

II | Subsidised Illiquidity Insulators - The Effect of FHLB Membership on Life Insurers' Strategic Asset Allocation

Abstract

Over the past decade, life insurers have significantly increased their holdings of illiquid alternative assets in pursuit of higher yields. This study explores the drivers behind this trend, demonstrating that it is not solely due to the insurers' illiquid liability structure but is also influenced by an implicit liquidity backstop provided by the Federal Home Loan Bank System (FHLB). Our analysis reveals that the "liquidity-of-last-resort" channel provided by the FHLB prompts life insurers to shift about 3% of their assets under management from liquid assets towards illiquid assets ex-ante, predominantly non-housing related assets such as non-residential mortgages, non-mortgage-related asset-backed securities and other long-term investments such as hedge funds and private equity partnerships. As the FHLB was initially established to support residential real estate financing, this finding is potentially at odds with the public's expectation regarding the role of the institution. Our results contribute to a broader literature on publicly funded liquidity relief programs for financial institutions, illustrating how the fungibility of the liquidity support provided can lead to unintended consequences.

Keywords: Federal Home Loan Bank, Illiquidity Premium, Lender of Last Resort, Life Insurance, Deferred Annuities, General Account Investments, Housing-related Assets

JEL Codes: G11, G22, G28, G32

“So, where do you get excess return? You can take credit risk. You can take equity risk. You can take business startup risk. You can take valuation risk. Or you can take liquidity risk. How much liquidity does a client need? In a retirement services company, you need appropriate amounts of liquidity, but you don’t need to be liquid every day.”

— Marc Rowan, Co-founder and CEO, Apollo Global Management

1 Introduction

Life insurers play a vital role as institutional investors in the U.S. financial system, managing nearly \$5 trillion in assets in 2022. This makes the life insurance sector one of the largest asset managers in the U.S. economy. As a result, their preferences and portfolio compositions have a measurable impact on both the structure of financial markets and the prices of the assets traded within them (Becker and Ivashina, 2015; Becker et al., 2022; Koijen and Yogo, 2023).

Like most investors, life insurers face a trade-off between generating competitive returns and managing risks. However, owing to the long-term nature of their liabilities towards policyholders, they enjoy a competitive advantage over other institutional asset managers in structuring their portfolios with respect to liquidity. Unlike these other institutions, such as banks and mutual funds, life insurers are not as susceptible to sudden spikes in outflows of the funds they invest on behalf of their clients. Furthermore, the main products life insurers sell, such as life insurance and annuities, promise actuarially predictable cash flows often years in the future in return for premiums paid today, making the corresponding liabilities much longer-dated and less prone to sudden liquidation than those of other financial products offered to retail clients.¹ As a consequence, the asset side of life insurers’ balance sheets are less reliant on the immediate convertibility of their investments into cash (i.e. *liquidity*) than those of other financial intermediaries. Given that financial markets value easily liquidated assets higher than those harder to convert into cash, a price difference known as an *illiquidity premium*, life insurers can generate excess returns by investing

¹This does not mean that life insurers cannot be subject to high volumes of surrenders in times of market stress, known as *mass surrenders* or *mass lapse*. This risk is however much lower and salient than the *bank runs* and *sudden fund outflows* faced by the other institutions mentioned above.

in illiquid assets (Longstaff, 1995; Pástor and Stambaugh, 2003; Amihud et al., 2006).

In this paper we go beyond this liability-driven investment story, arguing that insurers have been further driven towards investing in illiquid assets by a lesser known mechanism: *Advances* provided by the *Federal Home Loan Bank System* (FHLB). Created by the federal government in 1932 to reduce housing costs in the wake of the Great Depression, the FHLB has since grown to be a primary source of liquidity for a wide range of U.S.-domiciled financial institutions. To achieve this, the FHLB offers short-term loans collateralized by residential mortgage-related assets, known as advances, at very favorable rates to its members (Gissler and Narajabad, 2017a,b). We show that this easy access to liquidity not only supports life insurers ex-post in a liquidity crunch but also drives life insurers to change their investment behavior ex-ante, as they expect to be able to source cash easily from the FHLB. Our empirical analysis shows that after becoming members of the FHLB system, life insurers on average pivot about 3% of their assets under management from liquid assets towards illiquid assets yielding the aforementioned liquidity premium. However, we also show that this effect varies across different asset classes, with the majority re-allocated towards non-housing related assets. As the FHLB was set up with the explicit goal to support the financing of residential housing, this empirical result calls into question the efficacy of the FHLB system as a policy instrument to achieve this target in its interaction with life insurers.

Related Literature: Our research stands at the intersection of two strands of literature. First, we contribute to research on the effect of FHLB advances on the investment behavior of financial institutions. Previous work has focused on the effect FHLB advances have had on banks' liquidity management and loan portfolio composition (Ashcraft et al., 2010; Frame et al., 2012; Acharya et al., 2017). These studies find that banks use FHLB advances as a liquidity management tool, especially in times of crisis. In terms of portfolio composition, Frame et al. (2012) find that FHLB advances have positive effects on both housing and non-housing-related loans, increasing the volume of lending and smoothing it across the business cycle.

Second, we contribute to a more recent and growing branch of literature that centers around the strategic asset allocation of insurance companies. Becker and Ivashina (2015) and Becker et al. (2022) find that discontinuities in solvency capital regulation for fixed-income investments cause insurers to allocate greater portions

of their portfolios towards more favored asset classes (bonds and mortgage-backed securities with certain ratings, respectively). Ellul et al. (2022) find that the misestimation of liquidity needs by life insurers can be especially costly in a liquidity crunch, analyzing the investment behavior of large variable annuity sellers during the global financial crisis. Other studies provide evidence that non-life insurers also take into account the liquidity of their liabilities when determining the liquidity structure of their asset portfolios (Ge and Weisbach, 2021; Knox and Sørensen, 2023). Furthermore, Chodorow-Reich et al. (2021) and Coppola (2021) analyze the effect of the buy-to-hold approach of both classes of insurers, finding that assets predominantly held by these financial institutions are less volatile than comparable assets that are not due to a decreased likelihood of a (forced) sale to generate liquidity.

The remainder of the paper is structured as follows. Section 2 provides institutional background on the life insurance industry and the FHLB. Section 3 develops a model based on Allen and Gale (2009) and in the spirit of the liquidity transformation of Diamond and Dybvig (1983), showing how access to FHLB advances allows life insurers to take on greater liquidity risk. Section 4 describes the data and methodology we use to validate the main proposition developed in our model, which we empirically test in Section 5. Section 6 discusses our results, and Section 7 concludes.

2 Institutional Background

2.1 Life Insurers as Asset Managers

Insurance companies can broadly be categorized into three groups based on the type of risks they cover: *Property and casualty insurers*, which protect against damages to physical goods and financial liabilities; *health insurers*, which guard against the financial cost of healthcare; and *life insurers*, which cover mortality, longevity, and financial risks. The products offered by life insurers can be further divided into two lines of business: life insurance and annuities. Life insurance is the traditional product associated with life insurers, paying out a lump sum in the event of a policyholder's death to designated survivors, often immediate family members or other dependents. Annuities, on the other hand, provide a stream of income for as long as the policyholder survives, thereby often serving as a supplement to their retirement income. Many annuities come with an initial accumulation phase during which payments are deferred and the premium is invested, often in combination with various types of minimum performance guarantees. These products are therefore also known as deferred annuities to differentiate them from immediate annuities.

The core business model of all insurers is to offer financial coverage for future risks in exchange for a premium paid today. Between receiving the premium and paying potential claims associated with the covered risk, the insurer holds assets on the balance sheet reserved to cover these future liabilities when they mature. Consequently, insurers that are also adept investors possess a competitive advantage in the market. They can utilize the returns generated on the reserved assets to either charge lower premiums, offer more generous benefits or claims payments to policyholders, or simply increase profits paid out to shareholders.

The liabilities stemming from life insurance and especially (deferred) annuities are among the most long-dated in the industry and involve some of the largest premium volumes. This combination of sizable asset volumes accumulating over long periods makes life insurers the largest and most active asset managers in the insurance industry. Within their investment portfolio, which mirrors the expected future liabilities towards policyholders, also known as the *general account*, life insurers can choose to invest in a wide range of assets such as cash, stocks, government and corporate bonds, loans and mortgages, credit funds, and

structured credit products such as asset-backed securities (ABS) and mortgage-backed securities (MBS).

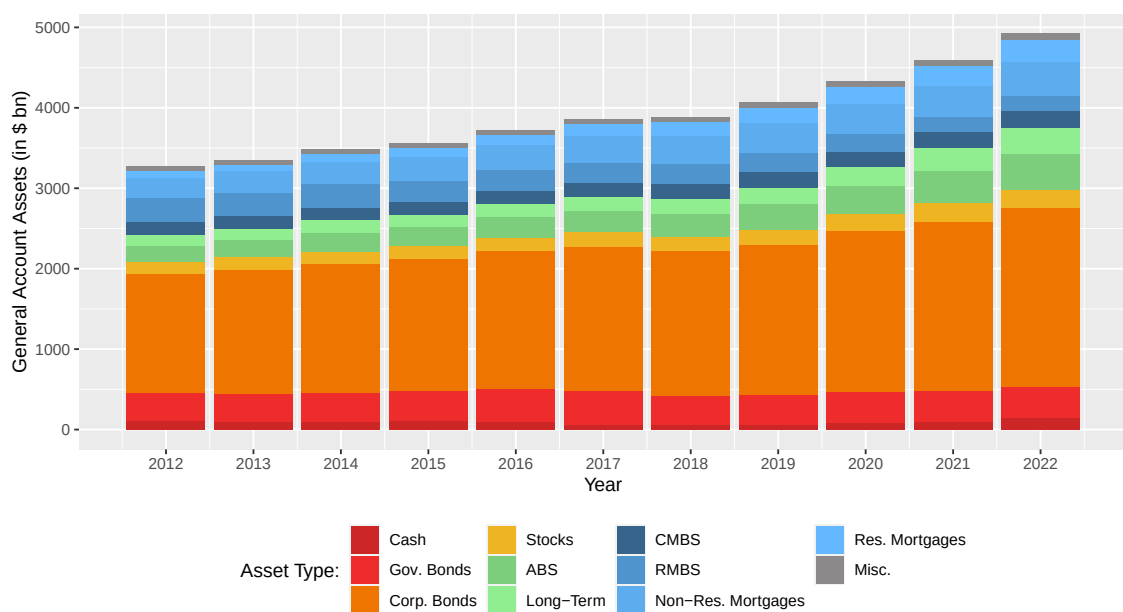
Figure II.1 shows the combined general account investments of the total U.S. life insurance industry from 2012 to 2022. We see that life insurers allocate only a small percentage of their assets towards the most liquid categories: cash,² and government bonds. A much greater share of assets is allocated towards stocks and corporate bonds, the latter being by far the largest asset class in insurers' portfolios. These four categories can broadly be classified as the conventional portfolio of a life insurer for which there exist reasonably liquid markets.³ The remaining assets can be split into three broad categories: illiquid investments, including ABS, and long-term assets such as hedge fund and private equity partnerships; mortgage-related assets, including commercial and residential mortgage-backed securities (CMBS and RMBS, respectively) and outright individual mortgages (both non-residential/commercial and residential); and miscellaneous assets such as loans and credit funds.

An obvious driver behind this diversification across multiple asset classes is the benefit of spreading risk across different types of investments (Markowitz, 1952). However, life insurers also consider other factors when determining their asset allocation in the general account. One key factor is regulation in the form of risk-based capital (RBC) requirements determined by the *National Association of Insurance Commissioners* (NAIC). Under these RBC requirements, life insurers must hold varying amounts of equity capital depending on the type and credit rating of the assets in their portfolios to safeguard against sudden drops in value due to changing market environments, credit defaults, or macroeconomic shocks (Becker and Ivashina, 2015; Becker et al., 2022). Another important factor is the maturity structure of their liabilities. Ideally, insurers aim to match cash outflows from their liabilities with cash inflows from their investments in the general account to mitigate risks. As this process of *cashflow matching* is challenging in practice, due to a lack of suitable assets or uncertainty regarding the exact timing of future cash flows, life insurers instead rely on a related but more flexible process known as *duration matching*. This approach aims to match the expected average volume-weighted time point of cash flows, also known as the *duration*, of their assets and liabilities to mitigate their exposure towards changes in interest rates.

²This includes cash-equivalents such as money market funds and short-term investments.

³The liquidity of corporate bonds may vary significantly based on the issuer, the size of the emission, non-standard covenants, and other bond characteristics.

Figure II.1: General account investments of U.S. life insurers from 2012 to 2022.



Note: This Figure shows the book value of the general account investments of U.S. life insurers as reported in their annual statutory filings at year-end from 2012 to 2022. Source: Statutory annual reports accessed via S&P Capital Intelligence.

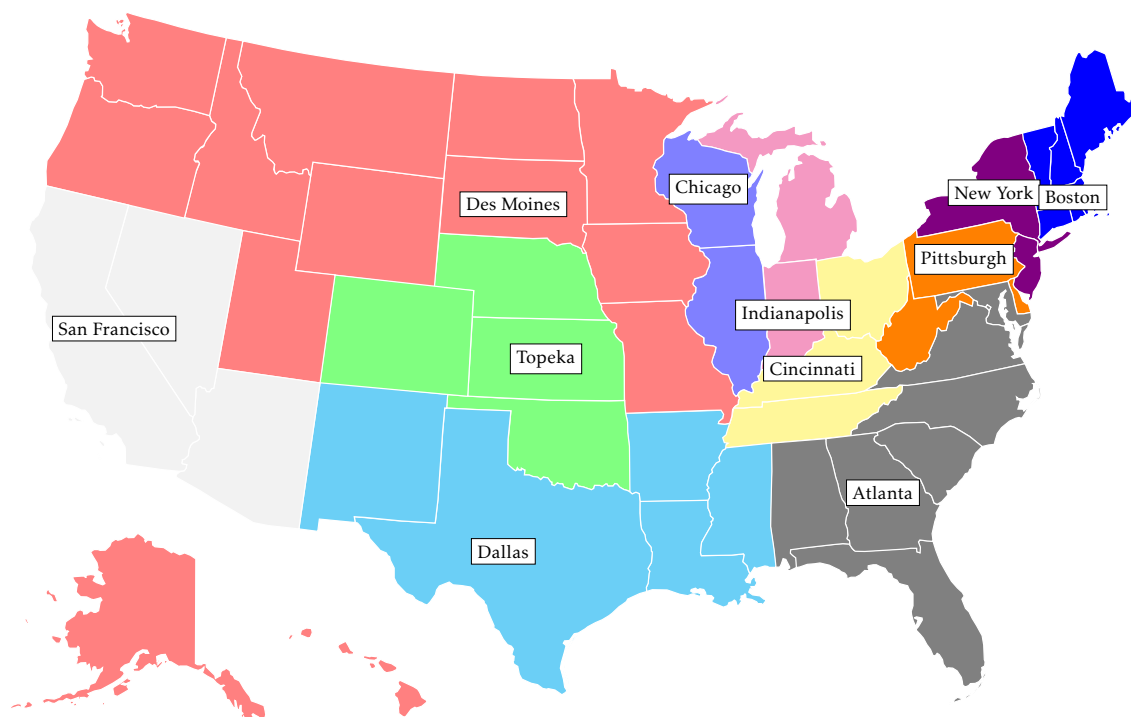
Especially the factor of liquidity, closely related to maturity, has recently come into focus for life insurers aiming to generate excess returns over the risk-free rate in their general account. The inherent *illiquidity* of life insurance liabilities, which stands in stark contrast to those of other financial intermediaries or investment managers such as banks or open-ended mutual funds, gives life insurers a natural edge as owners of assets without a deep and liquid market. Since owning such assets comes with an illiquidity premium in excess of risk-free returns, allocating a larger share of the general account towards illiquid assets is an attractive strategy to generate higher returns. Indeed, recent studies show how life insurance companies have been exploiting this competitive advantage (Knox and Sørensen, 2023), especially when backed by efficiency-seeking private equity firms (Kirti and Sarin, 2023).

