Asset-liability management in life insurance: Evidence from France

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Abstract

This paper studies the asset-liability management of life insurers. Our objective is twofold. First, we start with a life insurance investor's problem of the optimal contract liquidation date, as a function of taxes and rates of return. Given that investors' return taxation is decreasing in contract age, we find that investors whose contract is relatively older should favor liquidating 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 liquidation risks. Second, we build a novel confidential dataset and check that investors indeed liquidate as expected by the model. We test whether life insurers portfolio choice is responsive to liquidation risk. Using three different measures of liquidation risk and controlling for year fixed effects, we find that a one standard deviation increase in liquidation risk (i) increases the maturity of insurers' bond acquisition by 1.2 years on average, or one-third of its standard deviation, and (ii) decreases insurers' share of stocks in asset acquisitions by 25 basis points, or one-half of its standard deviation.

Keywords: Insurance companies, life insurance, surrender risk, liquidation 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.

Liquidity 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. There is a need to understand the liquidity risks that insurance companies deal with on both sides of the balance-sheet. 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 liquidity 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 liquidated on demand. Our objective is twofold. We first build a simple model of an individual's optimal liquidation date as a function of taxes and returns. Second, we check that in the data, investors indeed liquidate their contracts as expected in the model. We a novel confidential dataset from France containing data on investment choices by life insurers and investors liquidation at the insurer level.

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

The choice between these two options consists in determining the optimal liquidation date

[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.

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 liquidate 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 investors whose contract is relatively older should favor liquidating 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 liquidation risks.

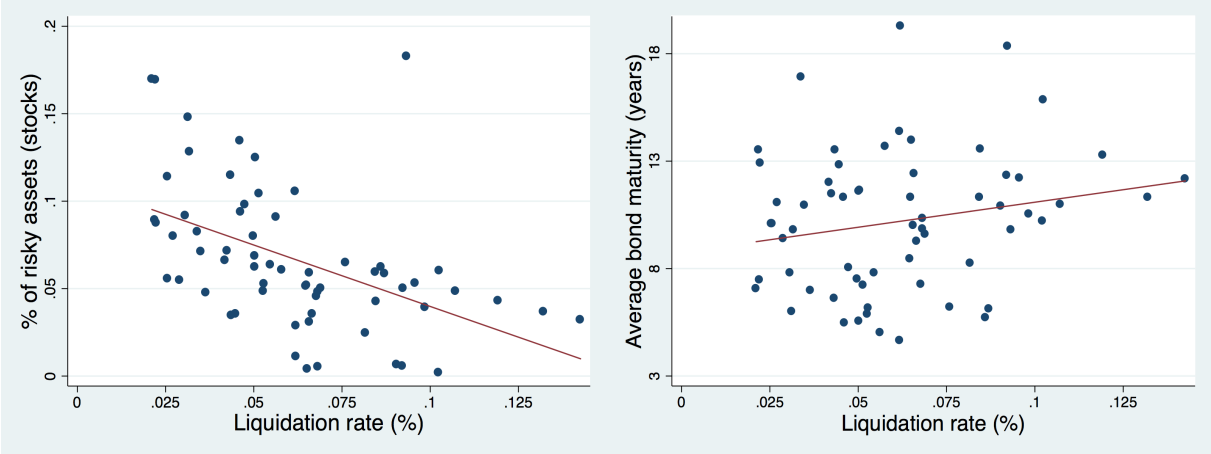
Concerning our second objective, we use a novel dataset built from regulatory reports and a proprietary survey on investor liquidations in France to test the model's predictions. The French life insurance market is a large and mature market, in which the value of Euro-denominated life insurance contracts 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). Therefore implications of money-like claims on the asset-liability management of financial intermediaries can be analyzed by studying life insurers' fund management. Moreover in France, the taxation of returns from life insurance contracts depends on the age of the contract at the time of liquidation, providing incentives for policyholders to liquidate their contracts around key anniversary dates that are orthogonal to the composition of their insurer's asset portfolio.

We 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) liquidation rate in our sample is 6%. However, the standard deviation of the liquidation rate is three time as large in the cross-section (3%) than in the time series (1%). The explanation for this fact is that different insurers specialize in different types of clienteles, and some clienteles are more prone to liquidate their contracts than others (e.g. wealthier or more financially literate investors). We verify that taxation plays a key role in investors' liquidation choices, with peaks of liquidation at contract anniversary dates when taxation of contract returns is reduced (around 4 and 8 years).

We then study whether life insurers portfolio composition depends on liquidity risk. We find evidence that liquidity risk induces life insurers to invest in bonds with longer maturity, and less in risky assets such as stocks. These main conclusions are conveyed by Figure 1.

Figure 1: Bond maturity and share of risky assets versus liquidations



Source: TCEP and Liquidation Survey (FFA), 2011 – 2015.

