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Asset-liability management in life insurance: Evidence from France

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Abstract

This paper studies the asset-liability management of life insurers. We start with a life insurance investor's problem of the optimal date to redeem, as a function of taxes and rates of return. The model predicts that life insurers whose investors' contract age is relatively young should be more exposed to redemption risk. We then build a novel confidential dataset and test whether life insurers' portfolio choice is responsive to redemption risk. Using different measures of redemption risk and controlling for year fixed effects, we find that a one standard deviation increase in redemption risk is associated with an average decrease in the share of directly-held stocks by 2.3% or slightly more than one-half of its standard deviation (4.5%). This result remains valid when accounting for indirect stock investment through funds. Finally, we check our model's prediction that redemption risk depends on insurers' investor contract age and use this to propose and exogenous measure of redemption risk and make a causal attempt.

Keywords: Insurance companies, life insurance, surrender risk, redemption risk.
JEL Codes: G22, G28, G32.

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1 Introduction

Life insurance companies are among the largest institutional investors worldwide, holding around 10% of global financial assets, or $20 trillion (IMF, 2016). In the EU, households hold approximately one third of their financial assets in life insurance (and pension) products, and in the US, 20%.[1] After the near-collapse of the insurer AIG during the crisis, a number of insurance firms were subsequently designated as globally systemically important.[2] A controversy over the systematically importance of insurers began in 2015 when Metlife Inc. suited the Financial Stability Oversight Council (FSOC) over their decision to classify Metlife a systemically important financial institution.

Redemption risk creates a liquidity risk, which is one of the most important risks to affect the solvency of life insurance companies. Redemption risk affects the available resources and capacity of the insurer to manage the financial flows to ensure that the company is able to meets its responsibilities when they fall due. There is a need to understand the liquidity risks that insurance companies deal with on both sides of the balance-sheet, and whether those companies manage those risks actively. However, we know little about asset-liability management in the life insurance sector, partly because of lack of data. For instance, it was not until 2010 that the Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS) first recognized the importance of a quantitative evaluation of redemption risk.

This paper studies the asset-liability management of life insurers backing one of the most widespread types of life insurance contracts: guaranteed contracts that can be redeemed on demand. Our objective is twofold. We first build a simple model of an individual's optimal redemption date as a function of taxes and returns. Second, we study whether insurers manage their redemption risk actively, and invest in different assets accordingly. We use a novel confidential dataset from France containing data on investment choices by life insurers and investors redemption at the insurer level. Finally, we make a causal attempt by proposing a measure of exogenous redemption risk based on an institutional feature of the French life insurance market.

Concerning our first objective, we start with two dates 1 and 2 and an investor's choice of the optimal redemption date for a given redemption need. The investor chooses whether she redeems at date 1, in which case her contract returns are taxed immediately, or at date 2, in which case she borrows to satisfy her redemption need and repays her debt at date 2, so that contract returns are taxed at date 2.

[1]This figure accounts for the cash value of any life insurance policies that can be withdrawn. This excludes term life insurance policies, which only provide a death benefit. See Fed (2014). In the EU, life insurance products are the second most commonly held asset type (held by 30.3% of households), the first being deposits (96.9%). See EIOPA (2016).

[2]The nine insurers designed as systematically important are Aegon N.V., Allianz SE, American International Group Inc., Aviva plc, Axa S.A., MetLife Inc., Ping An Insurance (Group), Company of China Ltd., Prudential Financial, Inc., Prudential plc.

The choice between these two options consists in determining the optimal redemption date as a function of taxation, contract returns and interest rates. All else equal, the higher the taxation rate at date 1 relative to date 2, the more incentives for the investor to redeem at date 2.

Given the institutional feature of the French life insurance sector, in which investors' return taxation is decreasing in contract age, we conclude that for a given redemption need, investors whose contract is relatively older should favor redeeming their contract later compared to investors whose contract is younger. As a result, life insurers whose investor base is relatively young should be more exposed to redemption risk.

Concerning our second objective, we use a novel dataset built from regulatory reports and a proprietary survey on investor redemptions in France to test the model's predictions. The French life insurance market is a large and mature market, in which the value of Euro-denominated life insurance contracts in 2015 is €1,300 billion, representing 80% of aggregate life insurance provisions and 40% of aggregate household financial wealth.

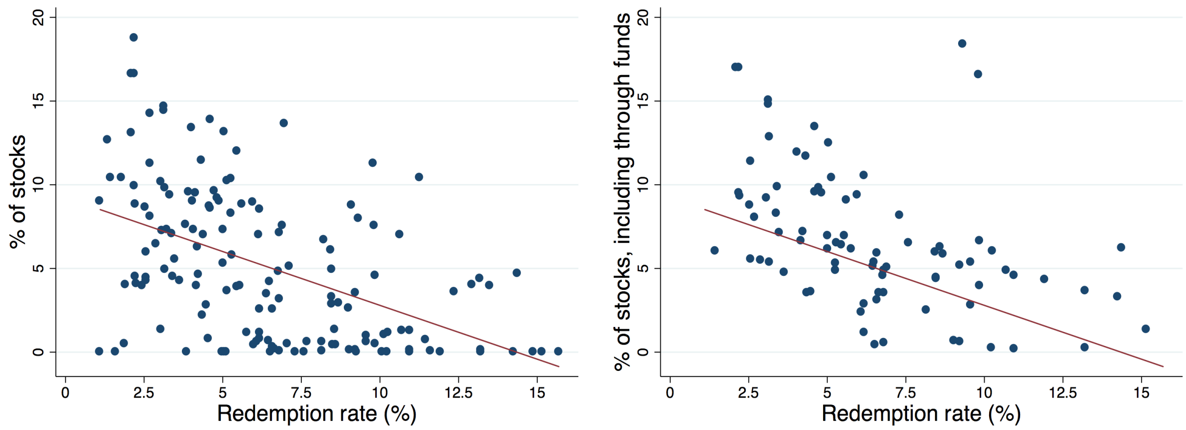
The French life insurance sector provides an ideal setting to test the asset-liability management of liability-driven portfolio choices because French life insurance contracts are standardized and regulated. Investors purchasing those contracts do not interfere with insurers' asset portfolio choices, which is managed at the fund level (not at the contract level). We also explain below how the French institutional context enables us to make a causal attempt at the relationship between redemption risk and life insurers asset portfolio choices.

We first document that market surrender rates of the major French life insurance companies have not reached alarming levels in our sample period (2007 – 2015). The mean (and median) redemption rate in our sample is 6%. However, the standard deviation of the redemption rate is three time as large in the cross-section (3%) than in the time series (1%).

We then study whether life insurers portfolio composition depends on redemption risk. We find evidence that redemption risk induces life insurers to invest less into stocks, both directly and through funds. These main conclusions are conveyed by Figure 1.

We test in a regression whether insurers which are more exposed to redemptions invest less into stocks. In our preferred estimation, we find that a 1 percentage point increase in redemption risk decreases insurers' share of directly-held stocks in total assets by 0.68% after controlling for year fixed effects, an estimate that is significant at the 1% level. Another way to gauge the economic significance of the point estimate is to multiply it by the standard deviation of the redemption rate (3% of provisions). It implies that a one standard deviation increase in the redemption rate is associated with an average decrease in the share of risky assets in insurers' portfolio by 2.3% or a little more than one-half of its standard deviation (4.5%). We find that this result is slightly smaller and not significant for the largest insurers, and that it also holds true when explaining the share of stocks

Figure 1 – Portfolio share of risky assets versus redemptions



Source: Regulatory reports, security-by-security asset holdings and redemption survey (FFA), 2011 – 2015.

held both directly and through funds.

We also test whether the maturity of insurers' bond portfolio is sensitive to redemption risk. We regress the share of insurers' bond portfolio invested in bonds of maturity less than 5 years, more than 5 years, and the average maturity of the portfolio, on redemption rates. We find no evidence that insurers respond to redemption risk by changing the maturity of their bond portfolio, neither directly nor through bond funds.