However, even for a life insurer with very long-dated liabilities, investing in a purely illiquid asset portfolio does not come without risks. Policyholders may cancel their policies prematurely, also known as a *lapse*, requiring the insurer to pay out the remaining value of the individual life insurance or annuity contract in cash (Gottlieb and Smetters, 2021). If lapses are uncorrelated across a broad range of contracts, they can be accounted for and reserved alongside other actuarial assumptions. However, if lapses either directly correlate with each other or occur simultaneously during macroeconomic shocks, a *mass lapse* event can place extraordinary strain on a life insurer's need to convert assets into cash (Koiijen et al., 2022). To account for this possibility, life insurers usually develop actuarial lapse expectations and hold excess liquid reserves in their portfolios to cover outflows in almost all considered scenarios. This practice mitigates the risk of *cash flow insolvency*, which occurs when there is no cash available to meet outflows, as opposed to the more common *balance sheet insolvency*, where the balance sheet values of assets cannot cover non-equity liabilities.

2.2 The Federal Home Loan Bank System

The Federal Home Loan Bank System (FHLB) is a corporation made up of *government-sponsored enterprises* comprising 11 regional banks (FHLBanks). It was established in 1932 by the Hoover administration with the primary objective of reducing the financial cost of homeownership. The regional FHLBanks operate as cooperative institutions, collectively owned by their member institutions, which include banks, thrifts, credit unions, and insurance companies. All member institutions

Figure II.2: Regions and associated hedquarter cities of FHLBanks.



Note: This Figure shows the 11 regions of the FHLB and the cities in which the associated regional FHLBank is located as of year-end 2022. Note that the now defunct FHLBank of Seattle, which covered the States of Alaska, Hawaii, Washington, Oregon, Idaho, Montana, Wyoming, and Utah, merged with the FHLBank of Des Moines in May 2015, explaining the large region of the latter (FHFA, 2016b). Source: Adapted from Gissler and Narajabad (2017a).

must have their headquarters located within the region served by the respective FHLBank (see Figure II.2 for an overview of all 11 regions and headquarters as of year-end 2022).⁴

To become eligible for membership in the Federal Home Loan Bank System (FHLB), financial institutions must meet specific criteria. According to 12 U.S.C. § 1422(10), these criteria include having 10% of their asset portfolio in mortgage-related assets or being designated as "community financial institutions". Once they pass an initial credit-screening process, new members are required to purchase dividend-paying FHLB stock, which makes them joint owners of their regional FHLBank.

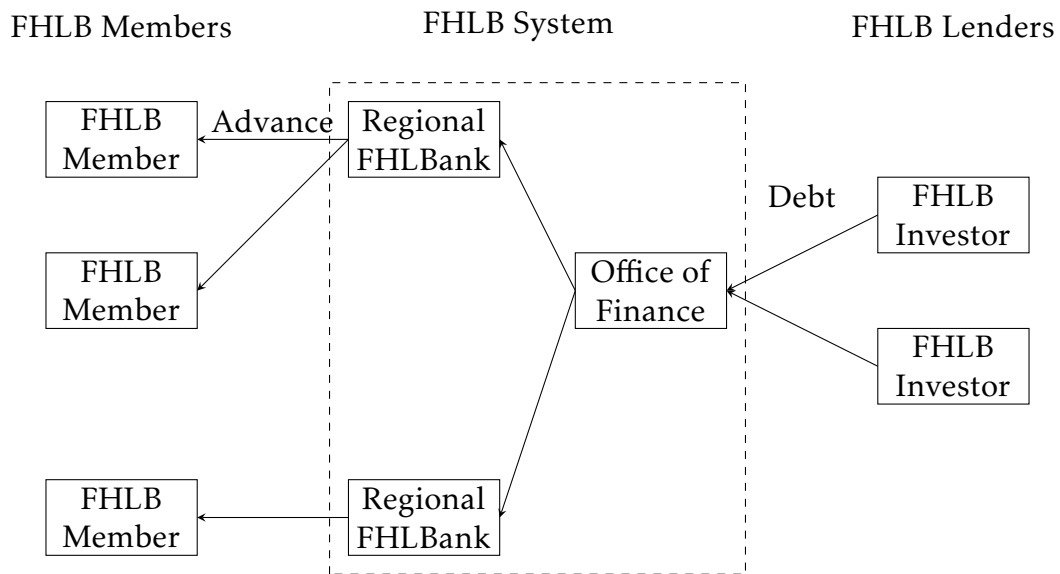
⁴There may be rare exceptions to the rule that the headquarters of a firm need to be located in the region of its FHLBank, often due to the firm's history or geographical proximity to another FHLBank.

Each of the 11 FHLBanks operates as a separate entity with its own board of directors, comprising directors who are either member-elected or independent. Member-elected directors are nominated and elected by the FHLBank's member institutions to represent their interests in formulating the institution's policies and strategies. The selection procedure for independent directors varies among FHLBanks but typically involves individuals with demonstrated expertise and experience in relevant fields, chosen by the full board of directors. The governance structure of FHLBanks includes oversight by the Federal Housing Finance Agency (FHFA), the regulatory agency responsible for supervising and regulating these institutions, along with the other two housing-related government-sponsored enterprises: the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac).

The main goal of FHLBanks is to support their member institutions by providing short-term over-collateralized loans known as *advances*. Advances are funded via debt issued by the FHLB's Office of Finance, which represents the FHLB system as a whole (see Figure II.3 for an overview). As government-sponsored enterprises, the FHLB system is perceived to have implicit government backing, similar to Fannie Mae and Freddie Mac, allowing it to source debt at very favorable rates. FHLBanks pass on this cheap financing to their member institutions via low interest rates charged on advances, which are only slightly above those at which the federal government can borrow (see Figure II.4, which shows that the rates charged on FHLB advances closely track yields on Federal Debt with a similar maturity). Collateral eligible to secure advances includes real estate investments, residential mortgage loans, and mortgage-backed securities meeting specific criteria. It is here that the FHLB system facilitates greater lending into mortgage-related assets, as the possibility to easily get cheap liquidity against assets included in the universe of eligible collateral makes these assets more attractive to invest into. To further protect against default risk, FHLBanks have a so-called "super-lien" status, which prioritizes them ahead of all other claimants should a member institution enter bankruptcy (Gissler and Narajabad, 2017a).

Historically, FHLB members have used advances to source liquidity on short notice in times of stress. Ashcraft et al. (2010) show how banks and credit unions borrowed extensively from the FHLB at the onset of the Great Financial Crisis, using the FHLB as a lender of "next-to-last resort" until more sweeping measures easing the liquidity crisis at the time were implemented by the Federal Reserve.

Figure II.3: The FHLB ecosystem.



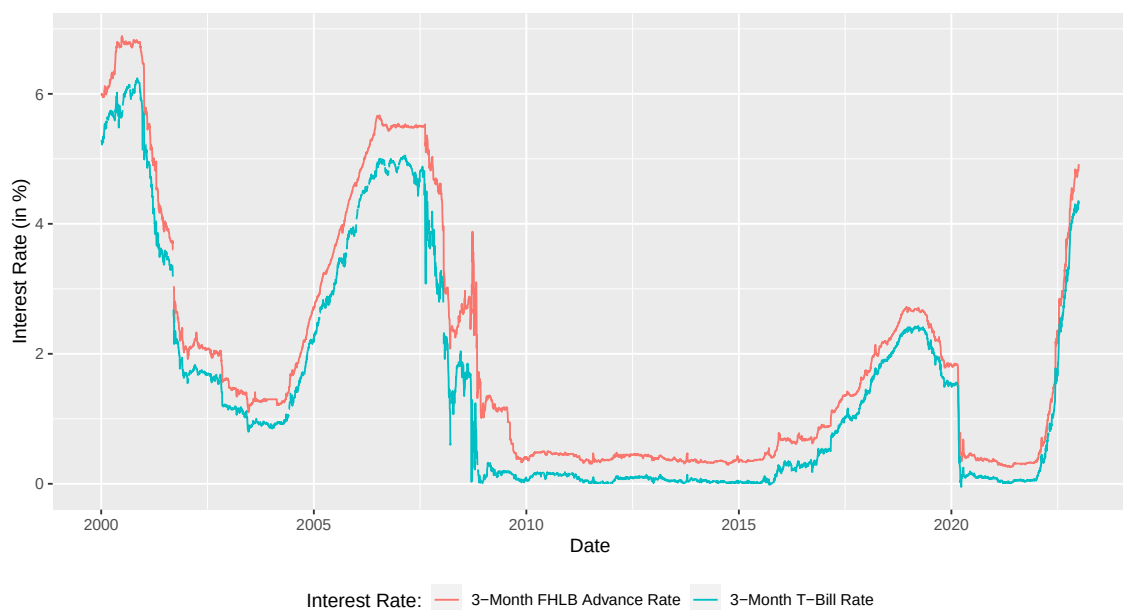
Note: illustrates the relationship between FHLB Members, the FHLB System, and FHLB Lenders. All FHLB Members are associated with a regional FHLBank, from which they receive advances. All Regional FHLBanks finance their lending via an Office of Finance central to the FHLB System. The Office of Finance, in turn, secures financing by issuing bonds in public markets. As the FHLB System has an implicit guarantee from the Federal Government, the Office of Finance can source debt from public markets at rates close to those of the Federal Government itself. It can pass this cheap financing on to the regional FHLBanks, which in turn pass it on to their member institutions. Source: Adapted from Gissler and Narajabad (2017a).

2.3 Life Insurers and the FHLB

Over the past decade, life insurers have taken on a more prominent position as active members in the FHLB system. From 2014 to 2022, life insurers increased their membership number by over 50%, a growth rate only surpassed by non-life insurance companies and miscellaneous firms such as real estate investment trusts (REITs) and community development financial institutions (CDFIs) (see Figure II.5).

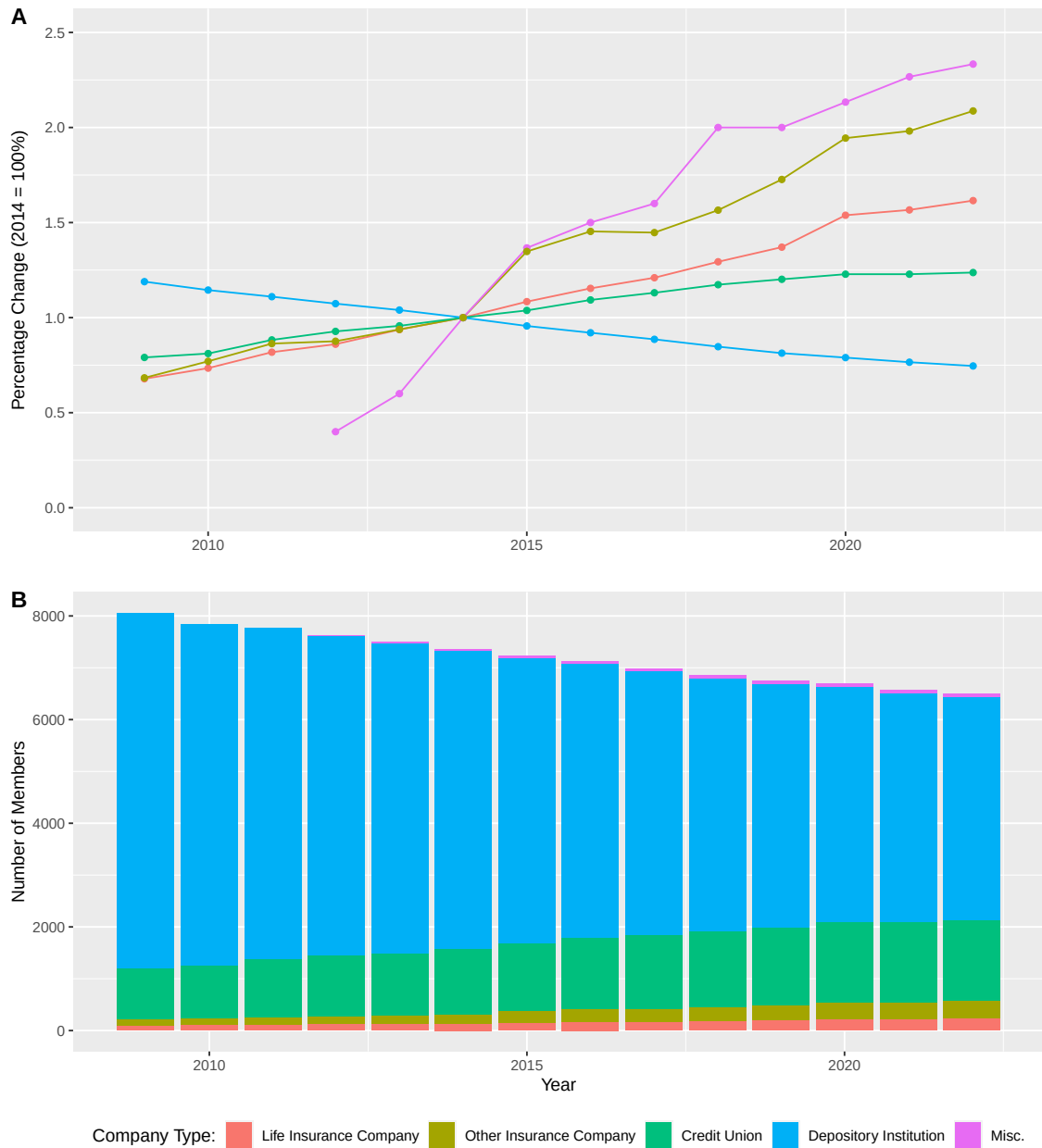
Figure II.6 shows that once they become a member, life insurers are by far the most active customer group of the FHLB, with an average outstanding advance volume more than four times the size of depository institutions and over ten

Figure II.4: Federal borrowing rates and FHLB advance rates from 2000 to 2022.



Note: This Figure shows the 3-Month T-Bill Rate, as a proxy for the borrowing rate of the Federal Government, and 3-Month FHLB Advance Rates at a daily level from 2000 to 2022. Source: FHLB Des Moines and FRED.

Figure II.5: FHLB membership by member type from 2009 to 2022.



