The Effect of QE and Regulation on the Structure of the Financial System*

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Abstract

Insurance companies' ownership share of long-term Euro area government bonds fell by 15 percentage points between 2016 and 2024, despite policy and regulatory forces that should have increased their bond demand. Using confidential EIOPA supervisory data on the universe of Euro area insurers, we show that insurers' long-run bond demand is primarily *liability-driven* rather than driven by active portfolio rebalancing. Both the scale and composition of liabilities matter: net inflows determine the size of insurers' balance sheets, while the products they sell determine how much of those balance sheets is invested in bonds. Low long-term interest rates and risk-based capital regulation reduced inflows and shifted insurers away from products with long-term guarantees, which are backed predominantly by bonds. Our results highlight how, over longer horizons, monetary policy and regulation reshape the financial system not only by changing how intermediaries allocate their portfolios, but by changing the size and composition of intermediaries' liabilities.

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1. Introduction

The life-insurance sector in the European Economic Area (EEA) is one of the largest in the world. At the end of 2025, the value of life-insurance contracts stood at approximately $8.1 trillion, notably exceeding the corresponding value in the United States, which was about $7.4 trillion.[1] Life-insurance policies have historically been the second-largest financial asset held by European households, after deposits. Moreover, life insurers are by far the most important investors in Euro area long-term bonds, in part because much of European private retirement saving is intermediated through life insurers rather than through the pension sector. Understanding their demand for long-dated bonds is therefore central to understanding government financing in the Euro area, and especially so in the current environment, in which long-term yields have reached multi-decade highs and the traditional buyers of long-dated debt are increasingly absent.[2]

In this paper, we use new confidential regulatory data to show that low long-term rates and tighter capital regulation significantly reduced insurers' presence in long-term bond markets, thereby changing the structure of the financial system. Our central finding is that insurers' long-run bond demand is primarily *liability-driven* rather than driven by active portfolio rebalancing. Bond demand depends both on the scale of insurers' liabilities and on their composition: net inflows determine the size of insurers' balance sheets, while the types of products they sell determine how much of those balance sheets is invested in bonds. Long-term interest rates and risk-based capital regulation affected both margins, making products with long-term guarantees less attractive to offer and to buy. Insurers therefore received fewer inflows and shifted away from traditional guaranteed products, substantially reducing their presence in long-term bond markets between 2016 and 2024.

Over short horizons, the literature has documented the importance of insurers' active portfolio rebalancing decisions. Domanski et al. (2017), Koijen and Yogo (2021), Jansen (2023), and Corell et al. (2026) show how both low long-term rates and risk-based capital regulation can induce insurers to rebalance their portfolios *toward* long-term bonds. At short horizons, the size and structure of insurers' liabilities are approximately fixed. Over longer horizons, however, liabilities also adjust. Euro area life insurers have traditionally offered retirement products with minimum long-term guarantees, known as 'profit-participation' products, whose inflows are invested predominantly in long-term bonds. The prolonged low-rate environment and the tightening of solvency regulation, however, made it persistently

[1] For the U.S., we compute these figures using the value of reserves for life-insurance and pension products reported as liabilities of life-insurance companies in the Flow of Funds. Relative to household wealth, the importance of life insurance in Europe is even more striking compared to the US.

[2] See, for example, "Global Bond Rout Sends Long-Term Borrowing Costs to Highest in Decades," *Bloomberg*, August 2026, "Pension Funds Won't Save the Bond Market," *Wall Street Journal*, May 2025.

costly for insurers to offer these products at attractive guaranteed rates. New guaranteed business contracted, and the product mix shifted toward full pass-through 'unit-linked' contracts (Barbu et al., 2025b), which we show are invested much more heavily in equities. Thus, while low rates and tighter regulation may increase insurers' demand for long-term bonds conditional on a fixed balance sheet, over time they also shrink the part of insurers' liabilities that is naturally backed by long-term bonds. Our main result is that this liability adjustment outweighs the short-run portfolio-rebalancing channel. Taken together, our findings paint a consistent picture of the insurance sector as the link between household savings and sovereign bond markets, and how a decade of QE and risk-based regulation fundamentally reshaped this link.

Despite their importance in both household portfolios and sovereign bond financing, European life insurers have received relatively little attention in the academic literature. This contrasts with the large number of papers studying the U.S. life-insurance sector. One important reason is the lack of unified data on insurers' assets and liabilities across Euro area countries. These data come from EIOPA and cover the universe of European insurers (Du et al., 2023a). To our knowledge, this is the first paper to connect life insurers' liabilities to their assets at *the insurer level* for the universe of Euro area insurers and to study how this connection shapes the evolution of their demand for bonds.

Our paper is structured in five blocks. First, we document three facts. *Fact 1*, the main fact, is a large reduction in the share of long-term bonds held by insurance companies in the Euro area. For Euro area sovereign bonds with maturities between 10 and 15 years, insurers' ownership share fell from 34% in 2016 to 19% in 2024, a decline of 15 percentage points. *Fact 2* is a contemporaneous decline in household allocation to life insurance. Between 2016 and 2024, Euro area households reduced both the share of their savings directed toward life-insurance products and the share of life insurance in their financial portfolios, from 24% to 19%. *Fact 3* is a change in insurers' product offerings: life insurers shifted away from products with long-term guarantees, such as profit-participation contracts, toward products that largely pass investment risk through to policyholders, such as unit-linked contracts.

Second, we provide evidence that these facts are tightly connected. We construct a new database of net premiums—net flows from the household sector into insurers—and combine it with bond transactions constructed from regulatory filings. We show that net premiums are a key determinant of insurers' bond trading, both in the cross-section and over time, an insight consistent with the contemporaneous evidence of Andonov et al. (2025) for U.S. pension funds. Moreover, we show that unit-linked liabilities are backed by portfolios that are fundamentally different from those backing long-term guaranteed products. Unit-linked portfolios are predominantly allocated to equities, whereas guaranteed products are backed

primarily by bonds. As insurers shift their product offering toward unit-linked contracts, their demand for bonds therefore declines. We then provide a simple decomposition of the long-run change in insurers' bond holdings into liability flows, the shift between guaranteed and unit-linked business, active rebalancing, and valuation effects. Flows are the dominant component both in the time-series of aggregate bond holdings and in the cross-section of individual insurers' holdings. In other words, bond demand is primarily *liability-driven* in the long run.

Third, we ask what drives households' reallocation away from long-term guaranteed products and insurers' shift in product offerings toward unit-linked contracts. We identify two key forces: changes in regulation and the decline in long-term interest rates. The introduction of Solvency II in 2016, with its risk-based capital requirements, encouraged insurers to shift away from guaranteed products and toward unit-linked contracts (Barbu et al., 2025b). At the same time, low long-term rates made it increasingly difficult for insurers to offer guaranteed returns that were attractive relative to deposits and other financial products.

Using changes in long-term rates instrumented with monetary-policy shocks and exploiting the cross-section of insurers, we find that a flatter yield curve—lower long-term rates relative to short-term rates—reduces net premiums into insurers. A one-percentage-point decline in the slope of the yield curve reduces net premiums by approximately one percent of insurers' assets. These effects are larger in peripheral countries. Policies such as QE compressed not only long-term risk-free rates but also sovereign credit spreads, pushing long-term bond yields even lower in these countries. We further exploit cross-sectional heterogeneity across insurers and show that the effects are stronger for insurers with greater exposure to guaranteed products in 2016 and for insurers specialized in life insurance. This cross-sectional variation allows us to include time fixed effects, thereby controlling for common macroeconomic and demographic trends. Finally, we show that net premiums fell sharply during the 2022 tightening episode, when the yield curve inverted and households exited existing policies through 'surrenders', and subsequently rebounded as long-term rates stabilized at higher levels. We use regulatory data on 'surrenders' to isolate this channel.

Fourth, we provide corroborating evidence from stock market valuations. If insurers' value derives from liability flows, then higher long-term rates, which raise those flows, should increase the value of future business, or *franchise value*, much as deposits do for banks (Drechsler et al., 2017). We exploit EIOPA data on the marked-to-market value of assets and liabilities to construct net asset value (NAV) for listed insurers and compare it to their stock returns. While NAV captures the existing book of business, stock valuations also incorporate the value of future business. Stock returns respond positively to long-term rates, but the

sensitivity of NAV is considerably smaller.[3] Insurers' duration gaps are therefore small, and a large part of the stock-price response to long-term rates operates through franchise value.

Fifth, we develop and calibrate a structural model of the insurance sector to disentangle and quantify the effects of low interest rates and regulation. This is important because the two forces changed almost simultaneously and interact within insurers' pricing decisions: tighter capital requirements are especially costly when low rates make guarantees expensive to provide.[4] Building on Koijen and Yogo (2015) and Koijen and Yogo (2022b), the model jointly determines the pricing and demand for long-term guaranteed and unit-linked products, with Solvency II capital requirements imposed at the product level. We discipline the model using the regulatory responses estimated by Barbu et al. (2025b) together with our own estimates of the sensitivity of insurance flows and product mix to interest rates. The quantitative results show that low interest rates were the dominant force: by themselves, they account for over 70% of the decline in guaranteed business. However, regulation substantially magnified this effect. Because regulatory costs rise precisely when low rates make guarantees most expensive, the joint decline in guaranteed business is more than 50% larger than the effect of the two forces considered separately.