Then, we test whether insurers which are more exposed to redemption risks invest less into other types of risky bonds, and more into riskless bonds. We test both for the share of risky bonds in insurers' bond portfolio, both for "speculative investment" grade bonds and financial bonds, for the share of sovereign bonds, and for the share of investment-grade bonds. Again, we find no significant effect of redemption risk on insurers' holdings of those bond types in our sample.

We know that intermediaries which are financed by an issue of claims with outcome-independent payment obligations may have an incentive to take excessive risks, as some of the risk of insolvency falls on their financiers rather than themselves (see e.g. Jensen and Meckling, 1976; Rochet, 1992). We therefore test whether we can observe risk-shifting for French life insurers. We do not find that insurers with a lower level of capital invest more in risky assets or bonds with longer maturity. If anything, the only significant coefficient we obtain indicates that when the capital position of insurers worsens by 1 percentage point (in percent of total provisions), insurers decrease their investment in stocks by 0.94%, after controlling for year fixed effects. We interpret these findings as a rejection of the risk-shifting hypothesis for French life insurers.

These results provide evidence of a correlation between redemption risk and asset portfolio choices. However, one may argue that this might not be a causal relationship. If investors redemptions depend on contract returns, the latter is directly linked to the asset portfolio and the above regressions are subject to reverse causality bias. In the remainder of the paper, we follow two strategies to tackle this issue.

First, we check whether investor flows are responsive to contract returns. We regress inflows into life insurance contracts, whether in euro or unit-linked contracts, and redemption rates, on contract returns. We find no significant relationship between the flows into and out of insurance contracts and contract returns.

Second, in France, the taxation of returns from life insurance contracts depends on the age of the contract at the time of redemption, providing incentives for policyholders to redeem their contracts around key anniversary dates that are orthogonal to the composition of their insurer's asset portfolio.

We use this institutional feature to propose a measure of redemption risk that is exogenous to life insurers' asset composition. The taxation rates of life insurance redemptions are exogenously set, and vary with contract age. In line with our model's prediction, we show that taxation plays a key role in investors' redemption choices, with peaks of redemption at contract anniversary dates when taxation of contract returns is reduced (around 4 and 8 years). We construct a predicted redemption rate driven by fiscal incentives for investors to redeem their contracts, which we argue is orthogonal to their insurers' asset portfolio and immune to reverse causality or omitted variable bias. Our predicted redemption rate is highly correlated with observed redemption rates, with a coefficient of correlation of 0.7.

We test whether this exogenous redemption risk, driven by taxation lockups, causes insurers to invest less into stocks. We do find consistent evidence of a causal effect of redemption risk on insurers' portfolio: a 1 percentage point increase in redemption risk decreases insurers' share of stocks in total assets by 0.5%, after controlling for year fixed effects. This estimate is significant, and its size is slightly smaller than previously found, which may be due to the fact that we have a smaller sample to construct our exogenous measure of redemption risk.

The type of products that we study in this paper is widespread globally. Guaranteed products represent the major share of life insurers' liabilities in Austria, Denmark, France, Germany, Netherlands, and Sweden. Although the details of the surrender option vary across countries, investors always have the option to redeem them to a certain extentÂă(ESRB, 2015).[3] These guaranteed products account for $1,500 billion or 34% of US life insurer liabilities in 2015 (Koijen, 2017). Paulson (2012) document that US insurance companies are now more vulnerable to runs, i.e. to redemption by investors who lose

[3]While typically there is a penalty (i.e., surrender charge) for exercising this option in the early years after a life insurance contract is issued, life insurance contracts can be thought of as putable bonds with a variable yield and an increasing strike price. Without the surrender option, life insurance contracts would decline in value as interest rates rise, just as any fixed income instrument does. See Briys and de Varenne (1996) for an option-value approach to life insurance contracts.

confidence in a particular insurer or in insurers generally, with approximately 54% of life insurers' liabilities in moderately to highly liquid categories.

The importance of redemption risk in the life insurance sector is illustrated by the fact that most of the recent cases of insurance companies insolvency occurred in the life insurance branch, as investors lost confidence in the company and redeemed policies that had a guaranteed interest rate (Plantin and Rochet, 2007). In general, assets backing life insurance contracts were non-liquid in the short term, giving rise to high losses when they were converted. redemption risk is difficult to assess because of its economic nature. Investors can redeem their life insurance contract due to rational arbitrage possibilities, e.g. falling contract returns, but also due to personal considerations or behavioral causes. redemption risk is consequently not an easy risk to manage, having a lot of causes which differ in nature. A striking illustration of the regulator's concerns about investors redemption in the life insurance sector is France, where a law was passed in 2016, giving the supervisor the power to suspend, defer or limit inflows or outflows in life insurance companies, for a period of maximum six months. This new power was given to cope with potential threats for the "stability of the financial system".[4] A similar example for legal provisions establishing circuit-breaking powers are already in place in Japan.

The exposure of banks and other depository institutions to interest rate risk has been a matter of concern to bank supervisors for a long time, a canonical example of interest rate risk in the financial sector coming from the Savings and Loans (S&L) crisis of the 1980s. Having granted very-long-term, fixed-rate mortgages until the early seventies, American S&L institutions found themselves squeezed by the high interest rates of the early 1980s. The rising interest rates led many institutions, including insurance companies, to reach for riskier assets offering higher yields while operating with less capital per dollar of assets. Life insurers were forced to redesign their product lines and to migrate toward interest rate sensitive products (White, 1991). This new environment induced life insurance companies to mismatch assets and liabilities and to invest in riskier assets with lower credit quality standards. From 1987 to 1991, more than 100 companies went bankrupt or insolvent. Canada went through the same kind of turmoil from 1992 to 1994, with several company bankruptcies. As for Europe, the difficulties experienced by banks in several countries in the early 1990s can at least in part be ascribed to the high interest rates that prevailed in the period 1989 to 1992, and to depressed real estate prices.

This paper connects to several strands of the literature. The first strand is the literature on redemption risk. In finance and insurance, studying redemption risk mainly means being able to price an option to pay back a credit in anticipation. This important issue arises in a number of situations where products (issued by both banks and insurance companies) are subject to a redemption risk. The finance literature addressing the prepayment of mortgage backed securities is by far the largest one (see e.g. Hanson, 2014).

[4] See the original law here (in French).

In contrast, the insurance literature studying redemption risk of insurance contracts is more restricted and mainly takes an actuarial approach (see e.g. Milhaud et al., 2011).

The literature has identified three motives for insurance contracts redemption. First, the emergency fund hypothesis contends that policyholders use the cash value of their redeemed contract as an emergency fund when facing personal financial distress (Outreville, 1990). Second, the interest rate hypothesis conjectures that investor redemptions increase with the market interest rate, as investors redeem their existing contract to invest in new contracts backed by higher-yielding assets. Finally, the behavioral hypothesis asserts that heuristic decision making by investors increases the probability to redeem, which is amplified by interactions with financial (il)literacy (Nolte and Schneider, 2017).

The second literature is the literature on life insurance companies. Using data from Germany, Domanski et al. (2017) argue that assets and liabilities must be considered jointly in the context of life insurance. They show how dynamic hedging of maturity mismatches can explain why insurers buy longer term securities when interest rates fall, thereby amplifying a decline in long-term interest rates. Becker and Ivashina (2015) show how risk-based capital requirements incentivize US life insurers to hold the riskiest bonds within each risk category. Koijen and Yogo (2015) show how US life insurers sold policies below actuarial costs during the financial crisis due to statutory accounting rules combined with financial and product market frictions. Eber (2016) proposes a theory based on earnings-targeting to explain why in the recent low interest-period starting in 2009, US life insurers have tilted their corporate bond acquisitions towards issues with lower credit quality, longer maturities and lower redemption.