Note: This Figure shows the growth of FHLB membership by member type (A) and the total FHLB membership numbers by member type (B) from 2009 to 2022. Source: FHFA.

times the size of other insurance companies.⁵ Furthermore, and in contrast to all other member types, life insurers have shown consistent growth in demand for advances on a per-member basis, indicating a greater usage of the FHLB over time (banks, such as credit unions and depository institutions, and other insurance companies show a more cyclical demand pattern). These trends combined have led to life insurers accounting for between 15% and 40% of all advances outstanding between 2020 and 2022, up from less than 10% of advances in 2010.

The reason for the difference in demand patterns between life insurers and other members of the FHLB system may stem from how each institution uses FHLB advances. In their annual reports, some life insurers explicitly acknowledge that they do not only rely on the FHLB for short-term liquidity but also see FHLB advances as a cheap funding opportunity for spread strategies.⁶ Here, life insurers take out and roll-over cheap FHLB advances to invest the proceeds into higher yielding assets, profiting off the spread between both. This usage of FHLB advances makes them direct substitutes to funding agreement-backed securities (FABS), which in essence provide additional funding for life insurers to invest in exchange for a fixed stream of repayments (Holmquist and Perozek, 2016). However, although this usage of advances as a cheap funding opportunity by life insurers may explain a significant portion of demand, they also use the instrument to manage their liquidity in times of stress (Foley-Fischer et al., 2022).

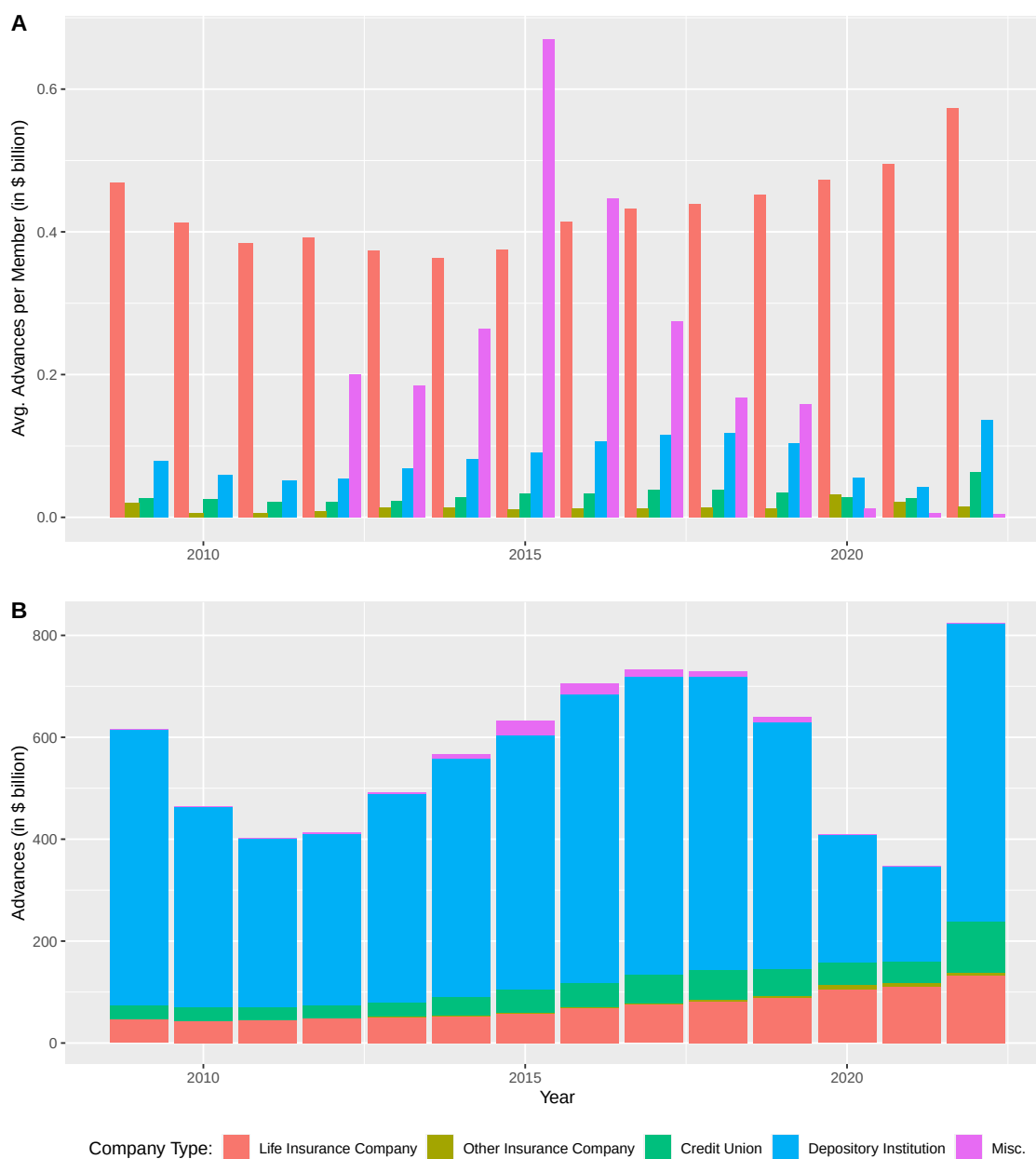
3 The Model

We develop a simple mortality-pooling model based on Allen and Gale (2009) to illustrate the cash flows and investments of a life insurance company selling annuities. To do so, we adjust the original model developed to illustrate the liquidity transformation conducted by banks by (i) adjusting it to a life insurers selling annuities and pooling mortality instead of liquidity risk and (ii) adding the option to take out FHLB advances, to show how this additional liquidity channel

⁵The spike and fall of per-member advances for miscellaneous members can be traced back to REITs and other historically non-eligible members making increased usage of insurance captives to access FHLB advances. In January 2016, the FHFA passed a final rule on FHLB membership, prohibiting this setup. Newly ineligible institutions that were already members at that time were permitted to stay members for five more years (without the option to take out new advances) and could pay back outstanding advances under the original terms (FHFA, 2016a).

⁶See Part 11 in the Financial Notes of annual statutory reports (LIFE-AS).

Figure II.6: FHLB advances by member type from 2009 to 2022.



Note: This Figure shows the average volume of outstanding advances per firm of a member type (A) and the quarterly total volume of outstanding FHLB advances by member type from 2009 to 2022. Source: FRED and FHFA.

incentivizes life insurers to invest more heavily into illiquid assets. The main proposition developed by our model is then tested empirically in the next sections.

3.1 The Basic Model

We model three periods $t = 0, 1, 2$ during which an all-purpose good that can be used for consumption or investing is traded. Agents are endowed with a single unit of the good and are subject to a non-zero idiosyncratic mortality risk between $t = 1$ and $t = 2$ with probability $\kappa \in (0, 1)$. They furthermore have preferences given by utility function

$$u(c) := \begin{cases} \frac{c^{1-\alpha}-1}{1-\alpha} & \text{if } \alpha > 1 \\ \ln(c) & \text{if } \alpha = 1 \end{cases}, \quad (\text{II.1})$$

with α as the positive coefficient of constant relative risk-aversion, giving them the overall expected utility function

$$U(C) = u(c_1) + (1 - \kappa)u(c_2) \quad (\text{II.2})$$

for consumption path $C = (c_1, c_2)$ at $t = 0$.

At $t = 0$, an agent can choose to invest fraction $\theta \in [0, 1]$ of their endowment in a liquid asset, which offers no interest but can be consumed in $t = 1$, and the remainder $1 - \theta$ in an illiquid asset, which yields gross return R in $t = 2$ but can only be consumed in that period. The agent is unable to short either the liquid or the illiquid asset. Theorem 1 gives the formula underlying the optimal allocation θ^* and the associated optimal consumption path $C^* = (c_1^*, c_2^*)$.

Theorem 1 (Optimal choice without life insurers). *An agent will choose to invest*

$$\theta^* = \frac{R^{\frac{\alpha-1}{\alpha}}}{(1 - \kappa)^{\frac{1}{\alpha}} + R^{\frac{\alpha-1}{\alpha}}} \quad (\text{II.3})$$

in the liquid asset. This yields the consumption path $C^* = (c_1^*, c_2^*)$ consisting of

$$c_1^* = \frac{R^{\frac{\alpha-1}{\alpha}}}{(1 - \kappa)^{\frac{1}{\alpha}} + R^{\frac{\alpha-1}{\alpha}}} \quad (\text{II.4})$$

and

$$c_2^* = \frac{(1 - \kappa)^{\frac{1}{\alpha}} R}{(1 - \kappa)^{\frac{1}{\alpha}} + R^{\frac{\alpha-1}{\alpha}}} \quad (\text{II.5})$$

Proof: See Appendix A.1.

3.2 Life Insurers and Annuities

We now introduce a life insurer selling annuities to the model. With an annuity, the life insurer collects the initial endowment (i.e. a *premium*) from the agents (i.e. *policyholders*) in $t = 0$, to offer them a guaranteed consumption path $C_{\text{Annuity}} = (c_1^A, c_2^A)$ (i.e. *annuity benefits*) in return in later periods. The life insurer has the right to divide the assets of the κ deceased policyholders between the $1 - \kappa$ surviving policyholders (which differentiates it from other financial intermediaries such as banks or investment funds). We assume that as all agents purchase annuities, the life insurer can fully diversify the agents' idiosyncratic mortality risk, such that he is sure to face $1 - \kappa$ surviving agents in $t = 2$ (we will validate this assumption once we solve the model).

The life insurer makes no profits and faces no costs, such that it pays out all of the premiums it collects plus investment proceeds to policyholders in form of an optimal annuity $C_A^* = (c_1^{A*}, c_2^{A*})$. The utility function of the life insurer is therefore perfectly aligned with that of the policyholder. After collecting the policyholders' endowment, the life insurer has to decide on an asset allocation, holding fraction $\theta^A \in [0, 1]$ of the collected premium in the liquid asset and the remainder, $1 - \theta^A$, in the illiquid asset. Figure II.7 illustrates the associated investments and cash flows from the perspective of the life insurer, whose optimal investment decision can be determined by solving the following optimization problem:

$$\max_{\theta^A} u(c_1^A) + (1 - \kappa)u(c_2^A) \quad (\text{II.6})$$

subject to

$$0 < \theta^A < 1 \quad (\text{II.7})$$

$$c_1^A = \theta^A \quad (\text{II.8})$$

$$c_2^A = \frac{(1 - \theta^A)R}{1 - \kappa}. \quad (\text{II.9})$$

The first constraint is due to the life insurer being unable to go short either the liquid or illiquid asset. The third constraint is due to the life insurer being able to distribute the assets of deceased policyholders to survivors. The solution of this optimization is given by Theorem 2.

Theorem 2 (Optimal annuities without FHLB advances). *A life insurer will choose asset allocation*

$$\theta^{A*} = \frac{R^{\frac{\alpha-1}{\alpha}}}{(1 - \kappa) + R^{\frac{\alpha-1}{\alpha}}}. \quad (\text{II.10})$$

This allows them to offer consumption bundle $C_{Annuity}^* = (c_1^{A*}, c_2^{A*})$ to agents with

$$c_1^{A*} = \frac{R^{\frac{\alpha-1}{\alpha}}}{(1 - \kappa) + R^{\frac{\alpha-1}{\alpha}}} \quad (\text{II.11})$$

and

$$c_2^{A*} = \frac{R}{(1 - \kappa) + R^{\frac{\alpha-1}{\alpha}}}. \quad (\text{II.12})$$

Proof: See Appendix A.2.

To manufacture the annuity payoff, the insurance company sets aside θ^{A*} of the premium in the liquid asset at $t = 0$ and invests the remainder, $1 - \theta^{A*}$, into the illiquid asset. Comparing the optimal consumption path of the annuity C_A^* to the one achieved in isolation C^* , we see that the risk-averse agents in our model would indeed always prefer the annuity, regardless of the other parameters in the model. We show this formally in Theorem 3.

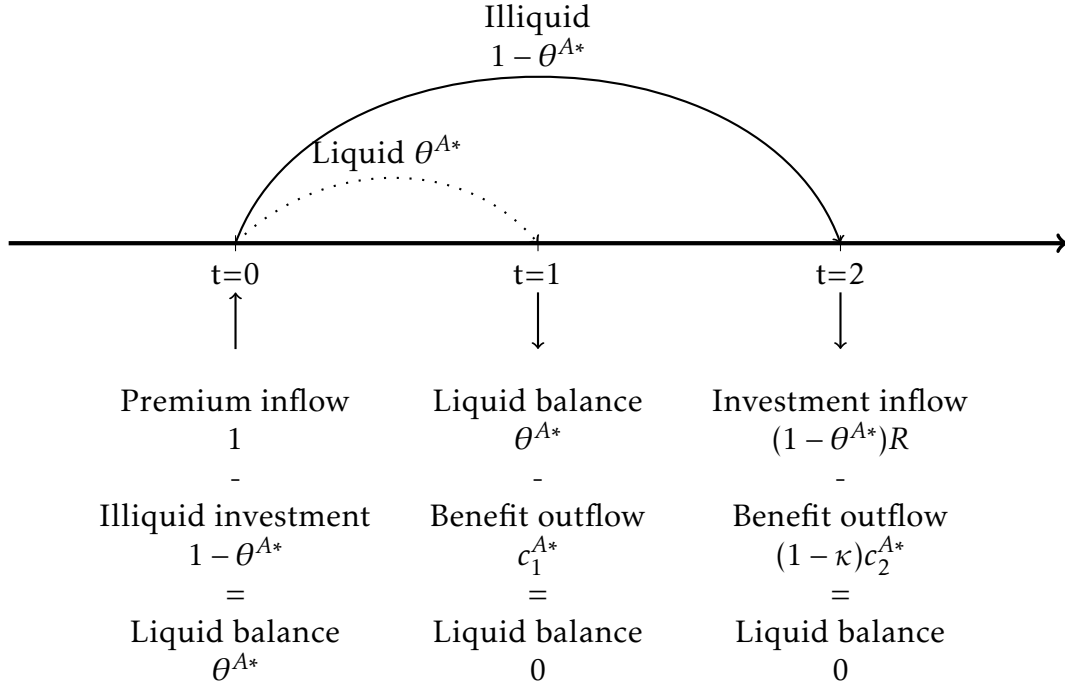
Theorem 3 (Risk-averse Agents always prefer Annuities). *The risk-averse agent would always prefer the annuity over holding her endowment in both the liquid and illiquid asset in isolation, i.e*

$$U(C_A^*) > U(C^*). \quad (\text{II.13})$$

Proof: See Appendix A.3.

This result aligns with seminal work of Yaari (1965), who shows that rational consumers with no bequest motive will invest all of their retirement wealth into an annuity. The cause of this is the diversification of mortality risk via the annuity

Figure II.7: Optimal asset allocation and cash flows without FHLB membership.