Finally, we provide a back-of-the-envelope calculation of the implications of insurers' reduced presence for long-term interest rates. We account for the fact that, in general equilibrium, households reallocated their savings toward other sectors. However, these sectors have lower portfolio shares in long-term bonds and therefore generate less demand for these securities. Our calculation suggests that long-term yields are now approximately 50 basis points higher because of the resulting increase in the term premium. The retrenchment of insurers, therefore, has important consequences for the bond market and for the financing of Euro area governments.

The paper is organized as follows. Section 2 describes the data and Section 3 documents the three facts. Section 4 connects them, and Section 5 examines the role of interest rates and regulation in shaping liability flows. Section 6 provides corroborating evidence from stock market valuations. Sections 7 and 8 develop and calibrate a model of life insurers, and Section 9 translates the contraction of the sector into an effect on long-term yields. Section 10 concludes.

[3]The interest-rate sensitivity of NAV provides a direct empirical measure of the duration mismatch between assets and liabilities (Begenau et al., 2015).

[4]Our micro data begin in 2016, the same year in which regulation changed and long-term rates fell sharply. Empirically disentangling the two channels is therefore difficult, making the structural model particularly useful for quantifying their separate and joint effects.

1.1 Related Literature

Our paper contributes to the literature studying the asset demand of intermediaries. A large body of work studies insurers' demand for bonds and the effects of unconventional monetary policies such as QE (Domanski et al., 2017; Koijen et al., 2017; Bretscher et al., 2022; Breckenfelder and De Falco, 2023; Jansen et al., 2024). Relatedly, Jansen (2023) analyzes the role of regulation and Solvency II in shaping insurers' bond demand. Other channels—such as tightening of constraints (Ellul et al., 2015; Sen, 2023; Becker et al., 2022), reaching for yield (Becker and Ivashina, 2015), and risk-bearing capacity (Li, 2024)—have also been studied in the context of insurers' portfolio choices. Other papers have studied the portfolio rebalancing effects of QE (examples in the Euro area are Albertazzi et al. (2021); Koijen et al. (2021); Corell et al. (2025); Corradin et al. (2025)). The focus of this literature has primarily been on the within-portfolio asset allocation decision, that is, portfolio rebalancing across asset classes, taking the size of intermediaries' balance sheets as given. In contrast, we show that persistent changes in regulation and monetary policy also affect the size of intermediaries' balance sheets, and that these quantity effects can dominate portfolio rebalancing in the long run. Taken together, our results highlight an important distinction across horizons. At short horizons, balance sheets are approximately fixed, making portfolio rebalancing the primary channel through which policy affects asset demand. At longer horizons, however, household allocation decisions reshape the balance sheet size of different intermediaries, each with distinct portfolio habitats. These shifts in the structure of the financial system become the dominant driver of aggregate asset demand in the long run.

Our paper studies both the liability channel and portfolio rebalancing across asset classes and maturities. We show that, in economic terms, rebalancing activity is dominated by trading driven by liability flows, which are ultimately determined by households. While liability-driven trading has been used to construct exogenous bond demand shocks (Mota and Siani, 2023; Kubitza, 2025) to identify bond market elasticities, we argue that these flows are large, volatile, and exhibit persistent trends. As a result, they constitute the primary driver of insurers' bond demand, both in the cross-section and in the aggregate time series. Because the insurance sector is a major participant in government bond markets (Greenwood and Vissing-Jorgensen, 2018) and its presence can contribute to making bonds safer (Coppola, 2025), changes in the size of the sector have first-order asset pricing implications. We show that a prolonged period of low long-term interest rates, together with permanent regulatory changes, persistently contracted the sector, reducing a key source of stable demand for long-term government bonds. The contraction of the sector was further amplified during the 2022–2023 tightening episode, when rising short-term rates triggered a wave of policy

surrenders. Extending the analysis of Grochola et al. (2023b) for Germany to all European countries, we show that surrender activity was concentrated in countries where outstanding policies carried low guaranteed rates written during the QE period, most notably Italy and France. We also use granular holdings to show that, in fact, insurers in those countries were net sellers of sovereign bonds during the 2022 rate hike.

Our findings also relate to an emerging literature that endogenizes the wealth distribution of financial intermediaries. Darmouni et al. (2022) show how fund flows can increase fragility in corporate bond markets, while Fang and Xiao (2025) study the effects of monetary policy on flows across intermediaries. We contribute by emphasizing the long-run effects of QE on insurers through a liability-driven channel. This liability channel is also studied in contemporaneous work by Li and Wenning (2025) for the U.S., who document sizable contractions in the supply of long-duration life insurance products and in the overall life insurance market. While they emphasize a duration-based mechanism, we focus on a demand-driven flow channel: when long-term rates are low, guaranteed returns become less attractive relative to alternative assets, leading households to reduce their demand for insurance products. By focusing on insurers' liability flows, we also link the literature studying the asset side of insurers' balance sheets to the literature studying the liability side, i.e., the products offered by insurance companies to households (Koijen and Yogo, 2015, 2016, 2022b; Hombert and Lyonnet, 2022). Jiang and Sun (2024) provide complementary evidence for the United States, documenting changes in investor composition and showing that different investor groups adjust their portfolios at different speeds. They also study the QT episode and argue that shifts in investor composition make demand more elastic, thereby attenuating the effects of QT on yields. While our evidence on investor composition is consistent with these findings, our paper points to a different implication for bond yields: the contraction of the insurance sector reduces a key source of inelastic demand for long-term bonds, which can *increase* bond yields during the QT phase.

Our stock market-based evidence on how interest rates affect insurers contributes to a large number of papers that estimate the sensitivity of insurers' stock returns to interest rates and other market factors (Hartley et al., 2016; Koijen and Yogo, 2022a,b). In particular, Grochola et al. (2023a); Grochola (2026) provide a detailed analysis of the sensitivity of European insurers' stock returns to interest rates and other market risk factors. In this paper, we take a different approach and compare the sensitivity of stock returns to that of net asset values (NAV), in order to shed light on how markets price insurers' franchise value.

Last, our paper contributes to the literature documenting the evolution of the life-insurance market using newly available regulatory data. While Du et al. (2023b) employ EIOPA data to study international portfolio frictions—focusing on the *cross-sectional* al-

location of insurance portfolios across countries—our analysis emphasizes the *time-series* dynamics of insurers' assets and their connection to the liability side of their balance sheets. Barbu et al. (2025a) show that regulatory changes have pushed insurers toward offering unit-linked products. Barbu (2023) highlights insurers' incentives to encourage customers holding high-guarantee contracts to switch into products with less favorable guarantees. Our paper studies the implications of these shifts for bond demand. In particular, we show that the transition toward unit-linked products leads to a reduction in bond demand in favor of equities. Aquilina et al. (2025) study the transformation of the life insurance industry, taking a global perspective.

2. Data

In this section, we describe the construction of our dataset. We combine aggregate data, confidential insurer-level data from EIOPA, and a set of ancillary datasets.

2.1 Aggregate Data: QSA

We use Euro area flow-of-funds data from the ECB's Quarterly Sector Accounts (QSA), which provide detailed information on household balance sheets, including both positions and transactions across financial instruments.

The data cover a broad set of assets, including deposits and currency, bonds, loans, equities, mutual fund shares, pension entitlements, life insurance policies, and other financial claims. A key advantage of the flow-of-funds data is that they report transactions separately from changes in asset values, allowing us to measure household flows into the insurance sector net of valuation effects.

At the quarterly frequency, flows are highly volatile and display strong seasonality. To address this, we smooth all series using a four-quarter rolling average, $\bar{F}_t = \frac{1}{4}\sum_{k=0}^{3} F_{t-k}$, where F_t denotes net flows in quarter t. This transformation reduces seasonality and attenuates valuation effects, yielding a measure that closely tracks year-over-year changes in household allocations to insurance.

Appendix B details the data construction for QSA data and how we construct net flows into insurers.

2.2 EIOPA

We use confidential regulatory data from EIOPA, providing insurer-level information on net premiums, balance sheets, asset holdings, and trading flows. The data begin in 2016, coinciding with the implementation of Solvency II, which establishes harmonized valuation standards and risk-based capital requirements. Insurers are classified as life, non-life, com-

posite, or reinsurance undertakings.

Balance Sheet We use granular level data on assets at the ISIN level. It is however useful to describe the structure of Euro area insurers' balance sheets at a more aggregate level. The data are reported in Appendix Table F1 for 2016, 2021 and 2024. At the end of 2024, total assets amounted to €8.7 trillion, down from €9.1 trillion in 2021 but still above the €7.8 trillion recorded in 2016. On the asset side, index-linked (IL) and unit-linked (UL) products represent the largest category, reaching €1.8 trillion in 2024 (21% of total assets), a 77% increase relative to 2016. Government bonds are the second-largest component (€1.6 trillion), although their value has declined from €2 trillion in 2016. Corporate bond holdings amount to €1.3 trillion, also declining over the period. Collective investment undertakings (CIUs) have grown substantially, increasing by 84% to €1.25 trillion. Participations remain sizable at over €1 trillion, while other asset classes—such as loans, equities, cash, and property—play a smaller but non-negligible role in portfolio diversification. Appendix Table F2 provides a country-level breakdown.

Technical Provisions On the liability side, the dominant component is technical provisions (TP), which capture insurers' obligations to policyholders. Under Solvency II, TP are defined as the sum of a best estimate—corresponding to the discounted value of expected future cash flows—and a risk margin, computed using a cost-of-capital approach.