We first test whether insurers which are more exposed to liquidations acquire bonds with longer maturity by regressing the average maturity of the acquired bond portfolio on different measures of liquidation exposure at the insurer level. We use three different measures of liquidation exposure. First, we take the average liquidation rate for each insurer across the sample. Second, having in mind that investors clienteles that liquidate more expose more their insurers to liquidation risk, we directly regress the average maturity of the acquired bond portfolio on on the liquidation rate. Third, we use a constructed exogenous measure of liquidity risk at the insurer-year level that is based on the average age of life insurance contracts with an insurer in a given year. Our predicted liquidation rate is driven by fiscal incentives for investors to liquidate their contracts, therefore we argue it is orthogonal to their insurers' asset portfolio and immune to reverse causality or omitted variable bias. Our predicted liquidation rate is highly correlated with observed liquidation rates, with a coefficient of correlation of 0.78.

We find that a 1 percentage point increase in the liquidation rate in associated with a 4 years increase in the average maturity of the acquired bond portfolio, after controlling for year fixed effects. Another way to gauge the economic significance of the point estimate is to multiply it by the standard deviation of the liquidation rate (3% of provisions). It implies that a one standard deviation increase in the liquidation rate is associated with an average increase in the maturity of the acquired bond portfolio of 1.2 years or a little less than one-third of its standard deviation (4 years). Our dataset is too small to measure a statistically significant relationship for larger bond acquisition portfolios, so that equal-weighted regressions provide significant estimates but regressions weighted by the value of the bond acquisition portfolio in total bond acquisition portfolios in the current year do not.

Then, we test whether insurers which are more exposed to liquidity risks invest less into risky assets. We test both for the share of acquired bonds that are risky, i.e. with a "speculative investment" grade, and the share of stocks in the acquired asset portfolio. We find evidence that a 1 percentage point increase in our measure of predicted liquidation rate is associated with a 1.9% decrease in the share of risky bonds in insurers' acquired bond portfolio, after controlling for year fixed effects. However this relationship is only true when observations are weighted by the share of insurer's bond acquisition portfolio in total bond acquisitions in a given year. When regressing the share of risky assets in the entire acquired asset portfolio on our measures of liquidation risk, we find more robust evidence in support for our model's prediction. Our estimates show that a 1 percentage point increase in liquidity risk decreases insurers' share of stocks in acquired assets by 0.82%, after controlling for year fixed effects, an estimate that is robustly significant across specifications. Finally, we use two different data sources (line-by-line asset holdings of insurers and regulatory reports) to test whether insurers which are more exposed to liquidation risk, hold less risky assets in their legacy asset portfolio (not just in their acquired asset portfolio). Reassuringly, we find robust evidence in support for our model's prediction, and our results are very similar in the two datasets, both in magnitude and significance. Our regressions indicate that a 1 percentage point increase in liquidity risk decreases insurers' share of stocks in total assets by 0.74%, after controlling for year fixed effects.

Finally, 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 insurer fixed effects. We interpret these findings as a rejection of the risk-shifting hypothesis for French life insurers.

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 liquidate them to a certain extent (ESRB, 2015).[3] These

[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

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 liquidation by investors who lose 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 liquidity 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 liquidated 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. Liquidation risk is difficult to assess because of its economic nature. Investors can liquidate their life insurance contract due to rational arbitrage possibilities, e.g. falling contract returns, but also due to personal considerations or behavioral causes. Liquidation 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 liquidation 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

to life insurance contracts.

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

prices.

This paper connects to several strands of the literature. The first strand is the literature on liquidation risk. In finance and insurance, studying liquidation 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 liquidation risk. The finance literature addressing the prepayment of mortgage backed securities is by far the largest one (see e.g. Hanson, 2014). In contrast, the insurance literature studying liquidation 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 liquidation. First, the emergency fund hypothesis contends that policyholders use the cash value of their liquidated contract as an emergency fund when facing personal financial distress (Outreville, 1990). Second, the interest rate hypothesis conjectures that investor liquidations increase with the market interest rate, as investors liquidate 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 liquidate, 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 liquidity.

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 5 presents an individual's problem of when to liquidate an insurance contract. Section 4 presents the data and summary statistics. Section 6 presents evidence on the relation between life insurers' portfolio choices and liquidation risk. 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 liquidate 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 liquidation value of initial investors.

We describe the institutional features of interest for Euro-denominated life insurance contracts in France: safety and liquidity. 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* 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.

[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/.

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 credited to investor accounts or to insurer income. Thus, life insurers' asset-liability management is better captured in our panel of insurers by looking at *aquisition* portfolios reflecting current changes in the environment rather than *legacy* portfolios.

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 liquidation

2.3.1 Tax base

Returns from life insurance contracts are taxed only when individuals liquidate their contract. The regulatory definition of the tax base is that for a given fraction of the total contract amount liquidated, the corresponding fraction of returns only is taxed. Denoting $liquidated.amount_t$ the amount liquidated (in euros) at liquidation 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 liquidation at date t, $tax.base_t$, writes:

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

If an investor liquidates 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

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

[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 liquidation

	Contract age upon liquidation		
	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%

investor liquidates her entire contract value, her tax base is equal to:

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

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 5 the implications for an investor's optimal liquidation date. An example is provided in Appendix A.2.1.