Note: This Figure illustrates the asset allocation and cash flows manufacturing optimal annuity payoffs in our model. The life insurance company receives premiums in period $t = 0$, which it invests to service benefit outflows in periods $t = 1$ and $t = 2$. To do so, the life insurer invests share θ^{A*} into a liquid asset generating no interest and the remainder $1 - \theta^{A*}$ into an illiquid asset generating gross interest R in $t = 2$. Source: Own illustration.

offered by the life insurance. In essence, the product allows agents to transfer wealth from the state in period $t = 2$ in which they have deceased to either the state in period $t = 2$ in which they survive or period $t = 1$, which they could not achieve in isolation. Theorem 3 also validates our previous assumption that all agents purchase annuities from the life insurer, as it is individually rational for each agent to purchase an annuity if all other agents are doing so such that all agents purchasing annuities is a steady state equilibrium.

3.3 FHLB Advances

We now introduce the FHLB to the model. In this new setup, insurance companies who are FHLB members again invest fraction $\theta^{FHLB} \in [0, 1]$ in the liquid asset. However, they now also have the option to take out an advance z^{FHLB} against fraction $\phi \in [0, 1]$ of their illiquid investments in $t = 1$ to generate liquidity.⁷ The advance is repaid in $t = 2$ with gross interest $1 + r$, with $1 + r < R$ reflecting the advantageous funding opportunities of the FHLB system. The consumption path of annuities offered by this type of insurer is given by $C_{FHLB} = (c_1^{FHLB}, c_2^{FHLB})$. Figure II.8 shows the associated investments and cash flows from the perspective of the life insurer who is also a FHLB member. As such, the life insurer can now generate liquidity in $t = 1$ via FHLB advances collateralized by illiquid asset, which are repaid with interest in $t = 2$. The new optimization problem of the life insurer can be summarized as follows:

$$\max_{\theta^{FHLB}, z^{FHLB}} u(c_1^{FHLB}) + (1 - \kappa)u(c_2^{FHLB}) \quad (\text{II.14})$$

subject to

$$0 < \theta^{FHLB} < 1 \quad (\text{II.15})$$

$$0 < z^{FHLB} < \phi(1 - \theta^{FHLB}) \quad (\text{II.16})$$

$$c_1^A = \theta^{FHLB} + z^{FHLB} \quad (\text{II.17})$$

$$c_2^A = \frac{(1 - \theta^{FHLB})R - z^{FHLB}(1 + r)}{1 - \kappa}. \quad (\text{II.18})$$

The solution of this optimization problem is given by Theorem 4.

Theorem 4 (Optimal annuities with FHLB advances). *There are two possible solutions for the optimal asset allocation θ^{FHLB*} and advance volume z^{FHLB*} for a life insurer with access to FHLB advances dependent on the parameters of the model.*

I If $\frac{R(1+r)^{\frac{-1}{\alpha}}}{(1-\kappa)+(1+r)^{\frac{\alpha-1}{\alpha}}} < \phi$, the optimal allocation is given by

⁷The parameter ϕ can be interpreted as an eligibility restrictions for a illiquid portfolio diversified over multiple assets, such as the FHLB only accepting residential mortgage-related assets as collateral for advances. Alternatively, it could also represent a haircut on the value of the illiquid asset used as collateral.

$$\theta^{FHLB*} = 0 \quad (\text{II.19})$$

and the optimal advance volume is given by

$$z^{FHLB*} = \frac{R(1+r)^{\frac{-1}{\alpha}}}{(1-\kappa) + (1+r)^{\frac{\alpha-1}{\alpha}}}, \quad (\text{II.20})$$

which result in consumption path

$$c_1^{FHLB*} = \frac{R(1+r)^{\frac{-1}{\alpha}}}{(1-\kappa) + (1+r)^{\frac{\alpha-1}{\alpha}}} \quad (\text{II.21})$$

and

$$c_2^{FHLB*} = \frac{R}{(1-\kappa) + (1+r)^{\frac{\alpha-1}{\alpha}}}. \quad (\text{II.22})$$

II If $\frac{R(1+r)^{\frac{-1}{\alpha}}}{(1-\kappa) + (1+r)^{\frac{\alpha-1}{\alpha}}} \geq \phi$, the optimal allocation is given by

$$\theta^{FHLB*} = \frac{R^{\frac{1}{-\alpha}}(R - \phi(1+r)) - (1-\kappa)\phi}{R^{\frac{1}{-\alpha}}(R - \phi(1+r)) + (1-\kappa)(1-\phi)} \quad (\text{II.23})$$

and the optimal advance volume is given by

$$z^{FHLB*} = \frac{(1-\kappa)(1-\phi)}{R^{\frac{1}{-\alpha}}(R - \phi(1+r)) + (1-\kappa)(1-\phi)}, \quad (\text{II.24})$$

which result in consumption path

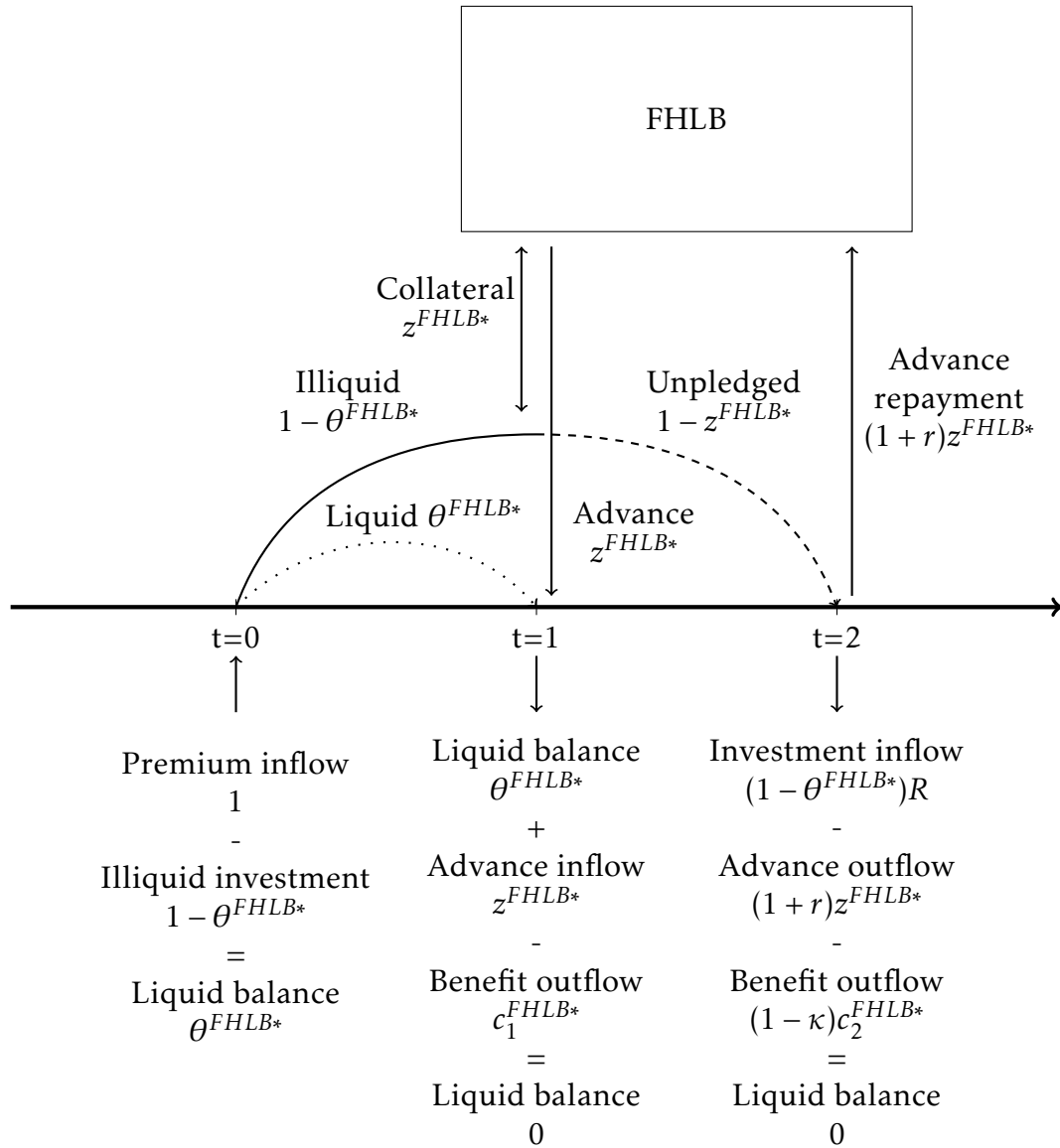
$$c_1^{FHLB*} = \frac{R^{\frac{1}{-\alpha}}(R - \phi(1+r))}{R^{\frac{1}{-\alpha}}(R - \phi(1+r)) + (1-\kappa)(1-\phi)} \quad (\text{II.25})$$

and

$$c_2^{FHLB*} = \frac{R - \phi(1+r)}{R^{\frac{1}{-\alpha}}(R - \phi(1+r)) + (1-\kappa)(1-\phi)}. \quad (\text{II.26})$$

Proof: See Appendix A.4.

Figure II.8: Optimal asset allocation and cash flows with FHLB membership.



Note: This Figure illustrates the asset allocation and cash flows manufacturing optimal annuity payoffs for FHLB members in our model. The life insurance company receives premiums in period t , which it invests to service benefit outflows in periods $t = 1$ and $t = 2$. To do so, the life insurer invests share θ^{FHLB*} into a liquid asset generating no interest and the remainder $1 - \theta^{FHLB*}$ into an illiquid asset generating gross interest R . As a FHLB Member, the life insurer also has the option to take out a liquid advance of size z^{FHLB*} in period $t = 1$ collateralized by the illiquid asset. The advance is repaid in period $t = 2$ with gross interest $1 + r$, which is lower than the gross interest R earned on the illiquid asset. Source: Own illustration.

3.4 Model Propositions

We see that the dynamics outlined in our model delivers a key proposition on how life insurers change their investment behaviour once they become FHLB members.

Proposition 1 (FHLB membership and asset allocation). *Ceteris paribus, insurance companies that are FHLB members allocate a lower share of their assets towards liquid investments*

$$\theta^{FHLB*} < \theta^{A*} \quad (\text{II.27})$$

to the benefit of illiquid investments.

Proof: See Appendix A.5.

Proposition 1 allows us to make predictions about the impact FHLB membership will have on life insurers' asset allocation. The opportunity to generate liquidity on short notice via FHLB advances reduces the need to hold liquid assets, such that insurers who are FHLB members are on the margin more willing to invest into illiquid assets to generate an additional illiquidity premium.

3.5 Limitations of the Model

Although our model illustrates the main concept we would like to show, it is simplified at several points to ease its exposition.

First, we only assume a three period model, although both annuities and life insurer operations run over many more time periods. Furthermore, the model also only allows life insurers to take out advances in period $t = 1$. However, extending the model over a longer set time periods would deliver similar results for the main effect we would like to illustrate but would add complications not directly relevant for it (Ponzi-like payoffs, etc.).

Second, we assume that the mortality rate κ is fixed and purely idiosyncratic. In practice, mortality can vary significantly for whole populations over time, such that life insurers have to make actuarial assumptions on their values based on past data and models, which are guided by regulatory restrictions and industry best-practices. For the purposes of our model parameter κ can be seen as conservative estimate, such as a value at risk, of the actual mortality rate.

Third, we assume that agents have no bequest motive. Yaari (1965) shows that adding a bequest motive to the utility of the agent makes annuities less attractive, such that agents would not invest their full endowment into annuities.

4 Data and Methodology

4.1 Identification Strategy

In this section, we empirically test the hypothesis laid out in Proposition 1: once life insurers become FHLB members they invest greater shares of their assets in illiquid assets at the expense of liquid assets. As we cannot randomly assign FHLB membership to life insurers, we have to rely on observational data for our analysis. This of course introduces the problem of endogeneity, as the decision to become a FHLB member is not independent of other characteristics of a life insurer or macroeconomic variables. Any empirical analysis not accounting for this would necessarily deliver biased estimates.

We attempt to control for this issue by choosing a fixed effects panel data approach to measure the effect of FHLB membership on the asset allocation of individual insurers. To do so, we track the development of the asset allocation for individual insurance companies that decided to become FHLB members during our sample period. This allows us to not only compare its allocation decisions to those of life insurers that are not FHLB members but also to its own decisions while it was not an FHLB member. This way, we can control for time-invariant insurer-specific variable and time-varying insurer-independent variables potentially biasing our estimates for the effect of FHLB membership. The only remaining source of endogeneity are time-varying insurer-specific variables, of which we attempt to include the most important in our analysis.

4.2 Data

Asset Allocation and other Financial Data

As FHLB membership is granted at a company-level, we gather data on life insurance companies from annual statutory filings via S&P Global Market Intelligence. Our final sample consists of 464 life insurance entities active between fiscal years 2012 and 2022, with average assets greater than \$100 million. This group of firms combined make up more than 95% of the total industry by asset volume.

Data on asset allocations are gathered from Schedules B, BA, D, DA, and E of the life insurer statutory filings, which contain comprehensive security level data on

investments held in the general account.⁸ We gather data on other characteristics of individual life insurers such as total assets, surplus, annuity liabilities and RBC-ratios from the main section of the same statutory filings.

FHLB Membership

We collect data on life insurer's FHLB membership from the Federal Housing Finance Agency (FHFA), the FHLB's supervisor. Membership data is reported quarterly and includes the precise dates on which individual insurance companies became members of their regional FHLB bank. We match membership data across insurance companies via *NAIC company codes*, a six-digit number assigned exclusively to insurance companies as a unique identifier by the NAIC.

4.3 Methodology

Asset Allocation

We calculate the asset allocations of the life insurers in our sample by first classifying individual securities by their schedule and, if necessary, their issuer, asset type, and property type, into the following eleven *subcategories*:

1. **Cash**, consisting of all assets reported in Schedule E, Part 1 (Cash) and Part 2 (Cash-Equivalents), independent of asset type and issuer
2. **Government Bonds**, consisting of all securities reported in Schedule D, Part 1 (Bonds) with issuer *US Government, Political Subdivisions, Government Agencies* and *All other Governments*, independent of asset type
3. **Corporate Bonds**, consisting of all securities reported in Schedule D, Part 1 (Bonds) with asset type *Issuer obligations*, independent of issuer
4. **Stocks**, consisting of all securities reported in Schedule DA, Part 1 (Preferred Stock) and Part 2 (Common Stock), independent of asset type and issuer
5. **Asset-backed Securities (ABS)**, consisting of all securities reported in Schedule D, Part 1 (Bonds) with asset type *Other loan-backed and structured securities*, independent of issuer
6. **Long-Term Assets**, consisting of all securities reported in Schedule BA (Long-Term Assets), independent of asset type and issuer

⁸We refrain from including data from the two missing schedules on assets: Schedule A covering real estate, as it is most commonly self-used office space, and Schedule DB on derivatives, as the majority of insurers self-report that they almost exclusively use these financial instruments to hedge market risks rather than generate investment income.