Finally, we connect to the banking literature on interest-rate risk and financial intermediaries as money-like claims issuers. Life insurance companies and banks have very close models in the case of life insurance products with guaranteed returns, but the nature of the relationship between the investor and the company remains of an insurance-type, such that life insurers do not fully hedge interest-rate risk (EIOPA, 2014; IMF, 2016), and have to manage it through asset portfolio choices. In the case of banks, Flannery and James (1984) were the first to show the robust stylized fact that bank stock returns react negatively to increases in interest rates. They further find that stock returns of banks with more short-term liabilities relative to short-term assets (i.e., which engage more in maturity mismatching) react more negatively to increases in interest rates.

The life insurance contracts that we study are closer to money-like claims than pure risk life insurance products or property and casualty insurance products. Because of their properties and the fact that life insurers manage all their outstanding insurance contracts within a single fund, studying the asset-liability management of this fund by life insurers is helpful to understand portfolio choices by financial intermediaries which issue money-like claims. Important papers theorizing financial intermediaries as providers of money-lie claims include Diamond and Dybvig (1983) and Gorton and Pennacchi (1990). The "liability-centric" view of financial intermediaries renders their asset-liability management particularly challenging, and we argue that life insurers provide an ideal laboratory to study this management.

The rest of the paper is organized as follows. The institutional environment is described in Section 2. Section 3 presents an individual's problem of when to redeem an insurance contract. Section 4 presents the data and summary statistics. Section 5 presents evidence on the relation between life insurers' portfolio choices and redemption risk. Section 6 proposes an exogenous measure of redemption risk to attempt at causality. Section 7 concludes.

2 Institutional environment: life insurance in France

Life insurance can be considered a liability-driven business, taking in in funds today in exchange for the promise to make conditional payments in the future. Life insurers frequently insist upon the long maturity of their liabilities. In the words of Warren Buffet, chairman of Berkshire Hathaway,

> Smart money's in insurance industry for many good reasons. It's a business of taking in premiums today, paying out claims later (...) During that time the insurer invests the money.

However, the redesign of life insurance policies and the pressure of competition call for a rethinking of the duration of life insurance products. Since the 1990s, life insurers have set contract returns high enough to match competition. Investors' option to redeem their contract, called a "surrender" option, makes the interest-rate risk exposure of life insurers not only a matter of mortality tables, but predominantly a matter of investors' behavior. When coupled with guarantees on the cash value of contracts, this option exposes life insurers to higher costs and difficulties in recovering initial policy issuance expenses (Belth, 1975; Carson and Dumm, 1999; Russell et al., 2013) and to financial risks. If the returns on long-term investments are given and subsequently the market rate of interest is high, the market value of the initial investment may fall below the redemption value of initial investors.

We describe the institutional features of interest for Euro-denominated life insurance contracts in France: safety and redemption. Most life insurance contracts in other countries share similar characteristics (ESRB, 2015). The cash deposited in investors' account is invested in asset markets through a fund managed by the insurer. We then detail the regulatory restrictions in asset holdings, as well solvency requirements, the insurer has to comply with.

2.1 Safety

French life insurers sell savings products called Euro-denominated life insurance contracts. When an investor purchases such a contract, she opens an account with the insurer on which she can deposit cash and withdraw cash at any time. Those contracts are called "Euro-denominated" because investors are entitled to withdraw the full value of their account at any time, in euros.

These contracts are savings products with guaranteed capital. To prevent insurers from charging fees up-front such that surrender values could be lower than principal or even null, surrender values are guaranteed by law and made of two parts. First, investors' principal is guaranteed, such that life insurers cannot pay negative returns on their contracts. Second, whatever the amount that life insurers pay out to investors, these latter benefit from the so-called "ratchet effect", which each year offers investors the full and entire ownership of the returns recorded in the past.

Provisions on the liability side of life insurers' balance-sheets correspond to insurers' commitments *vis-à-vis* their investors. Life insurers must hold a sufficient amount of provisions, defined by the regulator as the total account value of all policyholders. Therefore at all time and for all life insurers, provisions are equal to aggregate account value, in euros, representing investors' principal augmented by past returns.

If a life insurer is in bad shape, the supervisor either organizes the transfer of its contracts to other insurers, or appeals to a guarantee fund financed by life insurers.[5] In case of bankruptcy of a life insurer, investors' contracts are guaranteed up to €70k per investor. If many insurers go bankrupt, investors enjoy the guarantee for each insurer they hold a contract with. The guarantee fund has not been used since its creation in 1999.

2.2 Regulation

Asset restrictions The general guideline given by the law is that Life insurers can back their provisions using any bond, stock or real-estate from OECD countries.[6] Life insurers' asset portfolio must satisfy dispersion rules, that are typically not binding. Finally, there is a limit on assets held by life insurers that are denominated in other currencies than the Euro.

One important institutional feature for our analysis is that realized gains and losses on fixed income securities have to be credited to or debited from a reserve account called the capitalization reserve account (*réserve de capitalisation*). The capitalization reserve account can only be used to offset future losses on fixed income securities and cannot be

[5] This fund is called *Fonds de garantie des assurés contre la défaillance de sociétés d'assurance de personnes* (FGAP). See *Code des Assurances*, article L423, and http://www.fgap.fr/.

[6] See art. R.332- of *Code des Assurances*.

credited to investor accounts or to insurer income.

Solvency margins Life insurers must always satisfy simple solvency requirements, which impose that they hold a minimum amount of capital of at 4% of provisions.[7] When a life insurer does not comply with these requirements, the supervisor requires that a short-term refinancing plan be set up. Importantly for our analysis, solvency requirements are independent of the composition of assets.

2.3 Taxation upon redemption

2.3.1 Tax base

Returns from life insurance contracts are taxed only when individuals redeem their contract. The regulatory definition of the tax base is that for a given fraction of the total contract amount redeemed, the corresponding fraction of returns only is taxed. Denoting $redeemed.amount_t$ the amount redeemed (in euros) at redemption date t, $remaining.value_t$ the remaining contract value as of date t and $remaining.premia_t$ the remaining amount of premia (in euros) invested in the contract as of t, the tax base for a redemption at date t, $tax.base_t$, writes:

$$tax.base_t = redeemed.amount_t - \left(remaining.premia_t \times \frac{redeemed.amount_t}{remaining.value_t} \right) \quad (1)$$

If an investor redeems 10% of her contract's value at a given date, her tax base is 10% of total returns (in euros) generated since her contract's opening. In the particular case where an investor redeems her entire contract value, her tax base is equal to:

$$tax.base_t = redeemed.amount_t - remaining.premia_t$$

2.3.2 Summary of returns taxation

Table 1 summarizes the contract returns tax rates as a function of contract age. Importantly, we see that taxation is a decreasing function of contract age. We study in Section 3 the implications for an investor's optimal redemption date. An example is provided in Appendix B.

3 Individual's problem of optimal redemption date

As explained in Section 2.3.2, the tax rate on life insurance contracts returns depends on the time elapsed between the opening and the redemption of the contract – which

[7] This is the rule under Solvency I regulations, which is in place throughout our sample. See *Code des Assurances*, art. L 334.

Table 1 – Summary of returns taxation upon redemption

	Contract age upon redemption		
	0 – 4 years	4 – 8 years	> 8 years
lump sum allowance (yearly)	none	none	€4.6k if single €9.2k if married
returns taxation rate	35% (or income tax)	15% (or income tax)	7.5% (or income tax)
other taxes	15.5%	15.5%	15.5%

we refer to as "contract age".[8] An individual might be willing to redeem (part of) her contract for several reasons. First, if the benchmark interest rate increases, the redemption option enables investors to redeem their life insurance contract and invest in new vehicles with higher expected returns aligned with the newly prevailing interest rate. Second, if an investor faces liquidity needs (e.g. due to income shocks or increased expenses), she might redeem her contract regardless of market conditions. An investor willing to redeem (part of) her contract faces the following problem. Either she can redeem her contract upon redemption needs, or given that return taxation decreases over time, she might choose to redeem at a later date. In this Section, we consider an investor's problem of the optimal redemption date.