3 Individual's problem of optimal liquidation 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 liquidation of the contract – which we refer to as "contract age".[8] An individual might be willing to liquidate (part of) her contract for several reasons. First, if the benchmark interest rate increases, the liquidation option enables investors to liquidate 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 liquidate her contract regardless of market conditions. An investor willing to liquidate (part of) her contract faces the following problem. Either she can liquidate her contract upon liquidity needs, or given that return taxation decreases over time, she might choose to liquidate at a later date. In this Section, we consider an investor's problem of the optimal liquidation date.

Assumption 1 (Simplifying assumptions)**.** *We make the following assumptions:*

[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 liquidate 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.

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 liquidation 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 liquidate 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 liquidate 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 liquidity 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, when she liquidates 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 liquidate 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 liquidation 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 11), the investor's contract age will be a key determinant of the optimal liquidation 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 liquidation date)**.** *All else equal, the higher the taxation rate at date* 1 *relative to date* 2*, the more incentives for the investor to liquidate at date* 2*.*

Proof. Assuming a strictly increasing utility function, the investor liquidates 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 liquidating 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 11), we conclude from Proposition 1 that investors whose contract is relatively older should favor liquidating 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 liquidation 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' liquidations 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

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-provisions ratio of the average

Table 2: Balance sheets and regulatory variables: Summary Statistics

	Mean	Median	SD	N
Account value (bn euro)	18.2	4.5	37.8	311
Capital (bn euro)	0.9	0.3	1.5	311
Share bonds (%)	81.8	83.1	10.3	311
Share stocks (%)	11.8	10.6	7.1	311

Source: Supervisory Reports 2011–2015.
Number of insurers: 66.

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 line-by-line 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 Legacy 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 breaks down aggregate bond portfolio further and presents the fraction of total assets held in more detailed asset classes. 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.

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

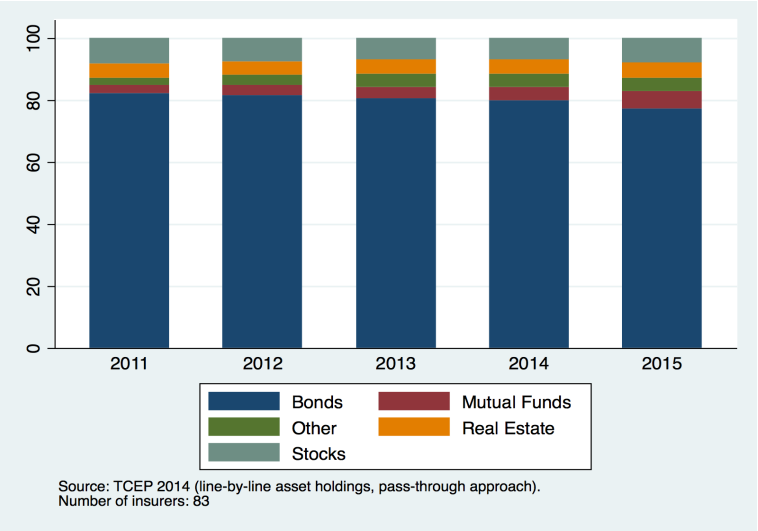


Table 3: Summary statistics on the cross-section of asset legacy portfolios

	Mean	SD	p90	p50	p10
Bonds	.82	.1	.93	.83	.69
maturity < 5 years	.61	.12	.75	.62	.44
maturity > 5 years	.39	.12	.56	.38	.25
sovereign	.32	.17	.57	.31	.09
French	.58	.13	.77	.57	.42
investment grade	.79	.11	.92	.79	.66
speculative grade	.04	.04	.08	.03	.01
Stocks	.06	.05	.12	.05	0
Listed stocks	.05	.05	.11	.05	0
Unlisted stocks	.01	.02	.02	0	0
Real Estate	.05	.07	.12	.03	0
Mutual Funds	.04	.04	.08	.03	.01
MMMF	0	0	.01	0	0
other MF	.03	.03	.07	.03	0
Other	.04	.04	.09	.02	0

Source: TCEP 2014, line-by-line (pass-through approach).
Number of insurers: 83

4.2.2 Acquisition portfolios

In the analysis, we link insurance companies' asset choices to the liability side of their balance sheets. As explained before, life insurers have no incentive to purchase or drop bonds from their legacy portfolios. Legacy portfolios therefore reflect past decisions to match assets and liabilities, but they do not reflect changes in the environment, and thus in liquidation risks, that we observe. We focus on insurance companies' acquisition portfolios.

To do so, we consider newly reported assets between two annual observations as assets acquired over the year. These leaves us with a sample period of 4 years, from 2012 to 2015. We take a weighted average of bond characteristics (maturity, market price, etc.), weighting each observation by its share in insurer's total acquisition volume for the year.