Flows Using the liability information reported in the Solvency II Quantitative Reporting Templates, we construct insurer-level net premium inflows and further decompose them by product type. Specifically, the Premiums, Claims and Expenses by Line of Business template (S.05.01.02) reports premiums written, premiums earned, claims incurred, and expenses incurred separately for each Solvency II line of business within the life segment: health insurance, insurance with profit participation, index-linked and unit-linked insurance, other life insurance, and annuities stemming from non-life contracts. These data allow us to distinguish inflows into life insurance products from non-life business and, within life insurance, to separately measure inflows into unit-linked (UL) products and profit-participation (PP) products with guaranteed returns.

For each insurer i, line of business ℓ, and quarter t, we construct net premiums as:

$$\text{Net Premium}_{i,t}^{\ell} = \text{Premiums}_{i,t}^{\ell} - \text{Claims}_{i,t}^{\ell} - \text{Expenses}_{i,t}^{\ell}. \tag{1}$$

We exclude reinsurance-related premiums and claims, since these flows are transferred between insurers rather than representing resources available for investment by the insurer itself. Our object of interest is the amount of funds generated by the insurer's underlying

business that can be deployed into financial assets. Summing Net Premium$_{i,t}^{\ell}$ across life lines of business, $\ell \in \{\text{PP}, \text{UL}, \text{Other Life}\}$, recovers total life inflows, while the PP/UL decomposition allows us to track how policyholders allocate savings between guaranteed products and products in which they bear investment risk.

At the insurer level, we use the terms *net inflows* and *net premiums* interchangeably.

2.3 Other Data

CSDB We match insurers' asset holdings to security-level information from the Centralised Securities Database (CSDB). The CSDB reports the total amount outstanding for individual bonds, which allows us to construct the aggregate amount of bonds outstanding across maturity buckets.

Financial Markets Data We use a comprehensive set of financial market data. As a measure of short-term interest rates, we use the 3-month interbank rate from FRED. To capture the term structure, we collect sovereign yield curves for all Euro area countries from Bloomberg. Unless otherwise specified, we define the *slope* as the difference between the 10-year German government bond yield and the 3-month short-term rate. We also use estimates of the term premium for the German yield curve from Adrian et al. (2013) and Favero and Fernandez-Fuertes (2023). The slope and the term premium are plotted in Figure F.1. Both series were positive—around 1.5%—until 2014, after which they declined markedly.

Sovereign Risk and Credit Risk Factor We account for sovereign and credit risk. For sovereign risk we construct the spread between the average yield of Spanish and Italian bonds minus the yield on German bonds. In the baseline specification, we use the 10-year yields. For credit spreads, we use either the ICE BofA Euro High Yield Index Option-Adjusted Spread or the iBoxx BBB OAS spread.

Monetary Policy Shocks To construct shocks to the yield curve, we exploit high-frequency monetary policy surprises measured at different maturities. In the paper, we report results using the full term structure of monetary policy shocks. We denote by Δi_t^n the monetary policy surprise to the n-year OIS rate, measured in a narrow window around ECB policy announcements, following Altavilla et al. (2019); Leombroni et al. (2021).

It is also useful to define a *slope monetary policy shock*. We construct this shock using the surprise to the 10-year rate, Δi_t^{10y}, and the corresponding surprise to the 3-month OIS rate, Δi_t^{3m}, both measured around policy announcements. The slope shock is defined as:

$$\Delta s_t \equiv \Delta i_t^{10y} - \Delta i_t^{3m}.$$

This construction isolates innovations that affect the long end of the yield curve relative to the short end. For example, shocks associated with forward guidance or quantitative easing, which disproportionately affect long-term rates, generate variation in Δs_t.

3. Three Facts About Insurers and their Government Bond Holdings

In this section, we document four facts about the evolution of the insurance sector from 2016 to 2024.

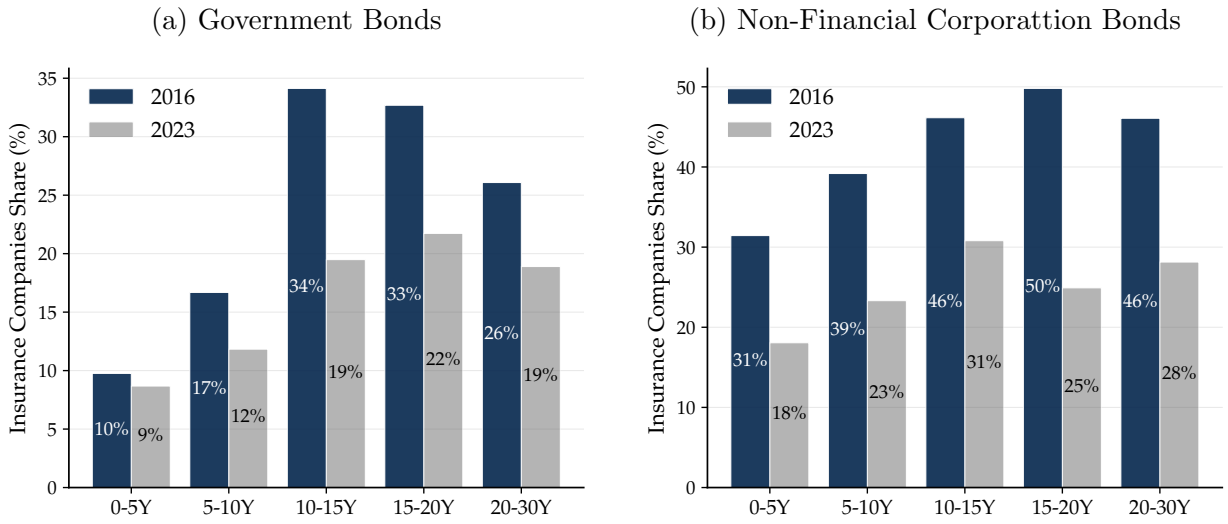
Fact 1: The Declining Presence of Insurers in the Bond Market We begin with the key fact that motivates the paper. Between 2016 and 2024, insurance companies dramatically reduced their ownership share of Euro area government bonds, with the decline especially pronounced at long maturities. Figure 1a illustrates this pattern by comparing the share of outstanding Euro area government bonds held by insurers in 2016 and 2024. Insurance companies were historically among the dominant holders of Euro area sovereign debt and therefore a key source of government financing (see Corell et al. (2026)). In 2016, they held more than one third of government bonds with maturities between 10 and 15 years, with an ownership share of 34%; by 2024, this share had fallen to 19%. A similar pattern appears at longer maturities: insurers' share of bonds with maturities between 15 and 20 years declined from 33% to 22%, while their share of bonds with maturities between 20 and 30 years fell from 26% to 19%.

Similarly, insurers substantially reduced their holdings of non-financial corporate bonds (Figure 1b). Their role in this market was even more dominant at the beginning of our sample. In 2016, insurers held 46% of non-financial corporate bonds with maturities between 10 and 15 years and 50% of those with maturities between 15 and 20 years. By 2024, these shares had fallen to 31% and 25%, respectively. In the 15–20 year segment, insurers' ownership share therefore fell by half.

These numbers point to a dramatic change in the financing of governments and corporations. Insurers have traditionally been patient, buy-and-hold investors that absorb long-maturity debt in order to match the duration of their long-term liabilities. Their retreat therefore represents a substantial change in the composition of the investor base for long-term bonds.

Fact 2: A Reduction in Household Flows into Insurers Second, we examine the composition of Euro area household portfolios and document a substantial shift away from insurance products. Using QSA data, we compute household portfolio shares across asset classes in 2016 and 2024, reported in Figure 2a. Deposits remain the dominant asset class,

Figure 1: Insurers' Holding Share of Outstanding Amount



Note: Panel (a) plots the share of insurance companies in the total outstanding amount of government bonds in 2016 and 2013. Panel (b) plots the share of Non-Financial Corporate Bonds.

accounting for approximately 32% of household financial wealth, a share that has remained broadly stable. In 2016, life insurance policies were the second-largest asset category, accounting for 24% of financial wealth, highlighting their importance in household portfolios. Equities accounted for 20%, while mutual funds represented 8%. By 2024, however, the composition had shifted markedly: the share of life insurance had declined to 19%, while the shares of equities and mutual funds had risen to 25% and 11%, respectively. Overall, these patterns point to a gradual reallocation of household savings away from insurance products and toward market-based investments.

One could argue that this significant change could be driven simply by valuations. However, a key advantage of the flow-of-funds data is that they separately report transactions, allowing us to measure flows from households into the insurance sector. These inflows combine two components: underwriting flows and capital flows. Underwriting flows—referred to as *net premiums*—are defined as premiums minus claims and expenses. When net premiums are positive, insurers accumulate resources that can be invested in financial assets; when claims exceed premiums, insurers must draw down reserves or liquidate assets. In addition, insurers may receive capital inflows through external financing, such as equity or debt issuance.

To quantify the importance of insurance within household portfolio decisions, we construct a normalized measure defined as the ratio of flows into insurance to total household financial flows. Conceptually, this corresponds to a portfolio allocation problem in which households distribute new savings across available assets. Figure 2b shows that, on aver-

age over 2001–2014, approximately 31% of household financial flows were directed toward insurance—roughly one third of total flows. In contrast, during the low long-term interest rate period from 2015 to 2023, this share declined sharply to 13%.

This shift is economically large. In a counterfactual in which the share of household savings allocated to insurers had remained at its pre-2015 level, the insurance sector would have accumulated roughly €2 trillion more in assets. The reallocation of household savings away from insurance products has therefore been a major driver of the slowdown in insurers' asset growth relative to the pre-2015 period.