Assumption 3.1 (Simplifying assumptions)**.** *We make the following assumptions:*

1. *The investor does not choose income taxation for his contract returns.*
2. *Premia are held constant, so that contract returns increase over time.*
3. *Contract returns are known.*

We consider two dates 1 and 2 and an investor's choice of the optimal redemption date for an euro amount L. We denote V_t the investor's account value at the end of date t, P the (constant) premia, y the contract returns and τ_t the returns taxation rate at date t.

The first option for the investor is to redeem at date 1, in which case her contract returns are taxed immediately on a tax base given by 1 and at a rate τ_1. In order to obtain an euro amount L at date 1, in the first option the investor must redeem at date 1 an amount equal to:

$$L \times \left[1 - \tau_1 \left(1 - \frac{P}{V_1}\right)\right]^{-1}. \tag{2}$$

The second option is to borrow the amount L of redemption needed at $t = 1$, at a fixed interest rate r. The investor will then have to repay $L \times (1 + r)$ euros at date 2,

[8] The taxation discussed in this paper is that of all contracts opened in France since 1997. For contracts opened before 1997, a slightly different taxation was effective. However, our sample starts in 2007 and on average, investors redeem their contract a little less than 10 years after opening it. Thus the vast majority of investors with our sample of life insurers are subject to the tax scheme studied here.

when she redeems her insurance contract and is taxed on her contract returns. In order to obtain an euro amount L at date 1, in the second option the investor must redeem at date 2 an amount equal to:

$$L \times (1+r) \times \left[1 - \tau_2 \left(1 - \frac{P}{V_2}\right)\right]^{-1}. \tag{3}$$

The choice between options 1 and 2 consists in determining the optimal redemption date as a function of taxation, contract returns and interest rates. Remark that given the negative relationship between return taxation and the contract age (Figure 15), the investor's contract age will be a key determinant of the optimal redemption date.

From 2 we have that the investor's total wealth at date 2 if she chooses option 1 is:

$$(1+y)\left[V_1 - L \times \left[1 - \tau_1 \left(1 - \frac{P}{V_1}\right)\right]^{-1}\right], \tag{4}$$

and from 5, her total wealth at date 2 if she chooses option 2 is:

$$V_1(1+y) - \left[L(1+y)\left[1 - \tau_2 \left(1 - \frac{P}{V_1(1+y)}\right)\right]^{-1}\right]. \tag{5}$$

We obtain Proposition 1.

Proposition 1 (Optimal redemption date)**.** *All else equal, the higher the taxation rate at date* 1 *relative to date* 2*, the more incentives for the investor to redeem at date* 2*.*

Proof. Assuming a strictly increasing utility function, the investor redeems at date 1 if (4) is greater than (5), which yields

$$\frac{1+r}{1+y} < \frac{\left[1 - \tau_2 \left(1 - \frac{P}{V_1(1+y)}\right)\right]}{\left[1 - \tau_1 \left(1 - \frac{P}{V_1}\right)\right]}.$$

Denoting $IC(y) \equiv (1+y)\left[\frac{\left[1-\tau_2\left(1-\frac{P}{V_1(1+y)}\right)\right]}{\left[1-\tau_1\left(1-\frac{P}{V_1}\right)\right]}\right] - 1$ the indifference curve between redeeming at date 1 and 2, we find

$$\frac{\partial IC(y)}{\partial y} = \frac{V_1(1-\tau_2)}{V_1(1-\tau_1) + P\tau_1} > 0.$$

□

Given the institutional feature of the French life insurance sector, in which investors' return taxation is decreasing in the contract age (Figure 15), we conclude from Proposition 1 that investors whose contract is relatively older should favor redeeming their contract later compared to investors whose contract is younger. As a result, life insurers whose investor base is relatively young should be more exposed to redemption risks.

4 Data and Summary Statistics

This section explains the source and construction of the data that will be used in subsequent analyses. The data can be separated into balance sheet and regulatory variables at the firm-year level, a granular dataset on each firm's asset holdings (at the asset level), and a survey on investors' redemptions at the firm-year level. The sample period over which the data is available is 2011 – 2015.

We use regulatory data from the national insurance supervisor *Autorité de Contrôle Prudentiel et de Résolution* and confidential data from the French Insurance Federation *Fédération Française de l'Assurance*. All variables are winsorized at the 1% level before aggregation to avoid results that are (potentially) driven by miscoded outliers.

4.1 Balance sheets and regulatory variables

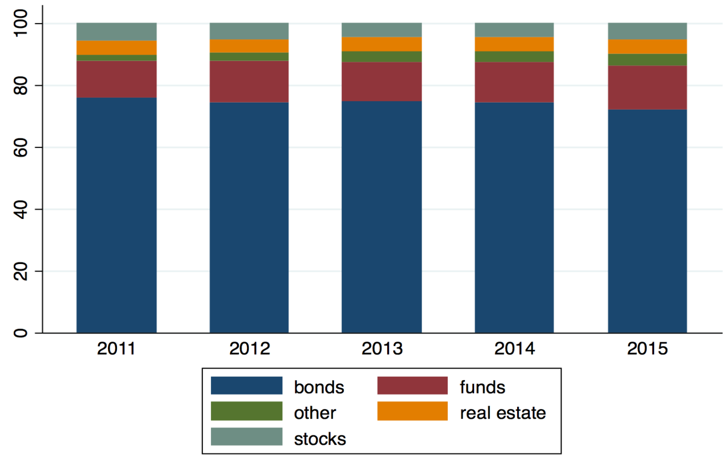
Table 2 – Balance sheets and regulatory variables: summary statistics

	Mean	Median	Std.Dev.	N
Account value (bn euro)	45.7	20.8	53.7	149
Inflows (%)	10.7	9.6	5.2	149
Outflows (%)	8.3	8.1	2.1	149
Capital (%)	5.4	4.9	2.1	149
Share of bonds (%)	76.4	78.0	9.6	149
Share of stocks (%)	5.1	4.3	4.5	149
Share of real estate (%)	3.9	3.2	3.5	149
Share of cash (%)	1.9	0.4	5.0	149
Share of loans (%)	1.1	0.5	1.3	149
Share of funds, inlc. stocks (%)	6.4	5.7	4.8	149
Share of funds, bonds only (%)	4.8	3.8	4.9	149
Contract return (%)	3.6	3.6	0.7	149

Source: Supervisory Reports 2007–2015.
Number of insurers: 27.

Summary statistics for balance sheet variables are presented in Table 2. We drop insurers with less than €10 million of life insurance provisions. The final sample comprises an unbalanced panel of 66 insurance companies. As is typical for size distributions, the distribution of yearly provisions has a thick right-tail: the median insurer's provisions is €4.5 billion while the provisions of the largest groups exceed €200 billion. The capital-to-

Figure 2 – All life insurers: breakdown of assets (in %)



provisions ratio of the average firm is 4.9%, slightly above the solvency requirements of 4%. In the analysis, we do not use aggregate portfolio data from the supervisory reports data because the latter does not allow us to distinguish assets that back provisions from assets owned by the life insurer, and neither do they provide precise decompositions across asset classes. Aggregating all assets by life insurer, i.e. assets backing life insurance contracts and assets owned by the life insurer, life insurance companies hold 81.9% of bonds and 11.9% of stocks in our sample, which is close to the median values of 83.1% and 10.8%, respectively.

4.2 Insurers' assets portfolios

A more detailed source of data on life insurers' portfolio is the security-by-security asset holdings of each life insurer, called TCEP (*"Tableau Complémentaire aux Éléments de Placements"*), available from 2011 to 2015. These data enable us to break down in details insurers' aggregate portfolio into its components.