4.2.3 Investor liquidations ("surrenders")

The data on liquidation by individual investors come from the survey on investor liquidations 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' liquidations for life insurers, these data are rare and highly confidential.

The data enable us to break down down investors' liquidations 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 liquidations 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 median) percentage of investors liquidating their insurance contract is 6% in our sample.

Comparing row 1 to row 3 in Table 4, we find that the standard deviation of the liquidation rate is three time as large in the cross-section (3 percentage points) than in the time series (1 percentage point). This suggests that liquidation 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 liquidate 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 liquidate their life insurance contract (Frey, 2016).

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

Table 4: Investors Liquidation Survey: Summary Statistics

	Mean	Median	SD	N
liquidation rate (%)	.06	.06	.03	157
Ave. contract age (years)	12.24	11.69	4.01	84
liquidation rate (%)	.06	.06	.01	8
Ave. contract age (years)	12.2	12.12	.94	4

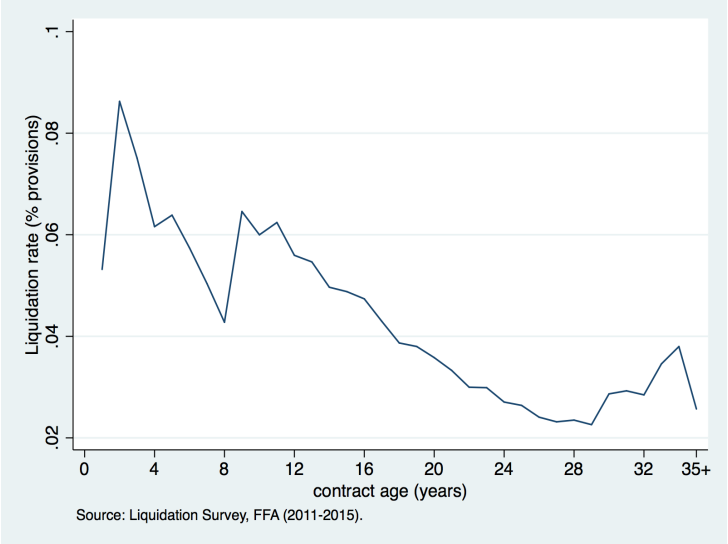
Rows 3-4: aggregated over years

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

Source: Investor Liquidation Survey (FFA), 2011–2015.
Number of insurers: 26.

To capture this phenomenon in more detail, we plot in Figure 3 the liquidation rate against contract age. We find that investors liquidate their contract around key anniversary dates. In the first two years, many investors liquidate their contract (however, we will see shortly that these liquidations are not quantitatively important), potentially because they misused or misunderstood their life insurance contract. We then observe liquidation peaks around the 4th and 8th anniversary dates, in line with optimization of liquidation 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.

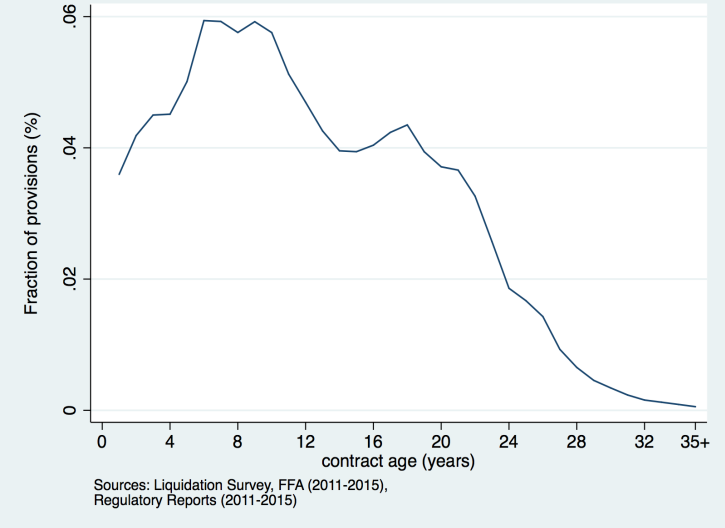
Figure 3: Liquidation and contract age



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 liquidations before 4 years are not very informative about the liquidation 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 liquidations rates to put the solvability of French life insurers at risk. However, asset-liability management by life insurers requires a close look at investors' liquidation behavior. The average percentage of liquidation is 6% yearly, but there is variation in the cross-section and for some insurers, it appears that liquidity risk is an important risk that they must account for in their asset portfolio choices.

Liquidation 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 liquidation. 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 liquidation 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.

Before turning to the model, we introduce a variable that we will use in the empirical analy-

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

sis. To deal with endogeneity issues detailed in Section 6, we use our observation that investors tend to withdraw around precise anniversary dates because of fiscal lockups. These incentives for investors to liquidate their contract are independent of insurers' portfolio choices. We use the market hazard rate across all dates in our sample, $h(j)$ where $j = contract\ age$, to construct the following variable:

$$\text{Pred. liquidation rate}_i = \frac{\sum_j h(j) \times prov(itj)}{\sum_j prov(itj)}$$

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. liquidation rate" is an *exogenous* measure insurers' exposure to liquidity risk, with fiscal lockups defined for reasons orthogonal to insurers' asset portfolio composition. We obtain 62 observations for our liquidation 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 liquidation rate and the observed liquidation rate is 0.78.