It is important to note that net inflows are positive for most of the sample, with the exception of a brief period in 2023–2024. Thus, the insurance sector was still *expanding* on net. However, it was growing at a substantially slower rate than over the previous fifteen years. As we discuss below, what matters for the bond market is not simply whether insurers' bond holdings are increasing in absolute terms, but whether they are growing faster or slower than the total supply of bonds in the economy.

Survey evidence from the ECB Household Finance and Consumption Survey (HFCS) shows that participation in life-insurance and retirement products declined most sharply among lower-income and lower-wealth households (see Appendix C, and in particular Figure C.1). These households are therefore the most likely to have reallocated toward deposits, given that their participation in equity markets is extremely limited.[5]

Fact 3: The Shift to Unit Linked Products Insurers in the Euro area offer two main types of life insurance products: profit-participation contracts and unit-linked contracts. PP contracts guarantee policyholders a minimum return and share part of the insurer's investment profits, exposing the insurer to interest rate and market risk. UL contracts, by contrast, tie policyholder benefits directly to the performance of an underlying investment portfolio, transferring investment risk to policyholders.

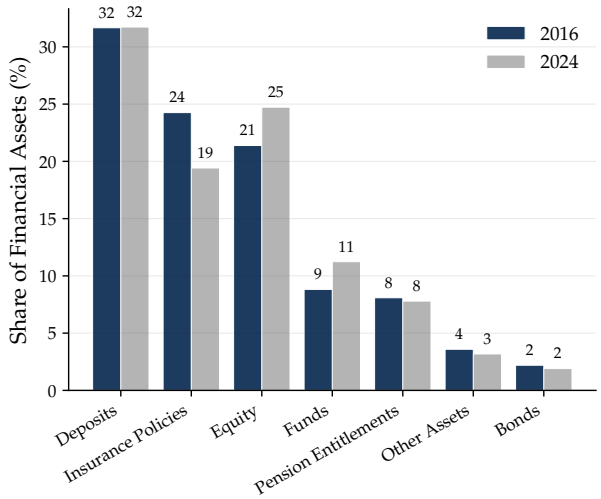
To quantify the relative importance of these two contract types, we use insurers' technical provisions, which represent the present value of insurers' liabilities to policyholders – the amount insurers must hold in reserve to meet future claims and benefits.

Life insurance technical provisions excluding UL declined from €4.4 trillion in 2016 to €3.8 trillion in 2024. In contrast, UL technical provisions increased from €1.0 trillion to €1.8 trillion, mirroring the expansion on the asset side. Non-life technical provisions amount to approximately €0.8 trillion, while other liabilities remain stable at around €0.9 trillion. Figure 3a illustrates the evolution of life insurance liabilities by product type, using granular insurance data. For these datasets, we have data until 2023. Contracts with profit participation remain the largest category, accounting for more than half of total liabilities throughout

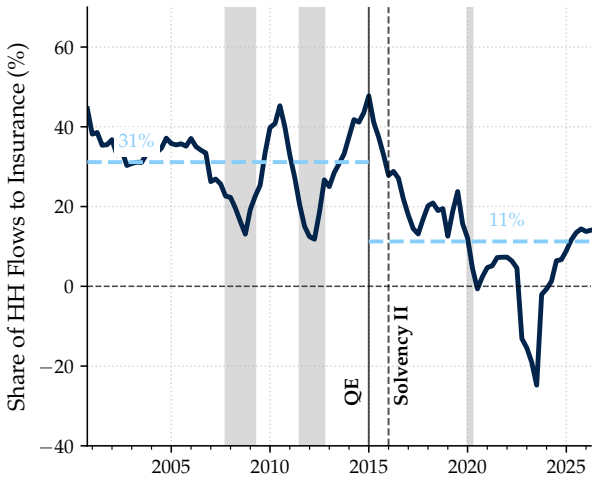
[5]This fact also motivates the modeling choices in Section 7.

Figure 2: Households Portfolio Shares and Flows Into Insurance Companies

(a) Households Portfolios



(b) Share of Flows to Insurance



Note: *Notes:* The figure documents the evolution of Euro-area households' financial asset allocation and the role of insurance and pension products in absorbing household saving flows. Panel (a) plots the composition of households' financial assets as a share of total household financial wealth, by instrument (currency and deposits, debt securities, listed shares, investment fund shares, and insurance, pension, and standardized guarantee schemes), in 2016 and 2024. Panel (b) plots the share of total household financial flows directed to insurance corporations, computed as net acquisitions of insurance and pension claims scaled by total net acquisitions of financial assets by the household sector. Shaded areas denote crisis periods. Data are from the ECB Quarterly Sector Accounts (QSA) for the Euro area aggregate.

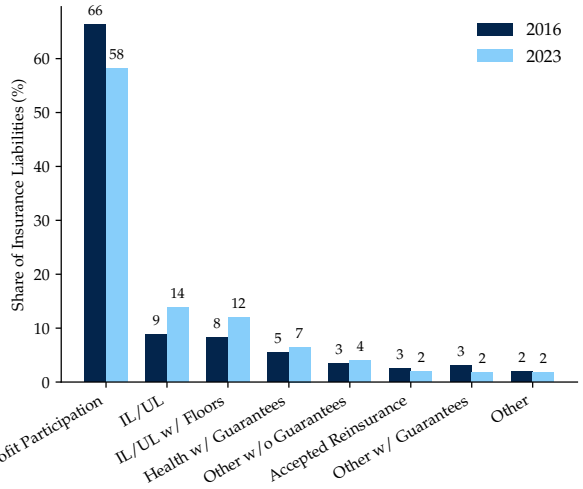
the sample. However, their share has declined from roughly two thirds in 2016 to 58% in 2023. At the same time, IL/UL products have grown steadily. Contracts without guarantees increased from 9% to nearly 14%, while those with guarantees rose from about 8% to 12%.

These patterns point to a structural shift in the industry: traditional guaranteed products remain dominant but are gradually losing importance, while UL/IL products are gaining prominence as insurers transfer more investment risk to policyholders. Appendix Table F3 shows the share by country.

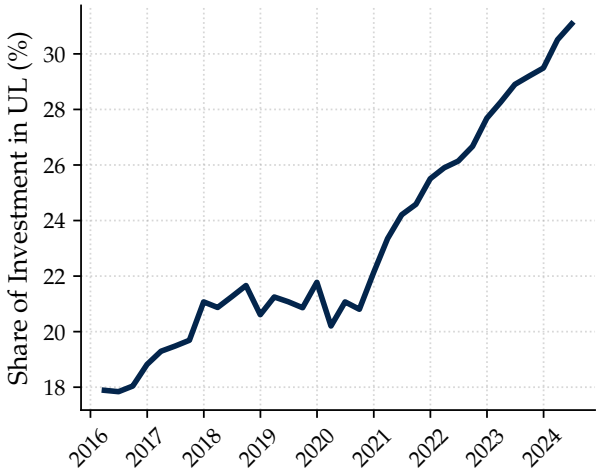
The shift in liabilities is accompanied by a corresponding change in the assets backing unit-linked products. Figure 3b shows that the share of insurers' assets associated with unit-linked products has increased steadily since 2016, rising from 18% to about 35%. This pattern mirrors the evidence in Barbu et al. (2025a) for the UK, where the ratio of unit-linked to traditional underwriting quadrupled from 1.5 in 2002 to 6 in 2014. Our evidence extends this finding to the Euro area, covering a broader set of countries and a more recent period, and shows that the shift toward unit-linked products is not confined to a single regulatory environment.

Figure 3: Insurance Contracts and the Rise of Unit Linked

(a) Shares of Insurance Liabilities by Product Type



(b) Share in UL



Note: The figure reports the contract value of technical provisions by policy type, expressed as a share of total technical provisions. Source: EIOPA.

4. Connecting the Facts: Insurers' Bond Allocation, Flows, and the Shift to Unit Linked Insurance

In this section we show how these facts are linked. First we show the importance of net premium or inflows to explain transactions in the bond market. Second, we show that the portfolio allocation for unit-linked policies strongly differs from the portfolio allocation of assets held under profit participation policies. Finally, we present a simple decomposition of the overall allocation to bonds into various components: net premium flows, change to unit-linked policies, portfolio rebalancing and valuation effects.

4.1 Insurer Allocation to Bonds and Net Premiums

First, we connect *Fact 2*—the decline in household flows into insurers documented in Section 3—to our main *Fact 1*: the decline in insurers' presence in the bond market.

We begin by documenting that inflows into insurers are a key determinant of their allocation to bonds, both in the time series and in the cross-section. To do so, we collect granular security holdings of Euro area insurers at the ISIN level. Solvency II requires insurers to report their security positions quarterly, including both quantities and market values, but does not require them to report transactions. We therefore use changes in reported positions to construct net flows at the individual security level and then aggregate these flows across asset categories, such as corporate and government bonds.

Our insurer-level data on security holdings and net premiums are available from 2016 onward. We also aggregate these micro data to construct sector-level measures of insurers' bond transactions and liability inflows. Reassuringly, these aggregate measures line up closely with the corresponding statistics from the Euro area flow-of-funds accounts. This is true both for net premiums (see Figure F.3) which capture net inflows into the insurance sector,[6] and for bond transaction flows, which measure net purchases net of valuation effects.