4.2.1 Asset portfolios

Figure 2 breaks down the aggregate legacy portfolio by asset type, summing up individual insurers' portfolios to obtain an aggregate balance sheet of the sector. Bonds form the most important asset type in French life insurers' portfolios, similarly as US life insurers (Becker and Ivashina, 2015). In 2014, €1,300 billion out of €1,700 billion were invested in bonds. Other significant asset classes are stocks, real estate investments and mutual funds. Before applying a pass-through approach into mutual funds' portfolio, we have that mutual funds account for approximately 20% of life insurers' portfolio, in line with the European average (ESRB, 2015).

Table 3 – Summary statistics on security-by-security asset portfolio

	Mean	Median	Std.Dev.	N
Share of bonds (%)	76.8	77.7	7.6	21
Share of short-term bonds	33.3	31.0	8.9	21
Share of long-term bonds	66.7	69.0	8.9	21
Share of sov. bonds	35.0	33.4	15.0	21
Share of fin. sec. bonds	40.3	42.4	9.2	21
Share of investment-grade bonds	85.7	84.9	7.9	21
Share of speculative-grade bonds	3.0	2.1	2.7	21
Share of stocks (%)	4.5	3.5	4.5	21
Share of listed stocks	65.5	78.8	36.5	21
Share of nonlisted stocks	25.0	13.7	30.4	21
Share of real estate	4.6	4.8	2.9	21
Share of funds	10.6	10.5	5.7	21
Share of MMF	2.9	2.4	2.3	19
Share of other funds	8.0	9.1	4.7	21
Share of other	3.5	2.2	4.5	21

Source: TCEP, year 2014.
Number of insurers: 21.

Table 3 breaks down aggregate bond portfolio further and presents the fraction of total assets held in more detailed asset classes using the security-by-security dataset (TCEP). The majority of bonds have a residual maturity of more than 5 years, and are investment grade. Other major categories are listed stocks, real estate and mutual funds. Table 12 in Appendix A provides a similar breakdown with a funds pass-through.

4.2.2 Investor redemptions ("surrenders")

The data on redemption by individual investors come from the survey on investor redemptions called *Enquête Rachat* conducted by the French Insurance Federation, *Fédération Française de l'Assurance*. The data is available from 2007 to 2015, with a gap in 2013 when the survey was not conducted.[9] Given the importance and sensitivity of investors' redemptions for life insurers, these data are rare and highly confidential.

The data enable us to break down down investors' redemptions with 26 French insurers, by contract age at an annual frequency. The sample of insurers represents around 50% of aggregate life insurance provisions in France. For the smaller period 2011 – 2015, we also observe investors' contract age distribution. Summary statistics for redemptions are presented in Table 4, with the cross-sectional variation on rows 1 and 2, and the time-series variation for data aggregated at the year level, on rows 3 and 4. The average (and

[9]The survey was not conducted in 2013 for technical reasons that are independent of the focus of our analysis.

median) percentage of investors redeeming their insurance contract is 6% in our sample.

Table 4 – Investors redemption survey: Summary Statistics

	Mean	Median	SD	N
Redemption rate (%)	6.39	5.78	3.46	149
Ave. contract age (years)	12.22	11.69	4.04	82
Redemption rate (%)	6.37	6.04	1.11	8
Ave. contract age (years)	12.18	12.14	.89	4

Rows 3-4: aggregated over years

Sources: Liquidation Survey (FFA), Regulatory Reports (2007-2015).

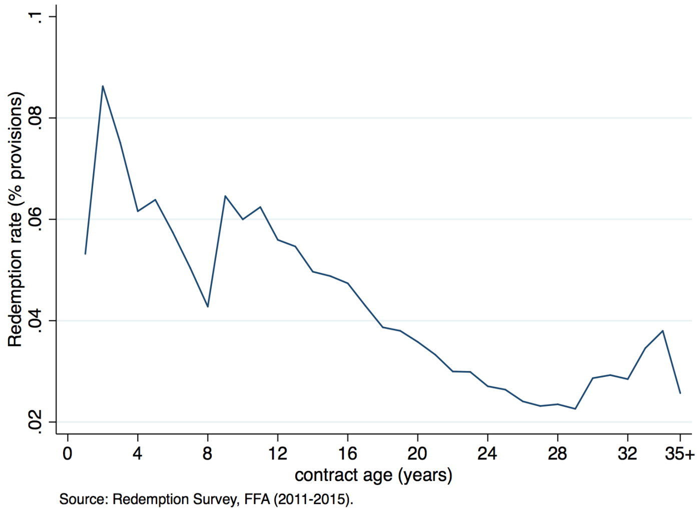
Source: Investor redemption survey (FFA), 2011–2015.
Number of insurers: 26.

Comparing row 1 to row 3 in Table 4, we find that the standard deviation of the redemption rate is three time as large in the cross-section (3 percentage points) than in the time series (1 percentage point). This suggests that redemption rates are fairly constant across years, but that they differ in the cross section of insurers. The explanation for this fact is that different insurers specialize in different types of clienteles, and some clienteles are more prone to redeem their contracts than others. Indeed, it has been shown that investors profiles are different across insurers, for instance some insurers specializing in wealthier investors, who are also more likely to manage their investment actively and thus to redeem their life insurance contract (Frey, 2016).

To capture this phenomenon in more detail, we plot in Figure 3 the redemption rate against contract age. We find that investors redeem their contract around key anniversary dates. In the first two years, many investors redeem their contract (however, we will see shortly that these redemptions are not quantitatively important), potentially because they misused or misunderstood their life insurance contract. We then observe redemption peaks around the 4th and 8th anniversary dates, in line with optimization of redemption around fiscal lockups as described in Section 2.3.1. Investors are found to be very sensitive to the taxation on their contract returns, suggesting that many investors use their life insurance contracts as a savings device that entails fiscal advantages.

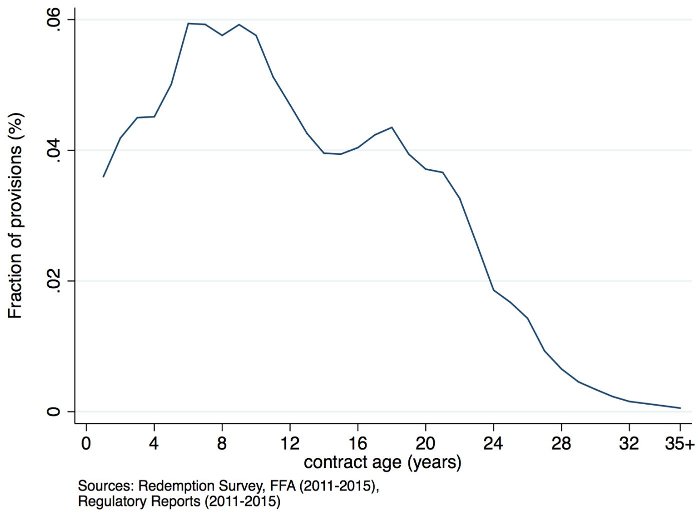
We present in Figure 4 the fraction of provisions across contract ages. These data is averaged across 2011 – 2015 (with a gap in 2013), the period for which these additional data are available. We observe that the bulk of life insurance contracts have been opened less than 10 years before, consistent with the fact that many investors purchase life insurance products with a short- to medium-term investment horizon, using life insurance contracts as a savings device rather than a traditional life insurance product. We note that the fraction of provisions with age less than 2 years is fairly small (less than 4%), which is why redemptions before 4 years are not very informative about the redemption

Figure 3 – redemption and contract age



risk faced by insurers.

Figure 4 – Average contract age



From these observations, we cannot conclude that the familiar banking concept of run can readily be applied to the French life insurance sector. Runs occur when many liability holders rush to withdraw their funds from an institution because they fear the money will run out, and we have not observed high enough redemptions rates to put the solvability of French life insurers at risk. However, asset-liability management by life insurers requires a close look at investors' redemption behavior. The average percentage of redemption is 6% yearly, but there is variation in the cross-section and for some insurers, it appears that redemption risk is an important risk that they must account for in their asset portfolio choices.