5 Model of portfolio choices by life insurers

To study asset choices by life insurers, we propose a model of the asset choice of an intermediary financed by investors with different investment horizons. The model builds on the seminal framework by Diamond and Dybvig (1983) and two of its extensions.

First, we build on Hellwig (1994) to study life insurer's investment maturity choices in light of interest-rate risk. We develop a model of life insurers' portfolio mix between short-term and long-term investments. We find that complete immunization of consumers against interest rate risk can be undesirable as it precludes the exploitation of favourable reinvestment opportunities. We then analyze the implications of liquidity on the liability side on portfolio investment mixture by analyizng surrender risk. Given that late consumers can surrender their contract at an earlier date than their consumption date, we see how this impacts life insurers' portfolio mix between short-term and long-term investments.

Second, we build on Allen and Gale (1998) to study life insurer's investment choices between safe and risky investments. When on investment yields high but uncertain returns and the other yields low but safe returns, we find that life insurers who have longer-term liabilities invest more in the risky investment. Again, we take the testable predictions to the data in section 4.

5.1 Individual's problem of optimal liquidation date

6 Results

6.1 Maturity of acquired bonds

From Section 4.2.3 we know that insurers are specialized into clientele types which are more or less likely to liquidate their policy, either because they have a shorter investment horizon and respond to fiscal lockups, or because they have certain characteristics that make them more sensitive to contract returns (e.g. they are more wealthy or financially literate). As a result, insurers which are more exposed to liquidations are also more exposed to the threat of disintermediation if they do not provide sufficient returns to their investors. The model then predicts that insurers which are more exposed to liquidations should acquire bonds with longer maturity.

We test this prediction by regressing the average maturity of the acquired bond portfolio on different measures of liquidation 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 the average maturity of the bond acquisition portfolio for insurer i in year t (each bond maturity being proportional to the bond's weight in the insurer's acquisition portfolio), the dependent variable X_{it} is a measure of liquidation exposure, γ_t is a year fixed effect, and ϵ_{it} is an error term. We test three different measures of liquidation exposure. First, we take the average liquidation 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 liquidation rate of insurer i in year t.[11] We label this variable "ave. liquidation rate". Second, having in mind that investors clienteles that liquidate more expose more their insurers to liquidation risk, we directly regress the outcome variable on the liquidation rate l_{it}, labelled "liquidation rate". Therefore in a third step, we use our constructed exogenous measure of liquidity risk at the insurer-year level, labelled "pred. liquidation rate". See Section 4.2.3.

We report the results for equal-weighted regressions in columns (1), (2) and (3), and for regressions weighted by the insurer share of bond portfolio acquisition in the current year in columns (4), (5) and (6) of Table 5.

The coefficient on liquidity risk in columns (1) and (2) is positive and statistically significant

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

Table 5: Maturity of insurers' acquired bond portfolio and surrenders

	Average maturity of acquired bond portfolio					
	(1)	(2)	(3)	(4)	(5)	(6)
ave. liquidation rate	36**			27		
	(17)			(42)		
liquidation rate		40**			34	
		(17)			(41)	
pred. liquidation rate			18			-1.2
			(10)			(26)
Weight	equal	equal	equal	value	value	value
Year FE	yes	yes	yes	yes	yes	yes
Adjusted R^2	0.13	0.15	0.08	0.06	0.08	0.04
Observations	63	63	63	63	63	63

Source: TCEP and Liquidation Survey. Panel regressions of the average maturity of the bond acquisition portfolio on measures of liquidation risk, with year fixed effects. Regressions in columns (1), (2) and (3) are equal-weighted and regressions in columns (4), (5) and (6) are weighted by the insurer share of bond portfolio acquisitions in the current year. Standard errors are clustered by insurer. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

at the 5% level. Focusing on column (2), the point estimate indicates that a 1 percentage point increase in the liquidation rate in associated with a 4 years increase in the average maturity of the acquired bond portfolio. Although this number might seem large, another way to gauge the economic significance of the point estimate is to multiply it by the standard deviation of the liquidation rate (3% of provisions). It implies that a one standard deviation increase in the liquidation rate is associated with an average increase in the maturity of the acquired bond portfolio of 1.2 years or a little less than one-third of its standard deviation (4 years). The coefficient in column (3) is not significant, suggesting that our sample size is not large enough to identify the effect of the predicted liquidation rate, which differs less across insurers than the observed liquidation rate (see Section 4.2.3). We conclude from columns (4), (5) and (6) that the aforementioned relationship between liquidation risk and maturity of acquired bond portfolio goes in the same direction, but is not significant for larger bond acquisition portfolios. Maybe larger insurers, with larger bond portfolio acquisitions, can diversify the interest-rate risk caused by investors liquidation with other means than smaller insurers (e.g. with better diversification because their asset portfolio is larger). As a result, our dataset is too small to measure a statistically significant relationship on value-weighted regressions.