Suppose we want to explain variation in bond transactions, or more generally changes in investors' portfolios, across investors or over time. The standard approach is to take investors' total assets as given and study how they reallocate those assets across securities and asset classes. If total assets are relatively stable, or if investors absorb inflows and outflows through cash buffers, this provides a close approximation to observed portfolio changes in both the cross-section and the time series. However, when net inflows are large relative to available cash buffers—as can be the case for insurers when net premiums fluctuate substantially—changes in liabilities can directly generate asset transactions. Insurers facing net outflows, with claims exceeding premiums, may need to liquidate existing positions, while insurers receiving net inflows must deploy the additional funds into financial assets.

This mechanism is well understood for mutual funds and non-life insurers. Life insurers, however, are typically viewed as having exceptionally stable funding, so that net inflows and outflows are thought to play only a limited role in their asset demand. We believe this view partly reflects the fact that life insurers' liabilities have proven remarkably stable during episodes of acute financial stress; Figure 2b, for example, shows little evidence of abrupt disintermediation during crises. In this paper, we argue that this stability at high frequency masks substantial variation at lower frequencies. Net inflows may not respond strongly to sudden changes in market conditions, such as a sharp widening in credit spreads Coppola (2025); Corell et al. (2025), but they can respond materially to persistent changes in the economic and regulatory environment, such as a prolonged decline in long-term interest rates or a structural change in regulation.

Cross-Section To illustrate this point, Figure 4a plots net bond flows against net inflows across insurers in 2024, the latest year in our sample. Constructing this figure is possible thanks to a new dataset we develop that measures net premiums and net bond flows for the universe of Euro area insurers, which is one of the contributions of the paper. Positive net bond flows, shown in green, correspond to insurers that were net purchasers of bonds, while

[6] In the flow of funds, these appear under life insurance and pension entitlements. Conceptually, they are closely related to *net premium flows*—premiums and contributions received net of benefits and claims paid—but in this exercise we use a broader measure of inflows that also includes other financing flows such as equity issuance and bond issuance. Appendix B.1 provides further detail on their construction and mapping to ESA 2010 accounts.

negative net bond flows, shown in red, correspond to insurers that were net sellers.[7]

The figure clearly shows that a large number of insurers were net sellers of bonds in 2024. These insurers were almost exclusively those experiencing large claims relative to premiums, and hence negative net premiums. Conversely, the largest bond purchases were concentrated among insurers receiving substantial net inflows. The figure also shows that there are exceptions. These cases correspond almost entirely to observations in which net premiums were negative but bond flows remained positive. In these instances, insurers did not liquidate bonds to accommodate claims. Instead, they appear to have absorbed the outflows by drawing down cash buffers or liquidating other assets.

More generally, the figure reveals a strong cross-sectional correlation between net premiums and bond flows, suggesting that liability-side flows are a key determinant of changes in insurers' bond positions.

Time Series We now turn to the aggregate data. The key advantage of the flow-of-funds data is their longer time-series coverage, extending back to the inception of the euro. We therefore use the EIOPA data for the micro-level analysis but the QSA data for the aggregate time-series analysis.

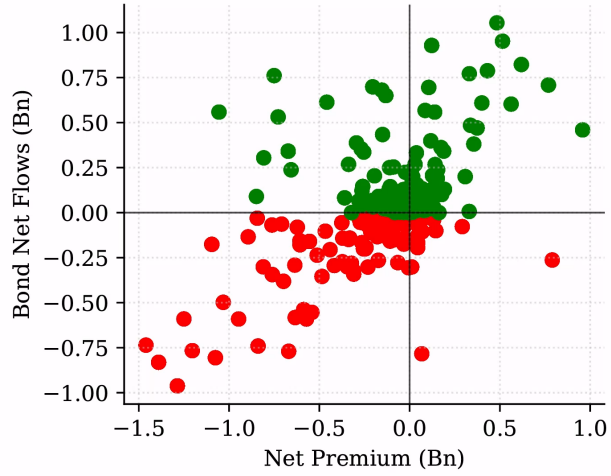
Figure 4b shows that insurers' bond purchases closely track liability flows. Both series are constructed at a quarterly frequency using rolling annual averages. Bond flows (in blue, left y-axis) move closely with liability flows (in teal, right y-axis), with a correlation of approximately 85%. A simple univariate regression of bond flows on liability flows explains roughly 73% of the time-series variation in bond purchases. The estimated pass-through coefficient is slightly below one, at about 0.85, and declines to approximately 0.7 in the post-2009 period. Remarkably, this estimate is very close to our cross-sectional estimates over 2016–2025, discussed in Appendix A. Taken together, these results point to a strong and remarkably stable pass-through from liability flows to insurers' bond demand.

Although insurers were consistently net buyers of bonds between 2000 and 2022, the magnitude of their purchases varied substantially over time. The sharp increase in short-term interest rates in 2022–2023 generated a further decline in inflows into the insurance sector, driven in part by an increase in policy surrenders, as we discuss below. Insurers consequently became net sellers of bonds during this episode. This behavior is difficult to reconcile with a pure duration-hedging mechanism, which would instead predict stronger demand for long-duration bonds following an increase in interest rates.

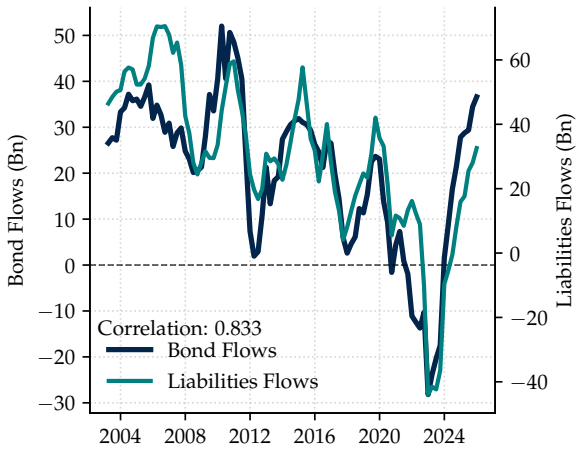
Overall, the goal of this subsection is to make a simple point: net premiums into life insurers are a key determinant of their aggregate bond demand. This establishes a direct

[7] Because the data contain some extreme observations, we construct the figure after trimming the most extreme 5% of observations, approximately 2.5% from each tail.

(a) Net Premium and Bond Flows in the Cross Section



(b) Net Premium and Bond Flows over Time



Note: Panel (a) plots the cross-section of insurers net premium and bond flows in 2024. Panel (b) figure plots insurance bond flows (blue, left y-axis) and insurance liability inflows (black, right y-axis) over time, both measured as transactions from Euro area flow-of-funds data.

link between our first two facts, described in Section 3. The decline in insurers' presence in bond markets is closely connected to the decline in household flows into insurance products. In Section 4.3, we provide a formal decomposition that quantifies the relative importance of this channel.

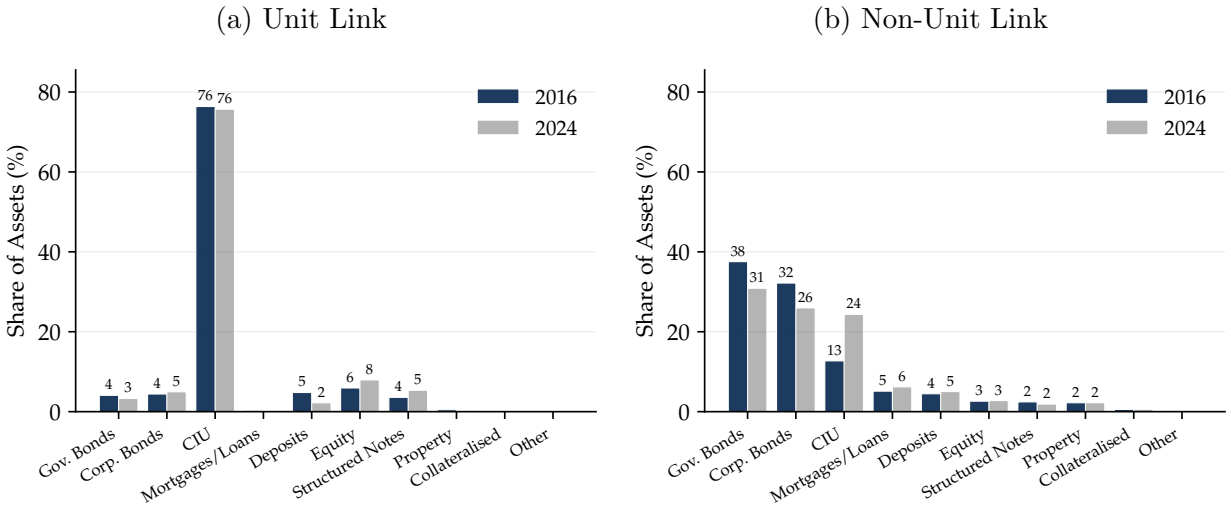
4.2 Liability Product and Asset Allocation

In this subsection, we connect *Fact 3*—the shift in insurers' product offerings—to *Fact 1*, the declining presence of insurance companies in the bond market.

We now use a novel dataset that, to our knowledge, has not previously been used in academic research to document how the asset allocation of unit-linked products differs from that of other life-insurance products. We compare insurers' asset allocations within their unit-linked and non-unit-linked portfolios. Figure 5 reveals a striking fact: the composition of the two portfolios is fundamentally different.