Redemption rates are all the more sensitive that they inform about investors' profile, and their elasticity to changes in the environment that may trigger a higher rate of redemption. A law was passed in France in 2016, giving the supervisor the power to suspend, defer or limit inflows or outflows in life insurance companies, for a period of maximum six months. This new power was given to cope with potential threats for the "stability of the financial system"[10], suggesting that a higher rate of redemption than that we observe in our data, might occur in other circumstances (such as a rise in interest rate). A similar example for legal provisions establishing circuit-breaking powers are already in place in Japan.

5 Results

We test whether insurers portfolio depend on redemption risk by regressing different characteristics of insurers portfolio on redemption exposure at the insurer level. In practice, we estimate the following cross-sectional model:

$$Y_{it} = \gamma_t + \beta \times X_{it} + \epsilon_{it}$$

where the outcome variable Y_{it} is a characteristic of the asset portfolio (typically, a fraction of insurers' portfolio invested in a given asset type) of insurer i in year t, and the dependent variable X_{it} is the redemption rate. γ_t is a year fixed effect, and ϵ_{it} is an error term.

5.1 Share of risky assets

Our model predicts that insurers which are more exposed to redemption risks invest less into risky assets. In this section, we test whether insurers which are more exposed to redemption risk hold a smaller fraction of stocks in their portfolio. We test this hypothesis using three sets of data. One is the regulatory reports data at the insurer level, another one is the security-by-security (TCEP) asset holding of insurers, and the last one is the security-by-security (TCEP) asset holding of insurers with a funds pass-through.

Table 5 presents the results. We obtain the robust finding that those insurers which are more exposed to redemption risk, hold less stocks in their portfolio. The coefficient in column (1) indicates that a 1 percentage point increase in redemption risk decreases insurers' share of stocks in total assets by 0.68%, an estimate that is significant at the 1% level. The results are similar across for stocks directly held by insurers (columns (1) and (3)), as well as with a funds pass-trough (column (5)).

We test whether this relationship holds across insurer sizes and find that all insurers invest less in stocks when exposed to redemption risks, except for the largest insurers. Columns (2), (4) and (6) show that the third decile of insurers (based on provisions)

[10] See the original law here (in French).

Table 5 – Share of stocks in insurers portfolio and redemptions

	%stocks					
	regulatory reports		security-by-security		security-by-security funds pass-through	
	(1)	(2)	(3)	(4)	(5)	(6)
Redemptions (%)	-.68***		-.72*		-.66*	
	(.17)		(.25)		(.22)	
1^{st} t. PM* Redemptions		-.63***		-.7**		-.58**
		(.14)		(.19)		(.15)
2^{nd} t. PM* Redemptions		-.85***		-.91*		-.96*
		(.23)		(.34)		(.3)
3^{rd} t. PM* Redemptions		-.54		-.52		-.49
		(.29)		(.42)		(.36)
Observations	149	149	84	84	84	84
Year FE	yes	yes	yes	yes	yes	yes
R^2_adj	0.22	0.25	0.21	0.26	0.20	0.32

Source: Regulatory reports, TCEP and redemption survey. Panel regressions of the share of stocks in insurers' portfolio on redemption rate, with year fixed effects. Standard errors are double-clustered by insurer and year. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

show a smaller coefficient that is not significant. We suggest that this may be explained by the fact that larger insurers have other ways to manage their redemption risks, for example they have distribution networks and specific clientele relationships that decrease their exposure to redemption risks.

Table 6 contains the results using alternative measures of redemption risk. First, we take the average redemption rate for each insurer across the sample, so that $X_{it} = X_i = \sum_{t=2011}^{2015} \frac{l_{it}}{4}$ where l_{it} is the redemption rate of insurer i in year t.[11] We label this variable "ave. redemption rate". Second, we compute the standard deviation of the redemption rate, also at the insurer level in our sample. Reassuringly, we find evidence in line with the results in Table 5: both a larger average and standard deviation of the redemption rate imply a smaller fraction of the insurer portfolio invested in stocks. The effect of the average redemption rate is found to be more significant, however.

In Appendix A, we report the results of similar regressions for other asset types. We find that insurers which are more exposed to redemption risk invest less in real estate, more into bond funds and hold more cash. Even though the estimates are important in size, they are not significant.

[11] Note that once merging the security-by-security asset holding sample with the redemption survey, missing in 2013, we have 4 years of data).

Table 6 – Share of stocks in insurers portfolio and alternative measures of redemptions

	%stocks					
	regulatory reports		security-by-security		security-by-security funds pass-through	
	(1)	(2)	(3)	(4)	(5)	(6)
av. redemptions (%)	-.91***		-.8*		-.7*	
	(.2)		(.26)		(.24)	
sd of redemptions (%)		-1.4*		-1.4		-.93
		(.63)		(.72)		(.71)
Observations	149	148	84	84	84	84
Year FE	yes	yes	yes	yes	yes	yes
R^2_adj	0.30	0.08	0.22	0.08	0.19	0.02

Source: Regulatory reports and redemption survey. Panel regressions of the stock portfolio share on redemption rates, with year fixed effects. Standard errors are double-clustered by insurer and year. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

5.2 Share of risky bonds

In line with the previous result that insurers invest less in stocks when exposed to a higher redemption risk, we ask in this section whether the share of risky bonds also decreases with redemption risk. Similarly, we test whether the share of riskless bonds increases with redemption risk.

Table 7 contains the results. Surprisingly, insurers with higher redemption risk seem to hold a lower fraction of riskless (sovereign) bonds, be sovereign or investment-grade bonds (columns (1) and (2)). A 1 percentage point increase in redemption risk induces insurers to hold 1.1% and 0.16% less of those bonds types (columns (1) and (2)). Those results are equivalent when looking at the bond portfolio through funds (columns (5) and (6)). However, those results are not significant.

When looking at risky bonds, we find that an increase of 1 percentage point in redemption risk induces insurers to hold 0.15% less of speculative-grade bonds directly (column (3)) , and 0.16% less when passing through funds (column (7)). The fraction of directly-held speculative-grade bonds (column(3)) is found to decrease with redemption risk, and that of financial bonds (column (4)) increases with redemption risk. These results are equivalent when looking at the bond portfolio through funds, and again they are not significant.

We conclude this Section by offering two explanations for these results. First, they can be explained by the regulatory requirement that gains and losses on fixed income securities such as bonds must be offset through the capitalization reserve (see Section 2.2). Second, our sample might be too small to find any significant correlation between the share of insurers' portfolio invested in riskless and risky bonds, whether directly or

Table 7 – Share of risky and riskless bonds in insurers' bond portfolio and redemptions

	% bonds				% bonds			
	sov.	inv. grade	spec. grade	financial	sov.	inv. grade	spec. grade	financial
	security-by-security				security-by-security (funds pass-through)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Redemptions (%)	-1.1	-.16	-.15	.34	-.91	-.039	-.16	.2
	(.82)	(.5)	(.16)	(.46)	(.72)	(.48)	(.16)	(.45)
Observations	84	84	84	84	84	84	84	84
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
R^2_adj	0.04	0.14	0.04	0.04	0.04	0.12	0.04	0.06

Source: TCEP and redemption survey. Panel regressions of insurers' bond portfolio shares of risky bonds on redemption rates, with year fixed effects. Standard errors are double-clustered by insurer and year. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

Table 8 – Maturity of insurers' bond portfolio and redemptions

	% bonds		portfolio	%bonds		portfolio
	%maturity $<$ 5years	%maturity $>$ 5years	maturity	%maturity $<$ 5years	%maturity $>$ 5years	maturity
	security-by-security			security-by-security (funds pass-through)		
	(1)	(2)	(3)	(4)	(5)	(6)
Redemptions (%)	-.79	.68	3.8	-.88	.78	5.3
	(.54)	(.46)	(10)	(.51)	(.46)	(8.7)
Observations	84	84	84	84	84	84
Year FE	yes	yes	yes	yes	yes	yes
R^2_adj	0.04	0.11	0.46	0.08	0.13	0.54

Source: TCEP and redemption survey. Panel regressions of different measures of bond portoflio maturity on redemption rates, with year fixed effects. Standard errors are double-clustered by insurer and year. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

through funds. Especially for long-term investors such as insurers, which have a long-term investment horizon.