6.2 Share of risky assets in acquisition porftolios

Our model predicts that insurers which are more exposed to liquidity risks invest less into risky assets. In this section, we first measure the share of risky assets in insurers' bond acquisition portfolio using the share of speculative-grade bonds into acquired bond portfolios. We regress this share on our three proposed measures of liquidity risk at the insurer-year level.

Table 6 contains the results. When observations are equal-weighted (columns (1), (2) and (3)), do not find a significant statistical relationship between liquidity risk and the fraction of acquired bonds that are risky. However, when observations are weighted by the total value of the acquired bond portfolio, we do find that those insurers which are more exposed to liquidity risk invest relatively less into risky bonds. The coefficient in columns (4) and (5) indicates that a 1 percentage point increase in liquidity risk induces insurers to purchase 2.7% less risky bonds in their acquired bond portfolio. This relationship is significant at the 10% level. As for column (6), we find that a 1 percentage point increase in our measure of predicted liquidation rate is associated with a 1.9% decrease in the share of risky bonds in insurers' acquired bond portfolio, significant at a 5% level.

Table 6: Share of investment-grade bonds in insurers' acquired portfolio and surrenders

	% Speculative-grade bonds in acquired portfolio					
	(1)	(2)	(3)	(4)	(5)	(6)
ave. liquidation rate	.6			-2.7*		
	(1.4)			(1.4)		
liquidation rate		.61			-2.7*	
		(1.4)			(1.4)	
pred. liquidation rate			.13			-1.9**
			(.76)			(.83)
Weight	equal	equal	equal	value	value	value
Year FE	yes	yes	yes	yes	yes	yes
Adjusted R^2	0.70	0.70	0.69	0.76	0.76	0.75
Observations	62	62	62	62	62	62

Source: TCEP and Liquidation Survey. Panel regressions of the share of speculative-grade bonds in bond acquisition portfolio on measures of liquidation risk, with year fixed effects. Regressions in columns (1), (2) and (3) are equal-weighted and regressions in columns (4), (5) and (6) are weighted by the insurer share of bond portfolio acquisitions in the current year. Standard errors are clustered by insurer. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

Then, we look at the share of risky assets in the entire acquired asset portfolio, not only bonds. We focus on the share of the most representative risky asset: stocks. We regress the share of stocks in the portfolio of assets acquired by an insurer in a given year, and regress this share on our three proposed measures of liquidity risk at the insurer-year level.

Results are contained in Table 7. We find a robust relationship between the share of stocks in insurers' acquired assets portfolios and our three liquidity risk measures, both in equal-weighted and value-weighted regressions. The coefficient in column (1) indicates that a 1 percentage point increase in liquidity risk decreases insurers' share of stocks in acquired assets by 0.82%, an estimate that is significant at the 1% level. The results are similar across specifications, although the economic magnitude of the relationship is somewhat smaller in the regressions with the predicted liquidation risk as a dependent variable (columns (3) and (6)). It remains that the economic magnitude of this effect is large: a one standard deviation increase in the liquidation rate is associated with an average decrease in the share of stocks in acquired asset portfolios of 25 basis points or a little less than one-half of its standard deviation (50 basis points).

Table 7: Share of stocks in insurers' acquired portfolio and surrenders

	% Stocks in acquired portfolio					
	(1)	(2)	(3)	(4)	(5)	(6)
ave. liquidation rate	-.82***			-.61**		
	(.25)			(.23)		
liquidation rate		-.76***			-.49*	
		(.25)			(.24)	
pred. liquidation rate			-.56**			-.46*
			(.21)			(.24)
Weight	equal	equal	equal	value	value	value
Year FE	yes	yes	yes	yes	yes	yes
Adjusted R^2	0.25	0.22	0.24	0.11	0.07	0.12
Observations	63	63	63	63	63	63

Source: TCEP and Liquidation Survey. Panel regressions of the share of stocks in asset acquisition portfolio on measures of liquidation risk, with year fixed effects. Regressions in columns (1), (2) and (3) are equal-weighted and regressions in columns (4), (5) and (6) are weighted by the insurer share of bond portfolio acquisitions in the current year. Standard errors are clustered by insurer. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

6.3 Share of risky assets in legacy portfolios

While bonds have a maturity and expose bond investors to interest-rate risk, stocks do not have a maturity. Therefore insurers' liquidation risk exposure should impact not only the share of stocks in their acquired asset portfolio, but also the share of stocks in their entire (legacy) portfolio. In this section, we test whether it is the case that those insurers which are more exposed to liquidity risk hold a smaller fraction of stocks in their portfolio.

In contrast to the previous sections we are only interested in the fraction of stocks in in-

surers' legacy portfolios, and not on specific characteristics of their assets nor their acquisition portfolio, we can test this hypothesis on two sets of data. One is the line-by-line (TCEP) asset holding of insurers, the other is the regulatory reports providing data at the insurer level.