The unit-linked portfolio (Figure 5a) is invested predominantly in investment funds, which account for 76% of assets in 2024. It also has a non-negligible allocation to equities (8%) and structured notes (5%), while the allocation to government bonds is only 3%. This composition has remained fairly stable since 2016, with only a modest increase in the equity share from 6% to 8%. By contrast, the non-unit-linked portfolio (Figure 5b) is much more heavily tilted toward bonds. In 2024, government bonds are the largest asset class, accounting for 31% of assets, followed by corporate bonds at 26%. Relative to 2016,

Figure 5: Asset Allocation: Unit Link vs Non-Unit Link



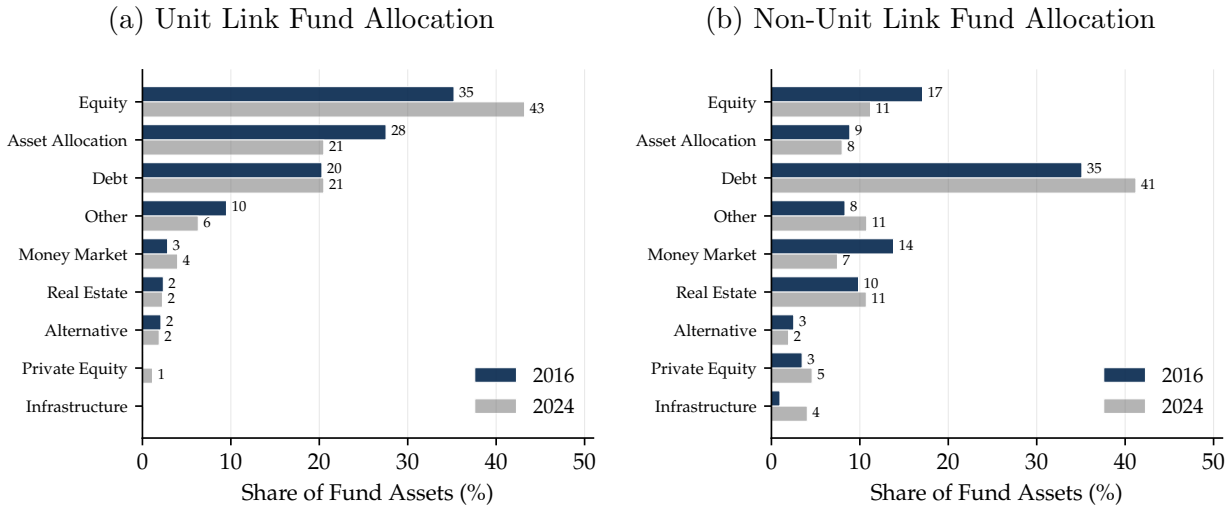
Note: The figure plots the composition of Euro area insurers' assets by asset class, expressed as a share of total assets within each portfolio, in 2016 (dark blue) and 2024 (grey). Panel (a) covers the unit-linked portfolio; Panel (b) covers the non-unit-linked (general account). CIU denotes collective investment undertakings. Source: EIOPA Solvency II regulatory filings.

however, the non-unit-linked portfolio has shifted away from sovereign bonds and corporate bonds—whose shares were 38% and 32%, respectively—and toward investment funds, whose share increased from 13% to 24% in 2024. Overall, these patterns show that the reallocation from non-unit-linked to unit-linked products is also a reallocation away from bond-intensive balance sheets.

We go one step further and examine the composition of insurers' investment-fund holdings, for which we observe the underlying fund type. Figure 6 again reveals a stark contrast between unit-linked and non-unit-linked portfolios. Within unit-linked portfolios, 43% of fund investments are allocated to equity funds and 21% to asset-allocation funds. Assuming that asset-allocation funds follow a 60/40 equity–bond mix, and including private-equity funds, we estimate that approximately 56% of unit-linked investments through collective investment undertakings (CIUs) are ultimately exposed to equities. Combining this indirect exposure with direct equity holdings implies that roughly 64% of unit-linked assets are invested in equities.

The corresponding equity exposure of non-unit-linked portfolios is much smaller. Direct equity holdings account for only 3% of assets. CIUs represent 24% of the portfolio, and we estimate that approximately 20% of these investments are ultimately allocated to equities, after accounting for equity funds, asset-allocation funds, and private-equity funds. Combining direct and indirect exposures therefore implies an overall equity allocation of approximately 8% for non-unit-linked assets. One notable development, however, is the

Figure 6: Fund Allocation: Non Unit Link vs Unit Link



Note: The figure plots the composition of Euro area insurers' holdings of collective investment undertakings (CIUs) by fund type, expressed as a share of total fund assets, in 2016 (dark blue) and 2024 (grey). Panel (a) covers the unit-linked portfolio; Panel (b) covers the non-unit-linked (general account) portfolio. Source: EIOPA Solvency II regulatory filings.

increasing allocation of non-unit-linked portfolios to private-equity and infrastructure funds.

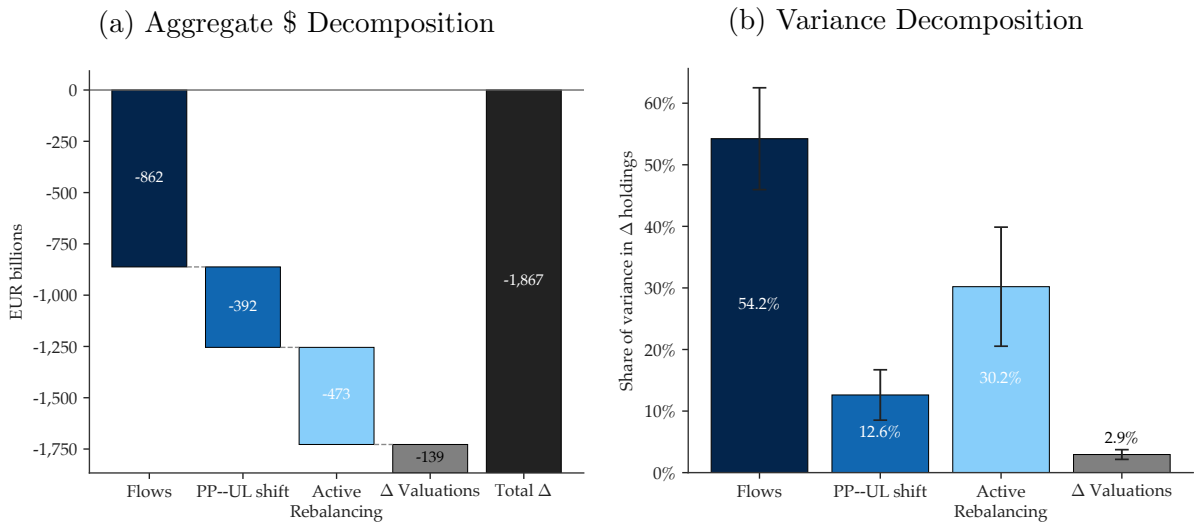
Overall, these findings show that each euro reallocated from non-unit-linked to unit-linked products is associated with a substantial reduction in bond exposure and a corresponding increase in equity exposure. Thus, even holding total liabilities fixed, changes in the composition of insurers' liabilities can have significant effects on their bond holdings.

4.3 Liability-Driven Demand versus Active Portfolio Rebalancing

In Section 4.1, we document that net premiums are an important determinant of insurers' net bond purchases. In Section 4.2, we show that the composition of insurers' liabilities—unit-linked versus non-unit-linked products—is a key determinant of asset allocation, with assets backing unit-linked products invested predominantly in investment funds and equities rather than bonds. We now bring these two margins together and provide a decomposition of the change in insurers' total bond holdings into the contributions of liability flows, shifts in product composition, and portfolio rebalancing.

For each insurer, we split business into a profit-participation division (PP) and a unit-linked division (UL). This decomposes the change in bond holdings into three components and a valuation residual. *Flows* capture how much holdings changed purely because total assets grew or shrank and reflect net contributions and withdrawals. The *UL shift* captures how much holdings changed purely because business moved between the PP and UL divisions, holding both divisions' bond weights fixed. *Rebalancing* captures the change coming from

Figure 7: Decomposing Insurance Govt. Bond Trading



Note: Panel (a) decomposes the aggregate change in insurers' government bond holdings (EUR bn) into shares attributable to flows, PP–UL portfolio shifts, active rebalancing, and residual valuation changes, shown as a waterfall summing to the total change. Panel (b) decomposes the cross-sectional variance of the change in insurers' government bond holdings into the shares attributable to flows, PP–UL portfolio shifts, active rebalancing, and residual valuation changes, with 95% confidence intervals.

actively changing the bond weight within each division. What remains are *valuation* effects, which cause changes in holdings in the absence of flows, UL shifts, and active rebalancing. Appendix A.5 presents the exact algebra and construction of each component.

Figure 7 plots the results. Panel (a) decomposes the aggregate change in bond holdings (i.e. the sum across all insurers) into the four components. Panel (b) plots the cross-sectional variance decomposition of insurer-level changes in bond holdings. Both in the aggregate time series, as well as in the cross-section of insurance companies, capital flows are the main driver of insurance companies' bond holdings.

Appendix A provides extensive further evidence on liability-driven trading versus active portfolio rebalancing. As with flow-induced trading by mutual funds (Lou, 2012), a net premium inflow equal to 1% of assets raises bond holdings by roughly 0.7%. Insurers, therefore, pass liability flows straight through to the bond market rather than absorbing them in cash or other asset classes. We also benchmark the impact of liabilities against that of net equity, which the literature has emphasized as a determinant of rebalancing through regulatory capital constraints. The contrast is stark. Across the cross-section, the difference in bond flows between the top and bottom deciles of the net premium distribution is 7.5% of total assets, against less than 1% for net equity, and the incremental explanatory power of net equity is close to zero. Active rebalancing, however, is not absent: higher net equity leads insurers to tilt toward riskier bonds, and net premium inflows toward longer maturities.