7. **Commercial Mortgage-backed Securities (CMBS)**, consisting of all securities reported in Schedule D, Part 1 (Bonds) with asset type *Commercial mortgage-backed securities*, independent of issuer
8. **Residential Mortgage-backed Securities (RMBS)**, consisting of all securities reported in Schedule D, Part 1 (Bonds) with asset type *Residential mortgage-backed securities*, independent of issuer
9. **Residential Mortgages**, consisting of all mortgages reported in Schedule B (Individual Mortgages) with asset type *Long-term Residential Mortgage* or property type *Apartment or Multifamily*
10. **Non-Residential Mortgages**, consisting of all remaining mortgages reported in Schedule B (Individual Mortgages) not falling into one of the above categories, independent of asset and property type
11. **Miscellaneous Assets**, consisting of all remaining securities reported in Schedule D, Part 1 (Bonds), not falling into one of the above categories, independent of asset and issuer type

Subcategory weights $CatWeight_{i,t}^j$ for each subportfolio $j \in \{1, \dots, 11\}$ of insurer i at time t are calculated by dividing the summed *book-adjusted carry value* of all securities classified into category j , $CatBookValue_{i,t}^j$, by the same value summed across all subcategories:

$$CatWeight_{i,t}^j = \frac{CatBookValue_{i,t}^j}{\sum_j CatBookValue_{i,t}^j} \quad (II.28)$$

We next aggregate the subcategories into four broad *subportfolios*:

- i. **Liquid Subportfolio**, consisting of Cash, Government Bonds, Corporate Bonds, and Stocks
- ii. **Illiquid Subportfolio**, consisting of Asset-backed Securities, Long-Term Assets, Non-Residential Mortgages, and Commercial Mortgage-backed Securities
- iii. **Housing Subportfolio**, consisting of Residential Mortgage-backed Securities and Residential Mortgages
- iv. **Other Subportfolio**, consisting of Miscellaneous Assets

We choose subportfolios to represent the liquid and illiquid parts of an average life insurer's asset portfolio. The liquid portfolio consists of cash itself and stocks and bonds, for which arguably deep and liquid markets exist ensuring

thier convertability to cash. The remaining illiquid subportfolio consists of assets harder to liquidate, which include structured securites, individual mortgages, hedge fund investments and private equity participations. From this subportfolio we extract all assets directly related residential real estate into a separate housing subportfolio, to be able to individually analyze the effect of FHLB memeberhsip on these assets in particular.

Subportfolio weights $PortWeight_{i,t}^k$ for each subportfolio $k \in \{i, ii, iii, iv\}$ of insurer i at time t are determined by first calculating the summed *book-adjusted carry value* of all securities classified into subportfolio k , $PortBookValue_{i,t}^k$.⁹ This value is then divided by the same value summed across all subportfolios to get the weights:

$$PortWeight_{i,t}^k = \frac{PortBookValue_{i,t}^k}{\sum_k PortBookValue_{i,t}^k}. \quad (II.29)$$

Financial Data

We calculate the control variable for size, $Size_{i,t}$, by taking the natural log of total assets measured in USD billions. The annuity share, $AnnShare_{i,t}$, is calculated by dividing annuity reserves reported as liabilities by total liabilities. The risk-based capital ratio, $RBC_{i,t}$, is taken directly from the annual reports, where it is reported as the *CAL RBC Ratio*. The leverage, $Lev_{i,t}$, is calculated by dividing the surplus of the firm by total assets.

FHLB Membership

FHLB membership for insurer i in year t , $FHLB_{i,t}$, is determined by comparing the year t with the year τ reported by the FHFA in which an insurer i became a member. For observations before the membership date, $t < \tau$, an insurer is coded as a non-member by setting $FHLB_{i,t}$ to zero. For years after and including that of the membership date, $t \geq \tau$, an insurer is coded as a member by setting $FHLB_{i,t}$ to one. If no membership date was reported by the FHFA, $FHLB_{i,t}$ is set to zero for all years in our sample.

⁹For subportfolio i these are subcategories 1, 2, 3, and 4, for subportfolio ii these are subcategories 5, 6, 7, and 10, for subportfolio iii these are subcategories 8 and 9, and for subportfolio iv this is subcategory 11.

4.4 Descriptive Statistics

Table III.2 reports descriptive statistics on the variables outlined above. We see that averaging across 2012 to 2022 the average life insurer allocated 75% of their general account assets to the liquid subportfolio, 15% towards the illiquid subportfolio, and 8% towards the housing subportfolio. The median allocation across the same sample paints a similar picture, with 75% in the liquid subportfolio, 14% towards the illiquid subportfolio, and 6% towards the housing subportfolio, which together with the 25th. and 75th percentiles indicate that subportfolio weights are fairly evenly distributed.

Turning to FHLB Membership, we see that the median life insurer became a member of the FHLB System in 2013.¹⁰ Over all of our firm-year observations, about a third were made for life insurers that were FHLB members. The majority of the life insurers in our sample do not write annuities, as indicated by the share of the associated liabilities to total liabilities. The median size is in the range of 1.5 billion USD, the median CAL RBC ratio about 450 %, and the median leverage about 20 %, with all three variables fairly evenly distributed as again indicated by the percentiles of their distribution.

¹⁰Note that membership dates before 1992 were coded as being in that year due to data restrictions, which is why the average value is not informative.

Table II.1: Summary statistics.

	N	Mean	SD	Min.	25th Pctl.	50th Pctl.	75th Pctl.	Max.
Category Weights								
Cash	4802	0.06	0.12	0.00	0.01	0.02	0.06	1.00
Gov. Bonds	4802	0.13	0.14	0.00	0.05	0.09	0.17	1.00
Corp. Bonds	4802	0.49	0.21	0.00	0.37	0.51	0.63	0.99
Stocks	4802	0.07	0.15	0.00	0.00	0.02	0.05	1.00
ABS	4802	0.06	0.07	0.00	0.01	0.03	0.08	0.64
Long-Term	4802	0.02	0.04	0.00	0.00	0.01	0.03	0.85
CMBS	4802	0.04	0.04	0.00	0.00	0.03	0.06	0.31
RMBS	4802	0.07	0.08	0.00	0.01	0.04	0.10	0.71
Non-Res. Mortgages	4802	0.04	0.05	0.00	0.00	0.00	0.07	0.45
Res. Mortgages	4802	0.02	0.03	0.00	0.00	0.00	0.02	0.45
Misc.	4802	0.01	0.03	0.00	0.00	0.00	0.02	1.00
Subportfolio Weights								
Liquid	4802	0.75	0.16	0.00	0.64	0.75	0.87	1.00
Illiquid	4802	0.15	0.12	0.00	0.05	0.14	0.23	0.85
Housing	4802	0.08	0.08	0.00	0.02	0.06	0.12	0.71
Other	4802	0.01	0.03	0.00	0.00	0.00	0.02	1.00
Mem. Ind.	4802	0.32	0.47	0.00	0.00	0.00	1.00	1.00
Mem. Year	2136	2012	7.11	1992	2007	2013	2018	2022
Ann. Share	4800	0.05	0.15	0.00	0.00	0.00	0.00	0.92
Log Size (in bn. USD)	4800	21.32	2.13	13.12	19.68	21.04	22.86	26.74
CAL RBC	4780	8.14	23.56	-4.55	3.48	4.57	6.33	606.33
Leverage	4800	0.19	0.20	-0.21	0.06	0.10	0.21	1.01

Note: This Table reports summary statistics on the asset allocation, FHLB membership, and other financial variables of all U.S. life insurers with average assets above \$100 million between 2012 and 2022. Note that weights across subcategories and subportfolios may not sum up to one due to rounding errors. Source: FHFA and Statutory Filings accessed via S&P Capital Intelligence.

5 Empirical Results

5.1 FHLB Membership and Subportfolio Weights

We run panel regressions to estimate equations

$$PortWeight_{i,t}^k = \alpha_i^k + \tau_t^k + \beta^k FHLB_{i,t} + \gamma^k X_{i,t} + \varepsilon_{i,t}^k \quad (II.30)$$

for subportfolios $k \in \{i, ii, iii, iv\}$, insurer fixed effects α_i^k , time fixed effects τ_t^k , control variables $X_{i,t} = (Size_{i,t}, AnnShare_{i,t}, RBC_{i,t}, Lev_{i,t})$ and over all insurance companies i and years t in our sample.

Table II.2 reports the results of estimating equations II.30. We see that FHLB membership has a highly significant positive association with asset allocations away from the liquid and towards the illiquid subportfolios, with the allocation towards the former on average being reduced by 3.0% and the allocation to the latter increased by 3.3%. In contrast, the estimated association with the allocation towards the housing portfolio is not significantly different from zero. The same can be said for the effect of FHLB membership on the allocation to the subportfolio consisting of other assets.

Looking at the estimated coefficients of the control variables, we see that they too align with general intuition. A higher annuity share has a significant negative effect on the allocation towards the liquid subportfolio and a positive effect on the allocation towards the illiquid and housing subportfolios, which aligns with the longer-dated liabilities underwritten in this line of business. Roughly the same effect can be seen for the size of the insurance company, with larger companies allocating larger shares of their assets towards the illiquid portfolio at the expense of the liquid portfolio. This effect may be due to the greater expertise required to value and invest into illiquid assets, which larger firms are more likely to have. Finally, the RBC ratio does not seem to have a significant effect on the allocation towards any subcategory, indicating that the capitalization of a life insurer is not systematically related to its asset allocation. All of these results are intuitive and support the validity of the model. In Appendix B.1 we show that the effects estimated here are robust to variations in the selection of the control group of non-member firms. Furthermore, Appendix B.2 shows that the same effects can be found in the subsamples of both large firms with assets greater than \$1 billion and small firms with assets between \$1 billion and \$100 million.

Table II.2: Regression results per subportfolio.

	<i>Dependent variable:</i>			
	Liquid (1)	Illiquid (2)	Housing (3)	Other (4)
FHLB Membership	−0.030*** (0.010)	0.033*** (0.008)	−0.001 (0.006)	−0.002 (0.003)
Annuity Share	−0.041*** (0.008)	0.026*** (0.007)	0.010** (0.005)	0.005* (0.003)
Log Size	−0.074*** (0.020)	0.069*** (0.017)	0.007 (0.013)	−0.002 (0.006)
CAL RBC Ratio	0.0001 (0.0002)	−0.00002 (0.0002)	0.00001 (0.0001)	−0.0001 (0.0001)
Leverage	0.022 (0.045)	0.007 (0.029)	−0.043 (0.027)	0.014 (0.010)
Firm-Year FE	Yes	Yes	Yes	Yes
Firm-Year Clustured SE	Yes	Yes	Yes	Yes
Observations	4,779	4,779	4,779	4,779

Note: This Table reports the estimates of model

$$PortWeight_{i,t}^k = \alpha_i^k + \tau_t^k + \beta^k FHLB_{i,t} + \gamma^k X_{i,t} + \varepsilon_{i,t}^k$$

for annual observations t from 2012 to 2022 and subportfolios $k \in \{i, ii, iii, iv\}$. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1; ** : p -value < 0.05; *** : p -value < 0.01.

5.2 Inferring Causality via the Timing of FHLB Membership

The model presented in equation II.30 does not make any statement about the cause-and-effect dynamics of FHLB membership and subportfolio weights. To infer the causal impact of one on the other, we follow the *dynamic difference-in-difference* approach pioneered by Autor (2003) and now commonly used in the causal inference literature to measure the dynamic impact of treatment variables on other variables of interest (Huntington-Klein, 2021). To do so, we estimate equation

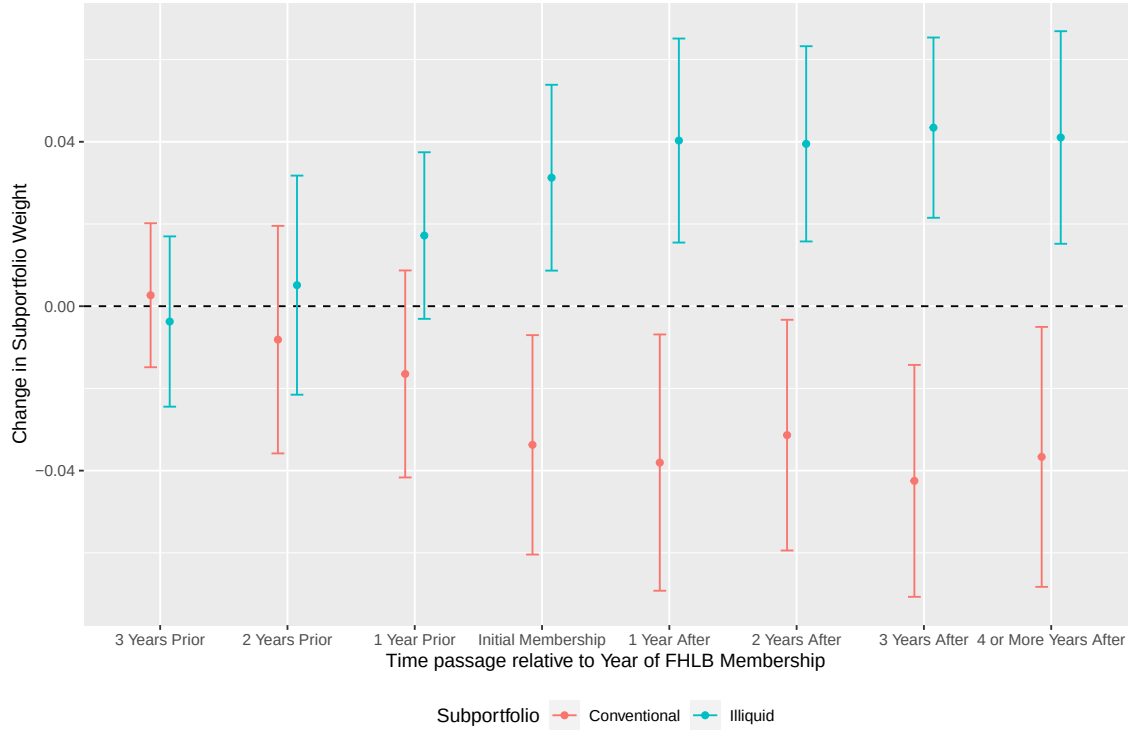
$$PortWeight_{i,t}^k = \alpha_i^k + \tau_t^k + \sum_{m \in \{-3, -2, \dots, 2, 3, 4+\}} \beta_m^k FHLBYear_{i,t}^m + \gamma^k X_{i,t} + \varepsilon_{i,t}^k \quad (\text{II.31})$$

where $FHLBYear_{i,t}^m$ indicates whether firm i became a FHLB member in year $t + m$ (including any following years in the case of $m = 4+$).

By including these leads and lags of FHLB membership in our model, we can assess the dynamic impact of FHLB membership on subportfolio weights over time. Given that we assume FHLB membership causes changes in subportfolio weights, we expect estimates of β_m^k for $m < 0$ to be close to zero (an exercise also known as a *placebo test*). These estimates are also informative about our assumption regarding parallel trends in the treated and non-treated groups, i.e. life insurers that became FHLB members in our sample and those that did not, as any systematic difference between both groups would show up here. On the other hand, we expect estimates β_m^k for $m \geq 0$ to be non-zero, with β_0^k showing the immediate effect of FHLB membership on portfolio weights and β_m^k for $m > 0$ potential long-term effects.