Table 8 presents the results on the line-by-line (TCEP) data on asset holdings by life insurers. As for acquired asset portfolios, we have the robust finding that those insurers which are more exposed to liquidity risk, hold less stocks in their legacy portfolio. The coefficient in column (1) indicates that a 1 percentage point increase in liquidity risk decreases insurers' share of stocks in total assets by 0.74%, an estimate that is significant at the 1% level. The results are similar across specifications, although less significant in the value-weighted specifications. This means that this relationship is less significant for larger insurers, and therefore our restricted dataset does not enable us to measure it significantly for larger insurers. Again, we suggest that this may be explained by the fact that larger insurers have other ways to manage their liquidity risks, for example they have distribution networks and specific clientele relationships that decrease their exposure to liquidity risks.

Table 8: Share of stocks in insurers' legacy portfolio and surrenders

	% Stocks in legacy portfolio					
	(1)	(2)	(3)	(4)	(5)	(6)
ave. liquidation rate	-.74***			-.47*		
	(.22)			(.27)		
liquidation rate		-.66***			-.32	
		(.21)			(.27)	
pred. liquidation rate			-.51**			-.47
			(.2)			(.28)
Weight	equal	equal	equal	value	value	value
Year FE	yes	yes	yes	yes	yes	yes
Adjusted R^2	0.25	0.20	0.21	0.06	0.02	0.09
Observations	86	86	86	86	86	86

Source: TCEP and Liquidation Survey. Panel regressions of the share of stocks in insurers' legacy portfolio on measures of liquidation risk, with year fixed effects. Regressions in columns (1), (2) and (3) are equal-weighted and regressions in columns (4), (5) and (6) are weighted by the insurer share of bond portfolio acquisitions in the current year. Standard errors are clustered by insurer. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

Table 9 contains the results on the regulatory reports data. Reassuringly, the results are very similar, both in magnitude and significance, to the ones on the line-by-line (TCEP) data in Table 8. We do not explicit them in details, however we note that the relationship between liquidity risk and risky asset investment for larger insurers, is better captured in the regulatory reports data than in the line-by-line data.

Table 9: Share of stocks in insurers' legacy portfolio and surrenders

	% Stocks in legacy portfolio					
	(1)	(2)	(3)	(4)	(5)	(6)
ave. liquidation rate	-.67**			-.55*		
	(.27)			(.31)		
liquidation rate		-.7***			-.52**	
		(.24)			(.25)	
pred. liquidation rate			-.53**			-.37
			(.22)			(.25)
Weight	equal	equal	equal	value	value	value
Year FE	yes	yes	yes	yes	yes	yes
Adjusted R^2	0.16	0.18	0.18	0.10	0.11	0.06
Observations	86	86	86	86	86	86

Source: Regulatory reports and Liquidation Survey. Panel regressions of the share of stocks in insurers' legacy portfolio on measures of liquidation risk, with year fixed effects. Regressions in columns (1), (2) and (3) are equal-weighted and regressions in columns (4), (5) and (6) are weighted by the insurer share of bond portfolio acquisition in the current year. Standard errors are clustered by insurer. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

6.4 Portfolio acquisitions 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 5.6% in our sample, with a median of 5.2% and a standard deviation of 2.3%.

We test two specifications, with results contained in Table 10. First, we test whether insurers take more interest-rate risk when their amount of capital decreases. In columns (1) and (2) we regress the maturity of insurers' acquired bond portfolio on their amount of capital (in % of provisions), where observations are equally-weighted in column (1) and weighted by the value of bond acquisition portfolio in column (2). Second, we regress the share of risky assets (stocks) in the asset acquisition portfolio on the amount of capital held by insurers.

We cannot find evidence that insurers with less capital take more interest-rate risk: the coefficients in columns (1) and (2) are neither significant nor consistent with each other, with standard errors larger or of the same magnitude as the coefficients. However, looking at col-

umn (3), we find evidence that insurers with a smaller amount of capital invest less in stocks. The coefficient in column (3), significant at the 1% level, indicates that a 1 percentage point increase in the percentage of capital in total provisions is associated with a 0.94 percentage point increase in the fraction of stocks in the acquisition portfolio. Although of smaller magnitude and not significant when these observations are value-weighted, we interpret these findings as a rejection of the risk-shifting hypothesis for French life insurers.

Table 10: Insurers' acquired portfolio and solvency

	(1)	(2)	(3)	(4)
capital	-1.6	44	.94***	.45
	(29)	(39)	(.25)	(.3)
Weight	equal	value	equal	value
Year FE	yes	yes	yes	yes
Adjusted R^2	0.04	0.10	0.25	0.04
Observations	63	63	63	63

Source: TCEP, Regulatory Reports and Liquidation Survey. Panel regressions of the average maturity of the bond acquisition portfolio (columns (1)-(3)), and of the share of stocks in acquired asset portfolio (columns (4)-(6)) on the percentage of capital in total provisions, with year fixed effects. Regressions in columns (1) and (3) are equal-weighted and regressions in columns (2) and (6) are weighted by the insurer share of bond portfolio acquisition in the current year and the insurer share of asset portfolio acquisition in the current year, respectively. Standard errors are clustered by insurer. ***, **, and * mean statistically significant at the 1%, 5%, and 10% levels, respectively.