These effects are statistically significant but economically small relative to the effect of net premiums on total bond demand.

Portfolio rebalancing therefore matters for the composition of insurers' bond portfolios at the margin, while liability flows determine the scale of those portfolios. The decline in insurers' bond-market share is therefore best understood as a balance-sheet phenomenon rather than an active portfolio choice phenomenon.

5. Insurers and Interest Rates

So far, we have presented evidence that net premiums and the composition of insurers' liabilities—in particular, the allocation between unit-linked and profit-participation products—are key determinants of insurers' bond demand. The decline in net premiums and the reallocation toward unit-linked products are therefore central drivers of the reduced presence of life insurers in the bond market. These developments, however, are themselves endogenous and ultimately reflect changes in the macroeconomic and regulatory environment.

Barbu et al. (2025b) provide evidence that the transition to risk-based regulation was an important driver of insurers' shift from profit-participation toward unit-linked products. Our model in Section 7 uses their estimates to discipline the quantitative importance of this regulatory channel.

A second factor frequently emphasized by insurers is the difficulty of offering attractive profit-participation contracts in a low-interest-rate environment. These contracts embed a minimum guaranteed return that is typically linked to long-term interest rates. This connection is natural: as we showed in Section 4.2, assets backing profit-participation contracts are invested heavily in long-term bonds, so the guarantees insurers can sustainably offer depend on the returns available on these assets. Moreover, regulators often cap the guarantee rate that insurers can promise on new business as a function of long-term market rates.[8]

This mechanism motivates our focus on the slope of the yield curve. In the model,

[8]In Germany, for example, this cap is the *Hochstrechnungszins*, recommended annually by the Deutsche Aktuarvereinigung and set by the Bundesministerium der Finanzen through the *Deckungsrückstellungsverordnung*. The cap is mechanically linked to market yields: it is based on the arithmetic mean of returns on a representative new-investment portfolio over the preceding five years, after applying a 40% safety margin. The maximum permissible guarantee is therefore a smoothed and substantially discounted function of prevailing long-term rates and declines as those rates fall.

Figure F.2 plots this ceiling against the 10-year German government bond yield, together with the rate implied by applying the regulatory formula to market yields. The series track each other closely from the early 2000s onward. As long-term rates declined, the maximum guarantee fell from 4.0% in 1994 to 0.25% by 2022, before increasing to 1.0% in 2025 following the normalization of interest rates—its first increase in three decades. The prolonged decline in long-term rates therefore translated directly into progressively lower guaranteed returns on new insurance products, reducing their attractiveness relative to alternative savings vehicles.

households choose between profit-participation products and an outside asset, which we model as a short-term interest-bearing asset such as a bank deposit. The attractiveness of profit-participation products therefore depends not simply on the level of long-term rates, but on the return they can offer relative to short-term alternatives. The slope of the yield curve is a natural sufficient statistic for this comparison: long-term rates determine the return insurers can offer on guaranteed products, while short-term rates determine the return on the household's outside option. We therefore investigate whether variation in the yield-curve slope helps explain households' allocation toward profit-participation products and, more broadly, flows into the insurance sector.

Empirically, we measure the slope of the yield curve using euro Swap rates, defined as the difference between the ten-year and the one-year Swap rate.

Figure 8a plots inflows into insurance companies, measured as a share of total household savings (the same series as in Figure 2b), together with the slope of the Swap curve. The dark blue line, shown on the left axis, reports the share of household financial flows directed toward insurers, while the light blue line, shown on the right axis, reports the Swap-curve slope. The two series are strongly positively correlated, with a correlation of 0.64, indicating that variation in the Swap-curve slope explains a substantial share of the time-series variation in insurance inflows. In fact, a simple linear regression of the household flow share into insurance on the slope of the Swap curve over the full sample yields a coefficient of 0.13,[9] with an R^2 of 41%.

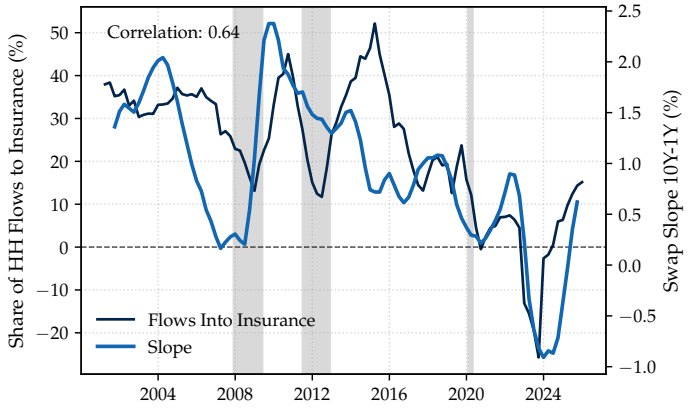
There are three important points to make on this analysis. First, we measure inflows as a share of total household financial flows rather than in levels. This normalization makes the series less sensitive to aggregate fluctuations in household saving and allows us to focus more directly on portfolio allocation decisions. The results are similar when we instead use total flows.

Second, inflows are not comparably correlated with the level of interest rates. Consistent with the mechanism in the model, it is the slope of the yield curve—rather than the level of rates per se—that appears most closely related to household allocation decisions.

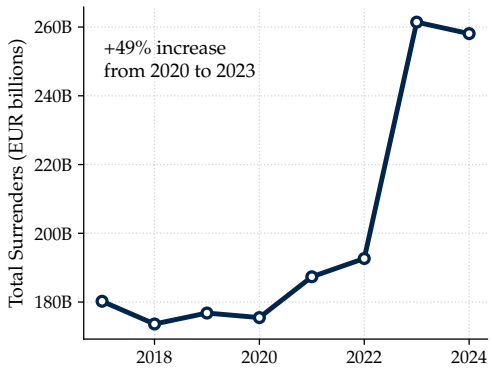
Third, inflows rebounded in 2024 alongside the recovery in the yield-curve slope. This timing is difficult to reconcile with an explanation based solely on regulation. The main regulatory reform was implemented in 2016, yet inflows had already begun to decline in 2015 and recovered in 2024 without a new regulatory change. Taken together, these patterns suggest that movements in the term structure of interest rates, alongside regulation, play an important role in shaping flows into insurance products.

[9] Newey–West standard error of 0.016, t-statistic of 8.1.

(a) Inflows and Interest Rate Slope



(b) Surrenders in the Euro Area



Note: Panel (a) plots inflows into the insurance sector as a share of household financial flows (left axis), together with the slope of the Swap curve (right axis). Inflows into insurance are measured as the ratio of total inflows into the insurance sector—comprising net premiums and capital flows—to total household flows into financial assets, using data from the QSA. The slope is defined as the difference between the ten-year and the one-year euro Swap rate. Both series are smoothed using four-quarter rolling averages. The sample runs from Q1 2001 to Q3 2025. Panel (b) plots the amount of policy surrenders for life insurance companies in the Euro area. Data are sourced from EIOPA and available from 2018 to 2024.

5.1 Evidence from Micro Data

We now provide more direct evidence on how changes in the slope of the yield curve affect net premiums into insurance companies. We use our EIOPA regulatory filings to construct insurer-level net premiums. Because net premiums exhibit strong seasonality, we smooth the series using a four-quarter rolling average. Our empirical analysis therefore uses a quarterly time series of overlapping annual observations.

The natural specification would regress net premiums on the contemporaneous annual change in the slope of the yield curve. However, such a regression may be affected by reverse causality if shifts in insurance flows themselves influence equilibrium interest rates. To mitigate this concern, we instead use the component of the annual change in the yield-curve slope that occurs within tight windows around ECB monetary policy announcements. During our sample period, ECB policy announcements—including those related to quantitative easing and forward guidance—generated substantial movements in the term structure of interest rates. We use these high-frequency changes to isolate variation in the slope that is more plausibly driven by monetary policy rather than by contemporaneous insurance-sector flows. We denote these changes as *slope shocks*. We estimate

$$np_{i,t}^{\text{NonUL}} = \alpha_i + \alpha_t + \alpha_{s(i)} + \alpha_{c(i)} + \beta_1 \,\text{Shock}_t + \beta_2\big(\text{Shock}_t \times X_i\big) + \beta_3 X_i + \varepsilon_{i,t}, \qquad (2)$$

where $np_{i,t}^{\text{NonUL}}$ denotes net premiums into non-unit-linked business for insurer i in quarter t,

scaled by total assets, and Shock_t is the monetary policy shock to the slope of the yield curve, defined as the difference between the ten-year and one-year shocks. The term X_i is an insurer characteristic along which we allow the response to vary: an indicator for insurers domiciled in fragile countries, an indicator for above-median size, the share of profit-participation contracts in 2016, or an indicator for pure life undertakings. The terms $\alpha_{s(i)}$ and $\alpha_{c(i)}$ denote asset-size and country fixed effects, and α_i and α_t insurer and time fixed effects; these are included progressively across specifications, with insurer fixed effects subsuming the asset-size and country effects wherever both are present. Standard errors are double clustered at the insurer and quarter level.[10]

Table I reports how insurers' underwriting flows into guaranteed products respond to monetary policy shocks to the slope of the yield curve. Column (1), which includes asset-size and country fixed effects, yields a coefficient of 0.97, significant at the one percent level. Because both the shock and the dependent variable are measured in decimals, the coefficient has a direct interpretation: a one-percentage-point steepening of the yield curve raises net premiums into non-unit-linked business by approximately one percent of assets. Column (2) adds insurer fixed effects, controlling for time-invariant insurer characteristics. The estimate rises to 1.31. The within-insurer response is if anything stronger than the pooled estimate suggests. Note that these are the effects on annual flows, meaning that a reduction in long-term rates reduced net premiums and the effects cumulate over time.