Table II.3 reports the results of estimating the above equation, which are illustrated in Figure II.9. We see that for the liquid and illiquid subportfolio weight the estimated results match our expectations outlined above, providing evidence that it is indeed FHLB membership that causes changes in subportfolio weights: β_m^k for $m < 0$ are not significantly different from zero for all negative values of m included in our model and β_m^k for $m \geq 0$ are significantly different throughout. We further note that the immediate effect of FHLB membership, β_0^k , is very close to the effect estimated for the model presented in equation II.30 (see Table II.2). This effect persists for all values of $m > 0$, with the estimated coefficients decreasing slightly below the -3.0% estimated for the liquid subportfolio and increasing above the 3.3% estimated for the illiquid portfolio. This indicates that FHLB membership

Figure II.9: Dynamic effects of FHLB membership on liquid and illiquid subportfolio weights.



Note: This Figure shows the estimated coefficients $\hat{\beta}_m^k$ and associated 95%-confidence intervals (based on firm-year clustered standard errors) of model

$$PortWeight_{i,t}^k = \alpha_i^k + \tau_t^k + \sum_{m \in \{-3, -2, \dots, 2, 3, 4+\}} \beta_m^k FHLBYear_{i,t}^m + \gamma^k X_{i,t} + \varepsilon_{i,t}^k$$

estimated with annual observations t from 2012 to 2022 and subportfolios $k \in \{i, ii\}$ (which correspond to the liquid and illiquid subportfolio). Source: Own illustration.

has an even stronger lasting effect on insurer portfolios in the direction predicted by our initial analysis, with life insurers on average reducing allocations towards the liquid subportfolio by about -3.7% and increasing allocations towards the the illiquid portfolio by about 4.1% in the long run after they become a member of the FHLB system.

Table II.3: Lead- and Lag-regression results per subportfolio.

	<i>Dependent variable:</i>			
	Liquid (1)	Illiquid (2)	Housing (3)	Other (4)
FHLB Mem. Year (-3)	0.003 (0.009)	-0.004 (0.011)	0.007 (0.007)	-0.006*** (0.002)
FHLB Mem. Year (-2)	-0.008 (0.014)	0.005 (0.014)	0.010* (0.006)	-0.007** (0.003)
FHLB Mem. Year (-1)	-0.016 (0.013)	0.017* (0.010)	0.007 (0.007)	-0.008*** (0.003)
FHLB Mem. Year	-0.034** (0.014)	0.031*** (0.012)	0.009 (0.008)	-0.006* (0.003)
FHLB Mem. Year (1)	-0.038** (0.016)	0.040*** (0.013)	0.002 (0.009)	-0.004 (0.006)
FHLB Mem. Year (2)	-0.031** (0.014)	0.040*** (0.012)	0.0003 (0.009)	-0.008** (0.004)
FHLB Mem. Year (3)	-0.042*** (0.014)	0.043*** (0.011)	0.006 (0.010)	-0.007* (0.003)
FHLB Mem. Year (4+)	-0.037** (0.016)	0.041*** (0.013)	0.004 (0.011)	-0.008** (0.004)
Covariates	Yes	Yes	Yes	Yes
Firm-Year FE	Yes	Yes	Yes	Yes
Firm-Year Clustered SE	Yes	Yes	Yes	Yes
Observations	4,779	4,779	4,779	4,779

Note: This Table reports the estimates of model

$$PortWeight_{i,t}^k = \alpha_i^k + \tau_t^k + \sum_{m \in \{-3, -2, \dots, 2, 3, 4+\}} \beta_m^k FHLBYear_{i,t}^m + \gamma^k X_{i,t} + \varepsilon_{i,t}^k$$

for annual observations t from 2012 to 2022 and subportfolios $k \in \{i, ii, iii, iv\}$. Firm-year clustered standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1 ; ** : p -value < 0.05 ; *** : p -value < 0.01 .

5.3 FHLB Membership and Subcategory Weights

To explore the underlying dynamics behind the effects we identified in the previous subsections, we also run more granular regressions of form

$$CatWeight_{i,t}^j = \alpha_i^j + \tau_t^j + \beta^j FHLB_{i,t} + \gamma^j X_{i,t} + \varepsilon_{i,t}^j \quad (II.32)$$

for categories $j \in \{1, \dots, 11\}$ and the same set of control variables.

Tables II.4, II.5, and II.6 reports the results of estimating equations II.32 per subportfolio, which present a more granular picture of the effects estimated in Table II.2.

In Table II.4 we see that in the liquid portfolio the allocation to all asset types is reduced after becoming a FHLB member, although none of the estimated coefficients are significantly different from zero. Together with the significant negative coefficient for the effect of FHLB membership on the liquid subportfolio reported in Table II.2, this indicates that life insurers decrease their allocation across all liquid asset classes at no fixed proportion, with some firms preferring to reduce cash or government bonds, others to reduce corporate bonds or stocks.

The results reported in Table II.5 show that the increased allocation towards the illiquid portfolio post-FHLB membership reported in Table II.2 mainly flows towards Non-Residential Mortgages, ABS, and Long-Term Investments (which include hedge funds and private equity partnerships).

Table II.6 disentangles the only moderate effect of FHLB membership on the allocation towards the housing subportfolio. We see that the effect for RMBS and individual Mortgages run in opposite directions (albeit not at a significant level for RMBS), which indicates that insurers significantly shift their portfolio towards individual Residential Mortgages as a consequence of FHLB membership, but that this effect on the Housing subportfolio is negated by a commensurate reduction in the allocation towards RMBS. This indicates that the FHLB is partially successful in its mission, as the increased liquidity of individual Residential Mortgages due to FHLB advances may contribute to making them a more appealing substitute for RMBS, whose weaknesses were demonstrated during the global financial crisis.

Just as for subportfolios, Appendix B.2 provides evidence that the same effects can again be found in the subsamples of both large firms with assets greater than \$1 billion and small firms with assets between \$1 billion and \$100 million.

Table II.4: Regression results for subcategories falling under the liquid subportfolio.

	<i>Dependent variable:</i>			
	Cash (1)	Gov. Bonds (2)	Corp. Bonds (3)	Stocks (4)
FHLB Membership	−0.003 (0.005)	−0.009 (0.010)	−0.015 (0.011)	−0.004 (0.004)
Annuity Share	−0.030*** (0.010)	−0.020 (0.013)	0.006 (0.013)	0.003 (0.004)
Log Size	0.014 (0.017)	−0.021 (0.018)	−0.058** (0.024)	−0.008 (0.008)
CAL RBC Ratio	0.0004** (0.0002)	0.0002 (0.0003)	−0.0004 (0.0003)	−0.0001** (0.0001)
Leverage	−0.012 (0.060)	0.078 (0.051)	−0.120* (0.066)	0.074** (0.031)
Firm-Year FE	Yes	Yes	Yes	Yes
Firm-Year Clustured SE	Yes	Yes	Yes	Yes
Observations	4,779	4,779	4,779	4,779

Note: This Table reports the estimates of model

$$CatWeight_{i,t}^j = \alpha_i^j + \tau_t^j + \beta^j FHLB_{i,t} + \gamma^j X_{i,t} + \varepsilon_{i,t}^j$$

for annual observations t from 2012 to 2022 and subcategories $j \in \{1, 2, 3, 4\}$. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1; ** : p -value < 0.05; *** : p -value < 0.01.

Table II.5: Regression results for subcategories falling under the illiquid subportfolio.

	<i>Dependent variable:</i>			
	CMBS (1)	Non-Res. Mortgages (2)	ABS (3)	Long Term (4)
FHLB Membership	0.002 (0.004)	0.013*** (0.003)	0.011** (0.005)	0.007** (0.003)
Annuity Share	0.003 (0.002)	0.006*** (0.002)	0.015*** (0.005)	0.001 (0.002)
Log Size	0.010 (0.007)	0.010* (0.005)	0.045*** (0.012)	0.005 (0.005)
CAL RBC Ratio	-0.00002 (0.00004)	0.0001** (0.00003)	-0.00004 (0.0001)	-0.00002 (0.00002)
Leverage	-0.007 (0.017)	-0.005 (0.012)	0.014 (0.021)	0.005 (0.010)
Firm-Year FE	Yes	Yes	Yes	Yes
Firm-Year Clustured SE	Yes	Yes	Yes	Yes
Observations	4,779	4,779	4,779	4,779

Note: This Table reports the estimates of model

$$CatWeight_{i,t}^j = \alpha_i^j + \tau_t^j + \beta^j FHLB_{i,t} + \gamma^j X_{i,t} + \varepsilon_{i,t}^j$$

for annual observations t from 2012 to 2022 and subcategories $j \in \{5, 6, 7, 10\}$. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1 ; ** : p -value < 0.05 ; *** : p -value < 0.01 .

Table II.6: Regression results for subcategories falling under the housing subportfolio.

	<i>Dependent variable:</i>	
	RMBS (1)	Res. Mortgages (2)
FHLB Membership	−0.009 (0.006)	0.008*** (0.003)
Annuity Share	0.003 (0.003)	0.007*** (0.002)
Log Size	−0.023** (0.010)	0.029*** (0.009)
CAL RBC Ratio	−0.0001 (0.0001)	0.0001** (0.00003)
Leverage	−0.042* (0.023)	−0.001 (0.010)
Firm-Year FE	Yes	Yes
Firm-Year Clustured SE	Yes	Yes
Observations	4,779	4,779

Note: This Table reports the estimates of model

$$CatWeight_{i,t}^j = \alpha_i^j + \tau_t^j + \beta^j FHLB_{i,t} + \gamma^j X_{i,t} + \varepsilon_{i,t}^j$$

for annual observations t from 2012 to 2022 and subcategories $j \in \{8, 9\}$. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1 ; ** : p -value < 0.05 ; *** : p -value < 0.01 .

6 Discussion

Interpreting our results, we see that they generally confirm Proposition 1, as FHLB members indeed shift greater portions of their portfolios towards illiquid assets, which provides empirical evidence for the economic mechanism we outlined in our model. As the opportunity cost of holding liquid assets is higher than that of securing FHLB advances against illiquid assets, this indicates that FHLB members reduce their liquid asset holdings ex-ante as they anticipate to instead use FHLB advances to manage any short-term liquidity needs.

Surprisingly, life insurers increase their allocation towards non-housing illiquid assets at much greater certainty and magnitude as their housing portfolio post-membership, even though the former is the only asset class directly benefiting from the liquidity relief provided by FHLB advances. This indicates that life insurers may use the fungible liquidity provided by the opportunity to take out advances to take greater positions in non-housing related illiquid assets.

Asset types falling into the illiquid category include CMBS, hedge funds, private equity shares, and ABS such as tranches of Collateralized Debt Obligations backed by consumer or leveraged loans. Especially the latter, also known as Collateralized Loan Obligations (CLOs), have taken on a more prominent role in insurer's asset portfolios over the last decade (Fringuelli and Santos, 2021). Kirti and Sarin (2023) show that this effect is especially pronounced for life insurers backed by private equity firms, with asset allocations shifted towards illiquid assets such as CLOs in a short time span after the take-over of a life insurer by such a firm. Foley-Fisher et al. (2021) show how life insurers have developed a new business models to source, structure and retain CLOs. This new *triangular setup* between a US life insurer, an offshore reinsurer, and an affiliated asset manager allows life insurers to not only reduce the fees and adverse selection issues commonly encountered in the structured credit market, but also to exploit avenues for regulatory arbitrage between different jurisdictions.

The implicit government-sponsored support of this new business model via FHLB advances poses interesting questions for policymakers and regulators. As the name suggests, the FHLB was originally founded with the mission to ease lending for residential real estate by providing liquidity to mortgage lenders in times of stress. However, the current system allows FHLB members that are not necessarily primary mortgage lenders to use FHLB advances to generate funds for investments that are not necessarily related to residential real estate.

7 Conclusion

In this paper, we show that FHLB membership has incentivized life insurers to invest greater portions of their portfolios towards illiquid assets. Life insurers' role as natural asset owners of illiquid long-term debt has recently come into the focus of policymakers and academics, with ongoing discussions on how this natural advantage can be used to benefit financial markets overall (Chodorow-Reich et al., 2021; Coppola, 2021; Knox and Sørensen, 2023). We provide evidence that for U.S. life insurers this effect is not only driven by the structure of liabilities stemming from the underlying business model, but also by an implicit public subsidy for illiquid assets provided by the government-sponsored FHLB.

We find that after becoming an FHLB member, U.S. life insurers on average shift about 3% of their general account assets from a more conventional liquid portfolio into illiquid assets (albeit non-housing-related). Our results show that a large proportion of the post-membership re-allocations towards illiquid assets go towards Non-Residential Mortgages, hedge funds, private equity partnerships and non-housing-related asset-backed securities. We do not find a significant change towards housing-related assets overall in response to becoming a FHLB member. Between housing-related assets, we find that life insurers significantly reduce their holdings of RMBS to the benefit of individual housing-related mortgages. This effect may be due to the liquidity-relief provided by the FHLB allowing individual Residential Mortgages to function as a viable substitute for RMBS, thereby partially fulfilling the original mandate of the FHLB, which was conceptualized before the advent of securitized structured finance to the housing market.

Given the original public mandate of the FHLB to cheapen housing costs, which is indirectly financed by the U.S. government via an implicit guarantee for the FHLB system, the question whether this indirect subsidization of other illiquid assets is a desirable outcome of the FHLB system should be a topic of further discussion. Future research could focus on the distributional effects of the FHLB system, analyzing to what degree the public subsidy provided by the implicit guarantee is passed on to the policyholders or shareholders of life insurance companies who are members. Further research measuring the price impact of the decreased demand for liquid assets and the increased demand for illiquid assets from life insurers who are also FHLB members could also generate further insights into the distributional effects of the current FHLB system.

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A Proofs

The following proofs only consider cases in which $\alpha \neq 1$ to ease exposition. However, all proofs can easily be extended to cases in which $u(c) = \ln(c)$ following the logic shown below.

A.1 Theorem 1

It is easy to show that the agent will solve the maximization problem

$$\max_{\theta} \mathcal{L} = u(\theta) + (1 - \kappa)u((1 - \theta)R) \quad (\text{II.A.1})$$

to maximize her consumption.

Taking the first derivative of this equation with regard to θ and setting it to zero yields

$$\frac{\partial \mathcal{L}}{\partial \theta} = u'(\theta^*) - R(1 - \kappa)u'((1 - \theta^*)R) \stackrel{!}{=} 0 \quad (\text{II.A.2})$$

which for the CRRA utility function given in equation II.1 implies

$$\theta^* = \frac{R^{\frac{\alpha-1}{\alpha}}}{(1 - \kappa)^{\frac{1}{\alpha}} + R^{\frac{\alpha-1}{\alpha}}}, \quad (\text{II.A.3})$$

which is evidently greater than zero and smaller than one.