5.3 Bond portfolio maturity

In this section, we test whether the maturity of insurers' bond portfolio is sensitive to redemption risk. We regress the share of insurers' bond portfolio invested in bonds of maturity less than 5 years, more than 5 years, and the average maturity of the portfolio, on redemption rates. The reports are reported in Table 8.

For bonds held directly, we find that a 1 percentage point increase in redemption rates induces insurers to hold 0.79% less of bonds with a maturity lower than 5 years (column (1)), and 0.68% more of bonds with a maturity larger than 5 years (column (2)). In total, we do not find that the average maturity of insurers' bond portfolio changes (0.038 years only, see column (3)) when redemption risk is increased. None of those estimates are significant, and they do not turn significant when looking through funds at the share of bonds with a maturity lower (column (4)) or higher than 5 years (column (5)), or at the average maturity of the bond portfolio (column (6)).

Even though insurers seem to hold bonds of larger maturity when they face higher redemption risk, our sample is too small to find any significant relationship between insurers' bond portfolio maturity and redemption rates, neither for bonds held directly (columns (1) to (3)) nor for all bonds including through funds (columns (4) to (6)).

5.4 Asset portfolio and solvency

We know that intermediaries which are financed by an issue of claims with outcome-independent payment obligations will have an incentive to take excessive risks, as some of the risk of insolvency falls on their financiers rather than themselves (see e.g. Jensen and Meckling, 1976; Rochet, 1992). We test whether we can observe risk-shifting for French life insurers: Do life insurers take more investment risks when capital requirements are binding?

We use a measure of capital that is more restrictive than the eligible items for satisfying the capital requirements of 4% of provisions, which explains why summary statistics for our capital variable are the following. The mean percentage of capital in total provisions is 5.4% in our sample, with a median of 4.9% and a standard deviation of 2.1% (see Table 2).

We test two specifications, with results contained in Table 9. First, we test whether insurers take more interest-rate risk when their amount of capital decreases. In columns (1) and (2) we regress the share of insurers' portfolio invested in stocks directly (from two data sources), and in column (3) the same share with a funds pass-through, on their amount of capital (in % of provisions).

We cannot find evidence that insurers with less capital take more risk. Quite on the contrary, we find that those insurers that insurers that invest more in stocks are better capitalized. A 1 percentage point increase in the percentage of capital in total provisions is associated with a 1.1 percentage point increase in the fraction of directly-held stocks in insurers' portfolio (columns (1) and (2)). Even looking through funds, insurers that are more exposed to stocks are more capitalized (column (3)). We interpret these findings as a rejection of the risk-shifting hypothesis for French life insurers.

6 Robustness checks

The previous results provide evidence of a correlation between redemption risk and asset portfolio choices. However, one may argue that this might not be a causal relationship. If investors redemptions depend on contract returns, the latter is directly linked to the asset portfolio and the above regressions are subject to reverse causality bias. We follow two strategies to tackle this issue.

Table 9 – Share of stocks and solvency

	%stocks in portfolio		
	regulatory reports	security-by-security	security-by-security funds pass-through
	(1)	(2)	(3)
Capital (%)	1.1***	1.2**	.91**
	(.3)	(.23)	(.28)
Observations	149	84	84
Year FE	yes	yes	yes
R^2_adj	0.22	0.30	0.20

Source: TCEP, Regulatory Reports and redemption survey. Panel regressions of the share of stocks in insurers' portfolio on the percentage of capital in total provisions, with year fixed effects. Standard errors are double-clustered by insurer and year. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

6.1 Reverse causality

If investor flows are responsive to contract returns and contract returns depend on insurers' asset portfolio, the previous findings might be subject to reverse causality bias. In this Section, we check whether investor flows are responsive to contract returns. We regress inflows into life insurance contracts, whether euro or unit-linked contracts, and redemption rates, on contract returns.

The results are presented in Table 10. We find no significant relationship between the flows into and out of insurance contracts and contract returns. In anything, inflows decrease by 1.4 percentage points following a one percentage point increase in contract returns (column (1)). With insurer fixed effects, inflows are even less responsive to past contract returns.

We conclude that current inflows are not significantly correlated with past contract returns. A larger share of stocks in insurers' portfolio, which is likely to result in a higher contract return on average, is therefore not found to mechanically increase inflows. Even though our model tells us that higher inflows would provoke higher redemption rates because the investor base would then be younger, we do not find evidence of increased inflows when past contract returns are higher. Hence it is unlikely that

We cannot reject that our previous estimates of insurers' portfolio composition on redemption rates, are not a good measure of the effect of redemption risk on asset portfolio composition.

Table 10 – Inflows, outflows, redemptions and contract returns

	%inflow	% inflow unit-linked	% redemptions	% inflow	% inflow unit-linked	redemptions
	(1)	(2)	(3)	(4)	(5)	(6)
Past contract returns (%)	-1.4	.46	-.41	-.42	-.41	.65
	(1.3)	(.5)	(1)	(.)	(.3)	(.55)
Observations	91	91	91	86	86	86
Year FE	yes	yes	yes	yes	yes	yes
Insurer FE	no	no	no	yes	yes	yes
R^2_{adj}	0.13	0.09	0.06	0.88	0.85	0.86

6.2 An exogenous measure of redemption risk

As detailed in Section 4.2.2, life insurance contract returns in France are taxed at a rate that depends on the age of the contract at the time of redemption, providing incentives for policyholders to redeem their contracts around key anniversary dates that are orthogonal to the composition of their insurer's asset portfolio.

We have indeed observed in Section 4.2.2 that investors redeem their contracts more around those key anniversary dates because of fiscal lockups. We use this institutional feature to propose a measure of redemption risk that is exogenous to life insurers' asset portfolio choices. We use the market hazard rate across all dates in our sample, $h(j)$ where $j = \textit{contract age}$, to construct the following variable:

$$Pred.\ redemption\ rate_i = \frac{\sum_j h(j) \times prov(itj)}{\sum_j prov(itj)}$$

Where $prov(itj)$ is the amount of provisions for contract of age j for insurer i's investors in year t. We argue that "pred. redemption rate" is an *exogenous* measure insurers' exposure to redemption risk, with fiscal lockups defined for reasons orthogonal to insurers' asset portfolio composition. We obtain 62 observations for our redemption risk measure, with a mean of 9.7%, a median of 9.9% and a standard deviation of 0.04 percentage points. The correlation coefficient between our predicted redemption rate and the observed redemption rate is 0.78.

The taxation rates of life insurance redemptions are exogenously set, and vary with contract age. In line with our model's prediction, we show that taxation plays a key role in investors' redemption choices, with peaks of redemption at contract anniversary dates when taxation of contract returns is reduced (around 4 and 8 years). We construct a predicted redemption rate driven by fiscal incentives for investors to redeem their contracts, which we argue is orthogonal to their insurers' asset portfolio and immune to reverse causality or omitted variable bias. Our predicted redemption rate is highly correlated with observed redemption rates, with a coefficient of correlation of 0.7.

We test whether this exogenous redemption risk, driven by taxation lockups, causes

Table 11 – Share of stocks in insurers portfolio and exogenous redemptions

	%stocks in portfolio					
	regulatory reports		security-by-security		security-by-security funds pass-through	
	(1)	(2)	(3)	(4)	(5)	(6)
Predicted redemptions (%)	-.5*		-.5*		-.52*	
	(.19)		(.2)		(.19)	
1^{st} t. PM* Pred. Redemptions		-.43*		-.47*		-.44**
		(.16)		(.16)		(.14)
2^{nd} t. PM* Pred. Redemptions		-.62*		-.59*		-.68*
		(.23)		(.25)		(.21)
3^{rd} t. PM* Pred. Redemptions		-.46		-.41		-.42
		(.29)		(.3)		(.25)
Observations	84	84	84	84	84	84
Year FE	yes	yes	yes	yes	yes	yes
R^2_adj	0.18	0.20	0.16	0.17	0.21	0.28

insurers to invest less into stocks. We do find consistent evidence of a causal effect of redemption risk on insurers' portfolio : a 1 percentage point increase in redemption risk decreases insurers' share of stocks in total assets by 0.5%, after controlling for year fixed effects (columns (1), (3) and (5)). Again, the result does not hold for the largest insurers (columns (2), (5) and (7)). This estimate is significant, and its size is slightly smaller than previously found, which may be due to the fact that we have a smaller sample to construct our exogenous measure of redemption risk.