7 Conclusion

Liquidity 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 liquidated on demand.

We first build a simple model that generates predictions about the link between investors' liquidation and life insurers' asset portfolio. The model predicts that insurers which are more exposed to liquidation 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 liquidation at the insurer level. We test three different measures of liquidation risk and controlling for year fixed effects, we find that a one standard deviation increase in liquidation risk (i) increases the maturity of

insurers' bond acquisition by 1.2 years on average, or one-third of its standard deviation, and (ii) decreases insurers' share of stocks in asset acquisitions by 25 basis points, or one-half of its standard deviation.

These findings shed a new light on the importance of liquidation risk for asset portfolio choices of long-term investors that represent a large share of the financial system. It also shows how investors liquidation can play against the solidarity between generations of savers. When investors liquidate their contracts, intergenerational risk sharing is jeopardized and life insurers cannot invest as much into risky assets, decreasing welfare (Gollier, 2008; Hombert and Lyonnet, 2017).

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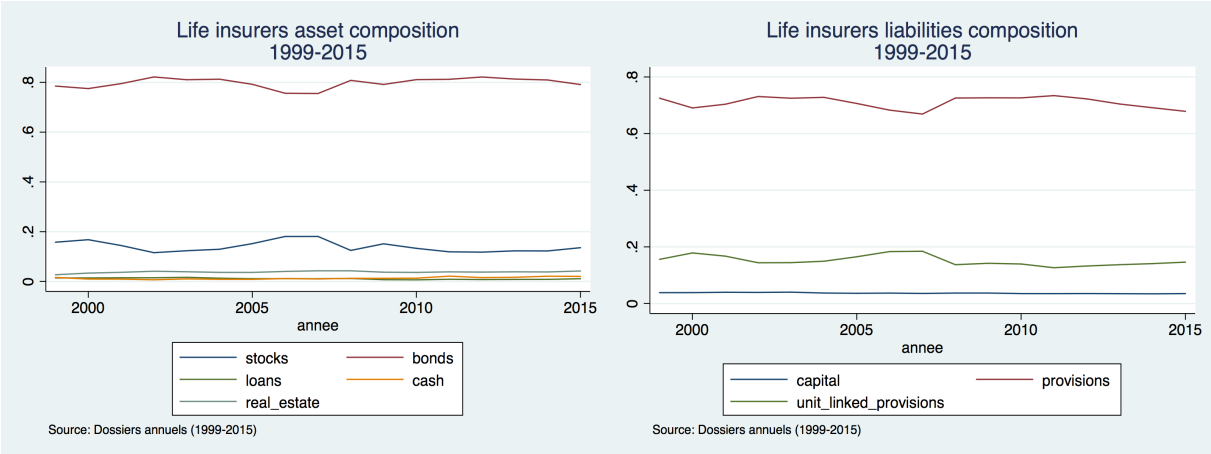
Appendix A Data

A.1 Assets and liabilities from 1999 to 2015

We use regulatory data from the national insurance supervisor. We restrict the analysis to stock insurance companies, which represent 97% of aggregate life insurance provisions. We drop insurers with less than €10 million of life insurance provisions. The final sample has 76 insurers and 978 insurer-year observations.



A.2 Taxation upon liquidation

A.2.1 Example of taxation changes as a function of contract age

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 11 illustrates how the taxation rate depends on the contract age upon liquidation.[12]

A.2.2 Example of liquidation after 8 years

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 liquidation amount as follows:

[12] First, if the contract age is under 4 years (the investor has opened his contract after June 1st, 2014) then the taxation rate is $35 + 15.5 = 50.5\%$, thus in our example, the taxation amount is $\frac{50.5}{100} * 25,000 = €12,625$. Second, if the contract age is between 4 and 8 years (the investor has opened his contract after June 1st, 2009 and before June 1st, 2014) then the taxation rate is $15 + 15.5 = 30.5\%$, thus in our example, the taxation amount is $\frac{30.5}{100} * 2.523 = €7,625$. Finally, if the contract age is greater or equal to 8 years (the investor has opened his contract before June 1st, 2009) then the investor benefits from alump sum allowance of 4.6k€, therefore she only pays a taxation rate of 15.5%, thus in our example, the taxation amount is $\frac{15.5}{100} * 2.523 = €3,875$.

Table 11: Illustration for a €100,000 liquidation out of a €200,000 contract with premia of €150,000

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

Year	Contract value before liquidation	Amount liquidated	Returns amount liquidated	Returns amount taxed	Taxation in €	Taxation in %	Amount of principal liquidated	Amount of principal remaining	Contract value after liquidation
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%			