The optimal consumption path is then given by

$$c_1^* = \theta^* = \frac{R^{\frac{\alpha-1}{\alpha}}}{(1 - \kappa)^{\frac{1}{\alpha}} + R^{\frac{\alpha-1}{\alpha}}}, \quad (\text{II.A.4})$$

and

$$c_2^* = (1 - \theta^*)R = \frac{(1 - \kappa)^{\frac{1}{\alpha}} R}{(1 - \kappa)^{\frac{1}{\alpha}} + R^{\frac{\alpha-1}{\alpha}}} \quad (\text{II.A.5})$$

A.2 Theorem 2

By incorporating constraints two and three we can simplify the optimization problem to

$$\max_{\theta^A} \mathcal{L} = u(\theta^A) + (1 - \kappa)u\left(\frac{(1 - \theta^A)R}{1 - \kappa}\right). \quad (\text{II.A.6})$$

Taking the first order condition and setting it equal to zero yields

$$\frac{\partial \mathcal{L}}{\partial \theta^A} = u'(\theta^{A*}) - Ru'\left(\frac{(1 - \theta^{A*})R}{1 - \kappa}\right) \stackrel{!}{=} 0 \quad (\text{II.A.7})$$

which for the CRRA utility function given in equation II.1 can be rearranged to yield

$$\theta^{A*} = \frac{R^{\frac{\alpha-1}{\alpha}}}{(1 - \kappa) + R^{\frac{\alpha-1}{\alpha}}}, \quad (\text{II.A.8})$$

a term again evidently greater than zero and smaller than one. The optimal allocation θ^{A*} results in annuity benefits

$$c_1^{A*} = \theta^* = \frac{R^{\frac{\alpha-1}{\alpha}}}{(1 - \kappa) + R^{\frac{\alpha-1}{\alpha}}} \quad (\text{II.A.9})$$

and

$$c_2^{A*} = \frac{(1 - \theta^*)R}{1 - \kappa} = \frac{R}{(1 - \kappa) + R^{\frac{\alpha-1}{\alpha}}}. \quad (\text{II.A.10})$$

A.3 Theorem 3

As for $\alpha > 1$ and $\kappa \in (0, 1)$ it is true that $1 > (1 - \kappa)^{\frac{1}{\alpha}} > (1 - \kappa)$, we see that

$$c_1^{A*} = \frac{R^{\frac{\alpha-1}{\alpha}}}{(1 - \kappa) + R^{\frac{\alpha-1}{\alpha}}} > \frac{R^{\frac{\alpha-1}{\alpha}}}{(1 - \kappa)^{\frac{1}{\alpha}} + R^{\frac{\alpha-1}{\alpha}}} = c_1^* \quad (\text{II.A.11})$$

and

$$c_2^{A*} = \frac{R}{(1 - \kappa) + R^{\frac{\alpha-1}{\alpha}}} > \frac{R}{(1 - \kappa)^{\frac{1}{\alpha}} + R^{\frac{\alpha-1}{\alpha}}} > \frac{(1 - \kappa)^{\frac{1}{\alpha}} R}{(1 - \kappa)^{\frac{1}{\alpha}} + R^{\frac{\alpha-1}{\alpha}}} = c_2^* \quad (\text{II.A.12})$$

such that $U(C_{Annuity}^*) > U(C^*)$ for the expected utility given in equation II.2.

A.4 Theorem 4

We again simplify the optimization problem to

$$\max_{\theta^{FHLB}, z^{FHLB}} \mathcal{L} = u(\theta^{FHLB} + z^{FHLB}) + (1 - \kappa)u\left(\frac{(1 - \theta^{FHLB})R - z^{FHLB}(1 + r)}{1 - \kappa}\right). \quad (\text{II.A.13})$$

Taking first order condition with regard to θ^{FHLB} we get

$$\frac{\partial \mathcal{L}}{\partial \theta^{FHLB}} = u'(\theta^{FHLB} + z^{FHLB}) - Ru'\left(\frac{(1 - \theta^{FHLB})R - z^{FHLB}(1 + r)}{1 - \kappa}\right) \quad (\text{II.A.14})$$

The same first order condition with regard to z^{FHLB} yields

$$\frac{\partial \mathcal{L}}{\partial z^{FHLB}} = u'(\theta^{FHLB} + z^{FHLB}) - (1 + r)u'\left(\frac{(1 - \theta^{FHLB})R - z^{FHLB}(1 + r)}{1 - \kappa}\right) \quad (\text{II.A.15})$$

From these first order conditions, we see that the opportunity cost of increasing consumption in $t = 1$ via the liquid asset θ^{FHLB} is always greater than sourcing it via advances z^{FHLB} , as $(1 + r) < R$, which is why the life insurer would always prefer this option if it is available.

We proceed by first assuming that the restriction $z^{FHLB} < \phi(1 - \theta^{FHLB})$ is not binding. In this case, the insurer would optimize c_1^{FHLB} via z^{FHLB} and choose $\theta^{FHLB*} = 0$, such that the first order condition with regard to z^{FHLB} would be

$$\frac{\partial \mathcal{L}}{\partial z^{FHLB}} = u'(z^{FHLB*}) - (1 + r)u'\left(\frac{R - z^{FHLB*}(1 + r)}{1 - \kappa}\right) \stackrel{!}{=} 0, \quad (\text{II.A.16})$$

which, for the CRRA utility function given in equation II.1, implies

$$z^{FHLB*} = \frac{R(1 + r)^{\frac{-1}{\alpha}}}{(1 - \kappa) + (1 + r)^{\frac{\alpha-1}{\alpha}}}, \quad (\text{II.A.17})$$

a term contained in $[0, \phi(1 - \theta^{FHLB})]$ by assumption. Optimal choices θ^{FHLB*} and z^{FHLB*} yield

$$c_1^{FHLB*} = \theta^{FHLB*} + z^{FHLB*} = \frac{R(1 + r)^{\frac{-1}{\alpha}}}{(1 - \kappa) + (1 + r)^{\frac{\alpha-1}{\alpha}}} \quad (\text{II.A.18})$$

and

$$c_2^{FHLB*} = \frac{(1 - \theta^{FHLB*})R - z^{FHLB*}(1 + r)}{1 - \kappa} = \frac{R}{(1 - \kappa) + (1 + r)^{\frac{\alpha-1}{\alpha}}}. \quad (\text{II.A.19})$$

Now let us assume that the upper restriction on advances is binding, which is the case if $\frac{R(1+r)^{\frac{-1}{\alpha}}}{(1-\kappa)+(1+r)^{\frac{\alpha-1}{\alpha}}} \geq \phi$, such that $z^{FHLB} = \phi(1 - \theta^{FHLB})$. In this case the binding first order condition is the one with regard to θ^{FHLB} , which changes to

$$\frac{\partial \mathcal{L}}{\partial \theta^{FHLB}} = u'(\phi + (1 - \phi)\theta^{FHLB}) - Ru'(\frac{(1 - \theta^{FHLB})(R - \phi(1 + r))}{1 - \kappa}) \stackrel{!}{=} 0 \quad (\text{II.A.20})$$

which, for the CRRA utility function given in equation II.1, implies

$$\theta^{FHLB*} = \frac{R^{\frac{1}{\alpha}}(R - \phi(1 + r)) - (1 - \kappa)\phi}{R^{\frac{1}{\alpha}}(R - \phi(1 + r)) + (1 - \kappa)(1 - \phi)} \quad (\text{II.A.21})$$

and

$$z^{FHLB*} = \frac{(1 - \kappa)(1 - \phi)}{R^{\frac{1}{\alpha}}(R - \phi(1 + r)) + (1 - \kappa)(1 - \phi)}. \quad (\text{II.A.22})$$

This yields the optimal consumption path

$$c_1^{FHLB*} = \theta^{FHLB*} + z^{FHLB*} = \frac{R^{\frac{1}{\alpha}}(R - \phi(1 + r))}{R^{\frac{1}{\alpha}}(R - \phi(1 + r)) + (1 - \kappa)(1 - \phi)} \quad (\text{II.A.23})$$

and

$$c_2^{FHLB*} = \frac{(1 - \theta^{FHLB*})R - z^{FHLB*}(1 + r)}{1 - \kappa} = \frac{R - \phi(1 + r)}{R^{\frac{1}{\alpha}}(R - \phi(1 + r)) + (1 - \kappa)(1 - \phi)}. \quad (\text{II.A.24})$$

A.5 Proposition 1

We want to show that $\theta^{FHLB*} < \theta^{A*}$. Note that this is trivially the case if $\frac{R(1+r)^{\frac{-1}{\alpha}}}{(1-\kappa)+(1+r)^{\frac{\alpha-1}{\alpha}}} < \phi$, as in this case

$$\theta^{FHLB*} = 0 \quad (\text{II.A.25})$$

and

$$\theta^{A*} = \frac{R^{\frac{\alpha-1}{\alpha}}}{(1-\kappa) + R^{\frac{\alpha-1}{\alpha}}} > 0. \quad (\text{II.A.26})$$

If $\frac{R(1+r)^{\frac{-1}{\alpha}}}{(1-\kappa)+(1+r)^{\frac{\alpha-1}{\alpha}}} \geq \phi$, we see that

$$\theta^{FHLB*} = \frac{R^{\frac{1}{-\alpha}}(R - \phi(1+r)) - (1-\kappa)\phi}{R^{\frac{1}{-\alpha}}(R - \phi(1+r)) + (1-\kappa)(1-\phi)} < \frac{R^{\frac{1}{-\alpha}}(R - \phi(1+r))}{R^{\frac{1}{-\alpha}}(R - \phi(1+r)) + (1-\kappa)} \quad (\text{II.A.27})$$

for $\phi > 0$. As $R^{\frac{\alpha-1}{\alpha}} > R^{\frac{1}{-\alpha}}(R - \phi(1+r))$, it follows that

$$\theta^{FHLB*} < \frac{R^{\frac{1}{-\alpha}}(R - \phi(1+r))}{R^{\frac{1}{-\alpha}}(R - \phi(1+r)) + (1-\kappa)} < \frac{R^{\frac{\alpha-1}{\alpha}}}{(1-\kappa) + R^{\frac{\alpha-1}{\alpha}}} = \theta^{A*}, \quad (\text{II.A.28})$$

which concludes our proof.

B Robustness Checks

B.1 Propensity Score Matching

As life insurers in our sample self-select into being FHLB members, it is apparent that there might be covariates affecting both the decision to become a member and subportfolio weights. Our original analysis attempts to account for this by controlling for firm fixed effects and common time trends, as well as a select list of time-varying covariates at a firm level. However, as the latter list can never be fully complete, some concerns may remain regarding the validity of our results.

An alternative approach developed in the literature on causal analysis to approximate the effect of a randomized treatment is that of *propensity score matching* (PSM), introduced to the literature on causal effects by Rosenbaum and Rubin (1983). On a high level, PSM attempts to replicate a randomized treatment by matching each treated observation to an untreated observation in the sample based on a *propensity score* estimating the likelihood of receiving treatment (in our case becoming a FHLB member). A new sample is then created consisting solely of these matched pairs, with which the original analysis is re-run.

Matching Algorithm

To match life insurers in our sample, we only consider firms that were not FHLB members in 2012.¹¹ Out of this subset of firms, we match future FHLB members, which we mark as the treated group, to counterparts that do not become FHLB members until 2022, which we mark as the untreated group. We formalize this intuition in a treatment variable assigned at a firm level as

$$Treated_i = \mathbf{1}_{\{\sum_t FHLB_{i,t} \neq 0\}} \quad (\text{II.B.1})$$

We estimate the propensity score $\pi^i = \mathbb{P}(Treated_i = 1)$ by

$$\pi^i = \frac{1}{1 + \exp(-\beta X_{i,2012})} \quad (\text{II.B.2})$$

with $X_{i,2012}$ denoting the matrix of covariates as defined for our original regression equations for year 2012. We calculate estimates of the coefficients

¹¹Note that seven firms in our sample were not active in 2012 such that they are also missing from the subsequent analysis.

in this equation, $\hat{\beta}$, via maximum likelihood estimation, which we plug back into the equation to get estimated propensity scores $\hat{\pi}^i$ for each firm in our sample.

We choose greedy nearest neighbour matching on the difference in estimated propensity scores $\hat{\pi}^i$ as our matching algorithm, which pairs firm i with firm j that solves

$$\min_{j \in J} |\hat{\pi}^i - \hat{\pi}^j|, \quad (\text{II.B.3})$$

with J denoting the set of all non-treated firms in our sample (i.e., all firms i for which $Treated_i = 0$). We choose this combination of a propensity score based on logistic regression and greedy nearest neighbour matching as it seems to be the most popular choice in the relevant literature (Thoemmes and Kim, 2011; Zakrisson et al., 2018)

We use this method to find matches for the 101 treated firms in our original sample, such that our final matched sample consists of 202 firms for which we again have annual data from 2012 to 2022.

Empirical Results for Matched Data

Table II.B.1 reports summary statistics on both our original sample and our matched sample for year 2012. We see that there are strong differences between (prospective) FHLB members and non-members in the original sample. FHLB members are on average (i) significantly more invested in illiquid assets at the expense of liquid assets in the liquid portfolio, (ii) larger, (iii) less capitalized and (iv) more leveraged than non-members. These differences mostly disappear in our matched sample, with prospective FHLB members being on average only slightly more invested in illiquid assets at the expense of liquid/liquid assets than their matched counterparts.

Table II.B.2 shows the result of re-running our original analysis with the matched sample. We see that the estimated effect of FHLB membership is still significant and in the same order of magnitude as in the original analysis (see Table II.2). This result supports our original empirical approach and indicates that the main result we find in it is robust towards the effect of unobserved covariates.

Table II.B.1: Summary Statistics of the Original and Matched Samples in 2012.

	Original Sample			Matched Sample		
	FHLB Mem.	Non-Mem.	Diff.	FHLB Mem.	Non-Mem.	Diff.
Category Weights						
Cash	0.05	0.09	-0.04***	0.06	0.07	-0.01
Gov. Bonds	0.12	0.17	-0.05***	0.15	0.15	0.00
Corp. Bonds	0.48	0.46	0.02	0.48	0.49	-0.01
Stocks	0.04	0.07	-0.03**	0.04	0.07	-0.03*
ABS	0.05	0.03	0.02***	0.04	0.03	0.01*
Long-Term	0.02	0.01	0.01***	0.02	0.01	0.01
CMBS	0.04	0.03	0.01***	0.04	0.04	0.00
RMBS	0.10	0.09	0.02*	0.10	0.09	0.01
Non-Res. Mortgages	0.05	0.02	0.04***	0.04	0.03	0.01
Res. Mortgages	0.01	0.01	0.01***	0.01	0.01	0.00
Misc.	0.02	0.01	0.00**	0.02	0.01	0.00
Subportfolio Weights						
Liquid	0.70	0.80	-0.10***	0.73	0.78	-0.05**
Illiquid	0.17	0.10	0.07***	0.14	0.11	0.03**
Housing	0.12	0.09	0.02***	0.11	0.10	0.01
Other	0.02	0.01	0.00**	0.02	0.01	0.00
Ann. Share	0.00	0.00	0.00	0.00	0.00	0.00
Log Size (in \$bn.)	22.05	20.27	1.78***	21.55	21.38	0.18
CAL RBC	5.57	10.96	-5.38**	6.34	7.02	-0.68
Leverage	0.13	0.24	-0.11***	0.16	0.17	-0.01
N	262	195		101	101	

Note: This Table reports mean values on the asset allocation, FHLB membership, and other financial variables as reported in 2012 for life insurers in the original sample and matched sample. Both samples are split by (prospective) FHLB membership with the differences between both reported in a separate column. The statistical significance of these differences is assessed with two-sided *t*-tests, with the following notation for statistical significance: * : *p*-value < 0.1; ** : *p*-value < 0.05; *** : *p*-value < 0.01. Note that portfolio weights may not sum up to one and differences in mean values may be over- or underreported due to rounding errors. Source: FHFA and Statutory Filings accessed via S&P Capital Intelligence.

