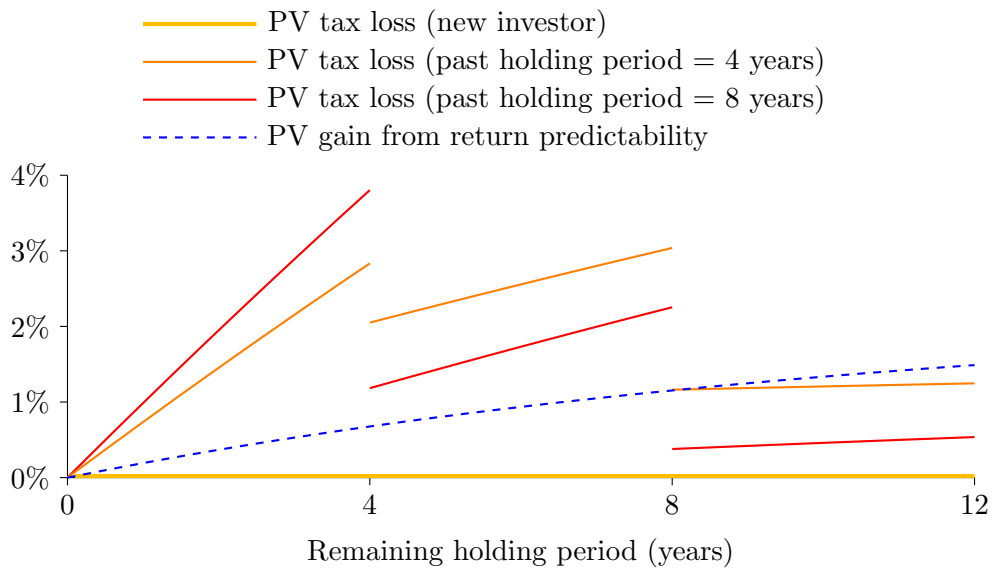
The tax cost of switching insurer is the year t-present value of (F.2) minus that of (F.1). This tax cost is plotted in Figure F.1 as a function of n, for $m \in \{0, 4, 8\}$.

We compare the tax cost of switching insurer to the gain of switching from an insurer with a low reserve ratio $\mathcal{R}_L$ to an insurer with a higher reserve ratio $\mathcal{R}_H > \mathcal{R}_L$. The gain is calculated as present value of additional contract returns obtained by switching to the high reserve contract. We discount the expected return difference between the two contracts at the risk-free rate, because the market beta of the long high-reserves/short low-reserves portfolio is zero (Table 7). Using that reserves are distributed to investors at a rate of $\frac{\partial y}{\partial \mathcal{R}} \simeq 3\%$ per year (Columns 1–2 of Table 3) and that the reserve ratio decays at rate $\delta \simeq 5.4\%$ per year (Appendix E), the present value for an investment of n years is

$$PV(n) = \frac{\partial y}{\partial \mathcal{R}} \times (\mathcal{R}_H - \mathcal{R}_L) \times \frac{1 - \big(1 - r_f - \delta\big)^n}{r_f + \delta}. \tag{F.3}$$

The present value is evaluated at the sample standard deviation of the reserve ratio $\mathcal{R}_H - \mathcal{R}_L = 0.068$ using $r_f = 3\%$. It is plotted in Figure F.1 as a function of the investment horizon n.

Figure F.1: Tax Cost of Switching Contract. The figure plots the tax losses of switching from an insurer with low reserves to an insurer with high reserves as a function of the remaining holding periods. The solid blue line is the present value of expected additional returns. The dashed red (orange) line is the present value of the tax loss for an investor who has held her previous contract for eight (four) years. The dashed green line is the present value of the tax loss for an investor who does not already hold a contract.



Two main results can be taken away from Figure F.1. First, new investors (yellow line) face no tax distortions and thus should always select contracts with higher reserves. Second, for investors already holding a contract for four yours (orange line) or eight years (red line), the tax loss outweighs the gains from predictability (dashed blue line) if investors plan to liquidate their investment within eight years whereas the gain outweighs the loss if investors plan to invest for another eight years or more. Given that the average holding period is twelve years, the majority of investors already holding a contract should find switching contract to be profitable. Thus, tax distortions do not seem qualitatively large enough to explain inelastic flows even for investors already holding a contract.