7 Conclusion

Redemption risk is one of the most important risks to affect the solvency of life insurance companies, reflecting the available resources and capacity of the insurer to manage the financial flows to ensure that the company is able to meets its responsibilities when they fall due. This paper studies the asset-liability management of life insurers backing one of the most widespread types of life insurance contracts, guaranteed contracts that can be redeemed on demand.

We first build a simple model that generates predictions about the link between investors' redemption and life insurers' asset portfolio. The model predicts that insurers which are more exposed to redemption risk invest more into bonds with longer maturity, and less into risky assets.

We then take these predictions to the data, using a novel confidential dataset from France containing data on investment choices by life insurers and investors redemption at the insurer level. We test different measures of redemption risk and controlling for year fixed effects, we find that a one standard deviation increase in redemption risk is associated with an average decrease in the share of directly-held stocks by 2.3% or slightly more than one-half of its standard deviation (4.5%). This result remains valid when accounting for indirect stock investment through funds. Finally, we check our model's prediction that redemption risk depends on insurers' investor contract age and use this to propose and exogenous measure of redemption risk and make a causal attempt.

These findings shed a new light on the importance of redemption risk for asset portfolio choices of long-term investors that represent a large share of the financial system. It also shows how investors redemption can play against the solidarity between generations of savers. When investors redeem their contracts, intergenerational risk sharing is jeopardized and life insurers cannot invest as much into risky assets, which might decrease welfare (Gollier, 2008).

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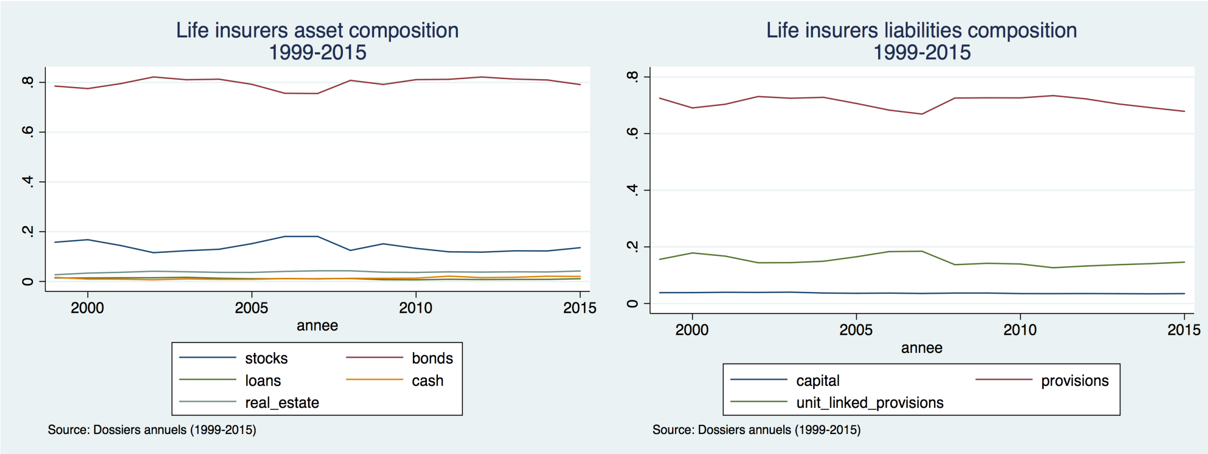
Appendix A Data

Figure 5 – Time series of aggregate assets and liabilities composition



Source: Regulatory reports 1999 – 2015.
Number of insurers:

Table 12 – Summary statistics on security-by-security asset portfolio (with funds pass-through)

	Mean	Median	Std.Dev.	N
Share of bonds (%)	82.1	82.6	6.6	21
Share of short-term bonds	36.2	35.7	8.0	21
Share of long-term bonds	63.8	64.3	8.0	21
Share of sov. bonds	32.8	32.8	12.9	21
Share of fin. sec. bonds	42.4	42.9	7.9	21
Share of investment-grade bonds	82.0	81.0	7.4	21
Share of speculative-grade bonds	3.1	2.1	2.6	21
Share of stocks (%)	6.4	5.3	4.2	21
Share of listed stocks	87.9	93.4	13.9	21
Share of nonlisted stocks	12.1	6.6	13.9	21
Share of real estate	4.6	4.8	2.9	21
Share of funds	3.3	3.4	1.9	21
Share of MMF	0.2	0.1	0.3	18
Share of other funds	3.1	3.3	1.7	21
Share of other	3.5	2.2	4.5	21

Source: TCEP (pass-through) 2011–2015.
Number of insurers: 21.

Table 13 – Other asset shares in insurers portfolio and redemptions

	%real estate	%cash	%bonds	%funds incl. stocks	%funds bonds only	%loans
Redemptions (%)	-.28	.65	.022	.027	.18	.088
	(.17)	(.47)	(.51)	(.18)	(.25)	(.069)
Observations	149	149	149	149	149	149
Year FE	yes	yes	yes	yes	yes	yes
R^2_adj	0.06	0.16	0.05	0.02	-0.02	0.04

Table 14 – Insurers' bond portfolio composition and redemptions

	%real estate		%bonds		%MMF	%other funds
	securities	buildings	short term	long term		
Redemptions (%)	-.19	-.044	-.99	.99	-.064	.02
	(.1)	(.11)	(.59)	(.59)	(.17)	(.33)
Observations	78	72	84	84	80	84
Year FE	yes	yes	yes	yes	yes	yes
R^2_adj	0.07	0.03	0.06	0.06	0.04	0.03

Appendix B Taxation upon redemption

Table 15 – Illustration for a €100,000 redemption out of a €200,000 contract with premia of €150,000

Take the following illustration. An investor who is single wants to cash out €100,000 from her life insurance contract on June 1st, 2017. Her contract value is €200,000 at this date, with premia equal to €150,000. Applying formula (1), taxable returns are equal to $100,000 - \left(150,000 \times \frac{100,000}{200,000}\right) = €25,000$. Table 15 illustrates how the taxation rate depends on the contract age upon redemption.[12]

	Contract age upon redemption		
	0 – 4 years	4 – 8 years	>8 years
taxation rate	12.6% (€12,625)	7.6% (€7,625)	3.9% (€3,875)

Table 16 – Example of taxation upon redemption after 8 years

We assume that an investor who is single invests €50k net of fees in his life insurance contract, and contract returns are 3.5% net of fees. The amount of tax on her contract gains after 8 years depends on the redemption amount as follows:

Year	Contract value before redemption	Amount redeemed	Returns amount redeemed	Returns amount taxed	Taxation in €	Taxation in %	Amount of principal redeemed	Amount of principal remaining	Contract value after redemption
9	65840€	10000€	2406€	0€	0€	0%	7594€	42406€	55840€
10	57795€	6000€	1598€	0€	0€	0%	4402€	38003€	51795€
11	53608€	0€	0€	0€	0€	0%	0€	38003€	53608€
12	55484€	8000€	2520€	0€	0€	0%	5480€	32524€	47484€
13	49146€	17000€	5750€	1150€	86€	0.51%	11250€	21274€	32146€
14	33271€	6000€	2164€	0€	0€	0%	3836€	17437€	27271€
Total		47000€	14437€	1150€	86€	0.18%			