Table II.B.2: Regression Results per Subportfolio, Matched Firms.

	<i>Dependent variable:</i>			
	Liquid (1)	Illiquid (2)	Housing (3)	Other (4)
FHLB Membership	−0.024** (0.011)	0.028*** (0.008)	−0.006 (0.007)	0.001 (0.002)
Annuity Share	−0.035** (0.015)	0.030** (0.012)	0.005 (0.007)	0.0003 (0.003)
Log Size	−0.066** (0.031)	0.054** (0.024)	0.008 (0.021)	0.004 (0.005)
CAL RBC Ratio	0.003*** (0.001)	0.0001 (0.001)	−0.003*** (0.001)	−0.0001 (0.0001)
Leverage	0.110 (0.073)	−0.052 (0.052)	−0.059 (0.043)	0.002 (0.011)
Firm-Year FE	Yes	Yes	Yes	Yes
Firm-Year Clustured SE	Yes	Yes	Yes	Yes
Observations	2,114	2,114	2,114	2,114

Note: This Table reports the estimates of model

$$PortWeight_{i,t}^k = \alpha_i^k + \tau_t^k + \beta^k FHLB_{i,t} + \gamma^k X_{i,t} + \varepsilon_{i,t}^k$$

over the propensity-score matched sample for annual observations t from 2012 to 2022 and subportfolios $k \in \{i, ii, iii, iv\}$. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1; ** : p -value < 0.05; *** : p -value < 0.01.

B.2 Large and Small Firms

In this subsection we test the robustness of our main result towards firm size. To do so, we split our in two based on the size of the balance sheet, with life insurers larger or equal to \$1 billion being classified as *large firms* and those below as *small firms*. Our cutoff points roughly splits our sample in two equal halves, with 56% of the firms in are sample beinf large firms and the remaining 44% small firms.

We see in Tables II.B.3 and II.B.7 that both small and large life insurers significantly shift their investments from liquid towards illiquid assets as FHLB members, the main effect we identify in this paper. However, we also see that small firms do so to a greater extent: on average, small firms decrease their liquid asset share by 6.5% opposed to large firms' decrease by 1.9%, and increase their illiquid asset share by 4.6% opposed to large firms' increase of 2.9% (the residual between both figures for a firm type can be attributed to the residential housing and other subportfolios). This difference in effect size may be traced back to alternative funding opportunities available to life insurers of different sizes. Large firms may be able to source liquidity via other types of short-term debt, such as lines of credit from large banks or Funding Agreement-Backed Securites or Notes (FABs or FABNs). In comparison, smaller firms may not have as easy access to these funding opportunities (or if they do, only at more unfavorable conditions), due to their lower credit quality or weaker integration into the financial system. As these substitutes for FHLB advances are therefore not as available to small firms, the option to take them out would be more valuable, such that they show a stronger response to becoming a FHLB member.

Within the illiquid portfolios, we also see a significant difference in the subcategories both firm types allocate these asset volumes to post-membership (see Tables II.B.5 and II.B.9). Large firms tend to allocate more towards Non-Residential mortgages, whereas small firms allocate towards ABS and and Long-Term investments. We also find differences in the housing portfolio, with large firms partially substituting a significant 1.4% reduction in RMBS with a 0.7% individual residential mortgages, an effect not found for small firms.

Empirical Results - Large Firms

Table II.B.3: Regression results per subportfolio, large firms.

	<i>Dependent variable:</i>			
	Liquid (1)	Illiquid (2)	Housing (3)	Other (4)
FHLB Membership	−0.017* (0.010)	0.027*** (0.009)	−0.008 (0.006)	−0.002 (0.002)
Annuity Share	−0.009 (0.014)	0.012 (0.010)	−0.002 (0.008)	−0.001 (0.003)
Log Size	−0.062*** (0.023)	0.050*** (0.018)	0.010 (0.015)	0.003 (0.007)
CAL RBC Ratio	−0.0004 (0.0004)	0.001*** (0.0002)	0.0005* (0.0003)	−0.001*** (0.0001)
Leverage	0.360*** (0.120)	−0.110* (0.062)	−0.260*** (0.093)	0.014 (0.016)
Firm-Year FE	Yes	Yes	Yes	Yes
Firm-Year Clustured SE	Yes	Yes	Yes	Yes
Observations	2,724	2,724	2,724	2,724

Note: This Table reports the estimates of model

$$PortWeight_{i,t}^k = \alpha_i^k + \tau_t^k + \beta^k FHLB_{i,t} + \gamma^k X_{i,t} + \varepsilon_{i,t}^k$$

for annual observations t from 2012 to 2022 and subportfolios $k \in \{i, ii, iii, iv\}$ for large life insurance firms with assets greater than \$1 billion. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1; ** : p -value < 0.05; *** : p -value < 0.01.

Table II.B.4: Regression results for subcategories falling under the liquid subportfolio, large firms.

	<i>Dependent variable:</i>			
	Cash (1)	Gov. Bonds (2)	Corp. Bonds (3)	Stocks (4)
FHLB Membership	−0.002 (0.005)	−0.004 (0.009)	−0.005 (0.011)	−0.005 (0.004)
Annuity Share	−0.016* (0.009)	−0.014 (0.017)	0.007 (0.015)	0.013 (0.008)
Log Size	0.007 (0.014)	−0.012 (0.015)	−0.058*** (0.022)	0.001 (0.008)
CAL RBC Ratio	0.001** (0.0005)	−0.001 (0.001)	0.001 (0.0004)	−0.001** (0.001)
Leverage	0.120 (0.071)	0.054 (0.170)	−0.170* (0.093)	0.360*** (0.093)
Firm-Year FE	Yes	Yes	Yes	Yes
Firm-Year Clustured SE	Yes	Yes	Yes	Yes
Observations	2,724	2,724	2,724	2,724

Note: This Table reports the estimates of model

$$CatWeight_{i,t}^j = \alpha_i^j + \tau_t^j + \beta^j FHLB_{i,t} + \gamma^j X_{i,t} + \varepsilon_{i,t}^j$$

for annual observations t from 2012 to 2022 and subcategories $j \in \{1, 2, 3, 4\}$ for large life insurance firms with assets greater than \$1 billion. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1; ** : p -value < 0.05; *** : p -value < 0.01.

Table II.B.5: Regression results for subcategories falling under the illiquid subportfolio, large firms.

	<i>Dependent variable:</i>			
	CMBS (1)	Non-Res. Mortgages (2)	ABS (3)	Long Term (4)
FHLB Membership	0.002 (0.004)	0.016*** (0.004)	0.008 (0.005)	0.002 (0.003)
Annuity Share	−0.001 (0.003)	0.001 (0.004)	0.015*** (0.005)	−0.002 (0.005)
Log Size	0.001 (0.007)	0.009 (0.008)	0.043*** (0.015)	−0.004 (0.008)
CAL RBC Ratio	0.0001 (0.0001)	0.0002** (0.0001)	0.0005*** (0.0001)	−0.0002 (0.0001)
Leverage	−0.046* (0.024)	−0.080** (0.033)	−0.004 (0.029)	0.020 (0.029)
Firm-Year FE	Yes	Yes	Yes	Yes
Firm-Year Clustured SE	Yes	Yes	Yes	Yes
Observations	2,724	2,724	2,724	2,724

Note: This Table reports the estimates of model

$$CatWeight_{i,t}^j = \alpha_i^j + \tau_t^j + \beta^j FHLB_{i,t} + \gamma^j X_{i,t} + \varepsilon_{i,t}^j$$

for annual observations t from 2012 to 2022 and subcategories $j \in \{5, 6, 7, 10\}$ for large life insurance firms with assets greater than \$1 billion. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1; ** : p -value < 0.05; *** : p -value < 0.01.

Table II.B.6: Regression results for subcategories falling under the housing subportfolio, large firms.

	<i>Dependent variable:</i>	
	RMBS (1)	Res. Mortgages (2)
FHLB Membership	−0.015*** (0.006)	0.007** (0.003)
Annuity Share	−0.008 (0.007)	0.006** (0.003)
Log Size	−0.015 (0.011)	0.024*** (0.009)
CAL RBC Ratio	0.0002 (0.0002)	0.0003** (0.0001)
Leverage	−0.200*** (0.056)	−0.062 (0.046)
Firm-Year FE	Yes	Yes
Firm-Year Clustured SE	Yes	Yes
Observations	2,724	2,724

Note: This Table reports the estimates of model

$$CatWeight_{i,t}^j = \alpha_i^j + \tau_t^j + \beta^j FHLB_{i,t} + \gamma^j X_{i,t} + \varepsilon_{i,t}^j$$

for annual observations t from 2012 to 2022 and subcategories $j \in \{8, 9\}$ for large life insurance firms with assets greater than \$1 billion. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1; ** : p -value < 0.05; *** : p -value < 0.01.

Empirical Results - Small Firms

Table II.B.7: Regression results per subportfolio, small firms.

	<i>Dependent variable:</i>			
	Liquid (1)	Illiquid (2)	Housing (3)	Other (4)
FHLB Membership	−0.066*** (0.019)	0.046*** (0.015)	0.015 (0.013)	0.005 (0.008)
Annuity Share	−0.055*** (0.010)	0.038*** (0.010)	0.013*** (0.004)	0.004 (0.003)
Log Size	−0.100*** (0.032)	0.099*** (0.027)	0.007 (0.021)	−0.001 (0.005)
CAL RBC Ratio	0.0001 (0.0002)	−0.0001 (0.0002)	−0.00003 (0.0001)	−0.00000 (0.00001)
Leverage	−0.069 (0.043)	0.044 (0.034)	0.006 (0.022)	0.018 (0.011)
Firm-Year FE	Yes	Yes	Yes	Yes
Firm-Year Clustured SE	Yes	Yes	Yes	Yes
Observations	2,055	2,055	2,055	2,055

Note: This Table reports the estimates of model

$$PortWeight_{i,t}^k = \alpha_i^k + \tau_t^k + \beta^k FHLB_{i,t} + \gamma^k X_{i,t} + \varepsilon_{i,t}^k$$

for annual observations t from 2012 to 2022 and subportfolios $k \in \{i, ii, iii, iv\}$ for small life insurance firms with assets between \$1 billion and \$100 million. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1; ** : p -value < 0.05; *** : p -value < 0.01.

Table II.B.8: Regression results for subcategories falling under the liquid subportfolio, small firms.

	<i>Dependent variable:</i>			
	Cash (1)	Gov. Bonds (2)	Corp. Bonds (3)	Stocks (4)
FHLB Membership	−0.009 (0.012)	−0.031 (0.027)	−0.030 (0.030)	0.004 (0.007)
Annuity Share	−0.030** (0.013)	−0.040*** (0.013)	0.012 (0.020)	0.003 (0.005)
Log Size	0.019 (0.032)	−0.037 (0.033)	−0.061 (0.054)	−0.025 (0.016)
CAL RBC Ratio	0.0004 (0.0002)	0.0004 (0.0003)	−0.001** (0.0003)	−0.00005 (0.00005)
Leverage	−0.046 (0.075)	0.068 (0.058)	−0.110 (0.077)	0.018 (0.027)
Firm-Year FE	Yes	Yes	Yes	Yes
Firm-Year Clustured SE	Yes	Yes	Yes	Yes
Observations	2,055	2,055	2,055	2,055

Note: This Table reports the estimates of model

$$CatWeight_{i,t}^j = \alpha_i^j + \tau_t^j + \beta^j FHLB_{i,t} + \gamma^j X_{i,t} + \varepsilon_{i,t}^j$$

for annual observations t from 2012 to 2022 and subcategories $j \in \{1, 2, 3, 4\}$ for small life insurance firms with assets between \$1 billion and \$100 million. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1; ** : p -value < 0.05; *** : p -value < 0.01.

Table II.B.9: Regression results for subcategories falling under the illiquid subportfolio, small firms.

	<i>Dependent variable:</i>			
	CMBS (1)	Non-Res. Mortgages (2)	ABS (3)	Long Term (4)
FHLB Membership	0.006 (0.009)	0.002 (0.004)	0.022* (0.012)	0.016** (0.006)
Annuity Share	0.006* (0.003)	0.007*** (0.002)	0.020*** (0.007)	0.004** (0.002)
Log Size	0.027** (0.013)	0.009* (0.006)	0.047*** (0.018)	0.016** (0.007)
CAL RBC Ratio	−0.00002 (0.00004)	0.00004** (0.00002)	−0.0001 (0.0001)	0.00001 (0.00001)
Leverage	0.004 (0.020)	0.012 (0.013)	0.021 (0.026)	0.008 (0.009)
Firm-Year FE	Yes	Yes	Yes	Yes
Firm-Year Clustured SE	Yes	Yes	Yes	Yes
Observations	2,055	2,055	2,055	2,055

Note: This Table reports the estimates of model

$$CatWeight_{i,t}^j = \alpha_i^j + \tau_t^j + \beta^j FHLB_{i,t} + \gamma^j X_{i,t} + \varepsilon_{i,t}^j$$

for annual observations t from 2012 to 2022 and subcategories $j \in \{5, 6, 7, 10\}$ for small life insurance firms with assets between \$1 billion and \$100 million. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1; ** : p -value < 0.05; *** : p -value < 0.01.

Table II.B.10: Regression results for subcategories falling under the housing subportfolio, small firms.

	<i>Dependent variable:</i>	
	RMBS (1)	Res. Mortgages (2)
FHLB Membership	0.008 (0.015)	0.006 (0.005)
Annuity Share	0.006** (0.003)	0.007*** (0.002)
Log Size	−0.025* (0.014)	0.033* (0.017)
CAL RBC Ratio	−0.0001 (0.0001)	0.00004** (0.00002)
Leverage	−0.004 (0.022)	0.010* (0.006)
Firm-Year FE	Yes	Yes
Firm-Year Clustured SE	Yes	Yes
Observations	2,055	2,055

Note: This Table reports the estimates of model

$$CatWeight_{i,t}^j = \alpha_i^j + \tau_t^j + \beta^j FHLB_{i,t} + \gamma^j X_{i,t} + \varepsilon_{i,t}^j$$

for annual observations t from 2012 to 2022 and subcategories $j \in \{8, 9\}$ for small life insurance firms with assets between \$1 billion and \$100 million. Firm-year clustured standard errors are reported in paranthesis, the statistical significance of two-sided t -tests against a null hypothesis of zero are indicated as follows: * : p -value < 0.1; ** : p -value < 0.05; *** : p -value < 0.01.