Column (3) examines whether the response differs by size, interacting the shock with an indicator for above-median assets. The evidence points toward the sensitivity of guaranteed-product inflows being concentrated among larger undertakings, though the difference is estimated imprecisely.

Column (4) provides further insight by interacting the shock with an indicator for insurers domiciled in fragile countries. Insurers in core countries display a response of 0.79, while the interaction coefficient of 1.81 implies a total response of approximately 2.60 in the periphery—more than three times as large. This pattern is consistent with the effects of policies such as quantitative easing, which not only reduce long-term risk-free rates but also compress sovereign credit spreads in peripheral countries Krishnamurthy et al. (2018). As a result, long-term yields fall by more in these countries, making guaranteed products relatively less attractive and generating a stronger decline in net premiums. The results also suggest that the effects of policies such as QE are different across countries and have different repercussions for the structure of the financial system.

Columns (5) and (6) replace our baseline annual shock with the corresponding quarterly

[10] We also compute Driscoll–Kraay standard errors, which allow for arbitrary cross-sectional dependence across insurers, and our results are unchanged.

monetary policy shock. While our preferred specification uses annual shocks, consistent with the horizon implied by the model, the results are robust to using standard quarterly monetary policy shocks. The estimated coefficients are 1.16 and 1.31, depending on whether insurer fixed effects are included. If anything, these specifications strengthen the estimated relationship.

Columns (7) and (8) repeat the baseline specification using premium inflows into unit-linked business as the dependent variable. The estimated coefficients are substantially smaller, at 0.28 and 0.33, and are less precisely estimated; without insurer fixed effects, the coefficient is not statistically significant. This contrast is consistent with the mechanism in the model. Unit-linked contracts do not embed a minimum return guarantee and pass investment risk directly to policyholders, so their demand should be much less sensitive to the term structure through the guarantee channel. The much weaker response of unit-linked inflows therefore supports the interpretation that the sensitivity of insurance flows to the slope of the yield curve operates primarily through guaranteed products rather than through a general shift in demand for insurance.

At the same time, the model implies that unit-linked inflows need not be completely insensitive to long-term rates. An increase in long-term rates relaxes insurers' balance-sheet and regulatory constraints associated with guaranteed products, allowing them to adjust equilibrium pricing, including fees, which can indirectly affect demand for unit-linked contracts. This indirect channel can rationalize the small positive coefficients we estimate for unit-linked inflows.

Table II examines which insurers drive the response documented above, by interacting the slope shock with characteristics that proxy for exposure to guaranteed business. Each block of three columns adds fixed effects progressively. Because the shock varies only over time, its level effect is absorbed once time fixed effects are included, so that the interaction is identified purely from cross-sectional differences across insurers within the same quarter. This is a demanding specification: it rules out the possibility that our estimates reflect aggregate developments that happen to coincide with monetary policy announcements.

Columns (1)–(3) interact the shock with the share of profit-participation contracts in 2016, our most direct measure of exposure to guaranteed products. The interaction is large and precisely estimated, between 3.86 and 4.06, and is essentially unchanged as time and insurer fixed effects are added. The level coefficient in column (1) implies that an insurer with no profit-participation business would, if anything, reduce inflows following a steepening, whereas an insurer whose liabilities consist entirely of profit-participation contracts displays a response of roughly 3.5. The sensitivity of flows to the slope of the yield curve therefore scales with the share of guaranteed liabilities, exactly as the mechanism predicts. This specification

Table I: Insurance Inflows and the Slope of the Yield Curve

	Dependent Variable							
	Non-UL Net Premium						UL Premium	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Slope Shock	0.973***	1.306***	0.209	0.789**			0.278	0.333*
	(0.330)	(0.418)	(0.601)	(0.329)			(0.167)	(0.184)
Slope Shock × Large Insurer			1.108*					
			(0.651)					
Slope Shock × Fragile Country				1.810**				
				(0.848)				
Quarterly Slope Shock					1.158***	1.309**		
					(0.366)	(0.609)		
Asset FE	✓	✓	✓	✓	✓	✓	✓	✓
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Insurer FE	✓	✓		✓		✓		✓
R^2	0.077	0.642	0.077	0.643	0.083	0.666	0.125	0.629
Observations	22,759	22,745	22,759	22,745	20,121	20,074	22,751	22,742

Note: The dependent variable in columns (1)–(6) is net underwriting flows into non-unit-linked life business, and in columns (7)–(8) premium inflows into unit-linked business, both scaled by total assets. The Slope Shock is the monetary policy shock to the slope of the yield curve, defined as the difference between the ten-year and one-year shocks. *Large Insurer* is an indicator for insurers with above-median total assets; *Fragile Country* is an indicator for insurers domiciled in Ireland, Italy, Spain, Portugal, Cyprus, or Malta. Columns (5) and (6) use the quarterly monetary policy shock lagged three quarters in place of the baseline shock. Standard errors, double clustered at the insurer and quarter level, in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Source: EIOPA Regulatory Filings, 2016-2024.

also allows us to include time fixed effects, thereby absorbing common macroeconomic and demographic factors that could otherwise confound the relationship.

Columns (4)–(6) replace this measure with an indicator for pure life undertakings. Composite insurers show a response indistinguishable from zero, while the interaction of 2.65 to 2.96 implies a response of approximately 2.8 for pure life insurers. This is consistent with composite undertakings being better able to retain policyholders through cross-selling of non-life products, which dampens the sensitivity of their inflows to interest rate movements. As with the profit-participation share, the estimate is stable across specifications, including the most saturated one with both time and insurer fixed effects.

Columns (7)–(9) interact the shock with a measure of interest rate exposure. We construct this measure by regressing each insurer's net asset value on changes in interest rates, which yields a proxy for the sensitivity of an insurer's net worth to the term structure. We standardize it to have mean zero and unit standard deviation, so that the coefficient on the shock gives the response of an insurer with average exposure and the interaction the additional response associated with a one-standard-deviation increase in exposure. A positive

exposure means that net asset value rises when interest rates increase or, equivalently, that net worth contracts when rates fall. Since our sample is characterized by a sustained decline in long-term rates, these are precisely the insurers whose net assets were most eroded and whose regulatory constraints tightened most over the period.

The interaction is positive, at 1.27 in column (7), implying that an insurer at mean exposure displays a response of 1.00 while a one-standard-deviation increase raises this to roughly 2.27. Read in the direction of the episode, a flattening of the yield curve reduces net premiums by more for insurers whose net worth is most sensitive to it. This is the pattern the model predicts: when long-term rates fall, insurers with greater interest rate exposure suffer larger losses in net worth, their solvency constraints bind more tightly, and they curtail the writing of new guaranteed business by more. The estimate is stable across columns (7) and (8) but falls to 0.80 and loses significance once insurer fixed effects are included; we therefore read this evidence as suggestive.

Overall, the estimates indicate that life insurers with higher exposure to profit-participation liabilities and a pure life focus exhibit the strongest flow responses to changes in the yield curve. These findings are consistent with the mechanism proposed earlier: when the yield curve steepens or long-term rates rise, the relative attractiveness of guaranteed policies increases, driving larger inflows into the insurance sector.

It is useful to emphasize that these flows primarily reflect the subscription of new policies by households (or the lack thereof), rather than active trading of existing positions. In this sense, the tight relationship we document does not contradict the well-established evidence that households adjust their financial decisions only gradually.[11] An important exception is the 2022–2023 period. During this time, the rapid tightening of interest rates by the ECB reduced the slope of the yield curve by about 2.5 percentage points, with short-term rates exceeding long-term rates by roughly 1.5%. This salient shift triggered a more active response from households, including the surrender of existing insurance policies, which we examine next.

Surrenders as Corroborating Evidence The evidence above shows that flows into insurance products respond to the slope of interest rates primarily through the extensive margin: households subscribe to fewer new policies when guaranteed returns are unattractive. A natural concern is that this relationship reflects slow-moving structural forces—demographic trends, changing household preferences, or industry consolidation—rather than a direct response to interest rates. The surrender episode of 2022–2023 provides complementary evidence against a purely structural explanation. When the ECB tightened policy rapidly and

[11] A large literature documents substantial inattention and portfolio inertia across many settings (e.g., Agnew et al., 2003; Brunnermeier and Nagel, 2008; Andersen et al., 2014).

Table II: Insurance Inflows and the Slope of the Yield Curve: Insurer Heterogeneity

Interacted Characteristics (X_i)	*Dependent Variable: Non-UL Net Premium*								
	PP Share (2016)			Life Insurer			Interest Rate Exposure		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Slope Shock	−0.423*			0.116			1.002**		
	(0.214)			(0.332)			(0.376)		
Slope Shock × X_i	3.906***	3.859***	4.060***	2.699***	2.645***	2.960***	1.265**	1.235***	0.800
	(1.070)	(1.067)	(1.091)	(0.677)	(0.680)	(0.690)	(0.562)	(0.060)	(0.573)
X_i	−0.008***	−0.009***		−0.004*	−0.004*		0.001	0.001	
	(0.003)	(0.003)		(0.002)	(0.002)		(0.002)	(0.002)	
Asset FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Country FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time FE		✓	✓		✓	✓		✓	✓
Insurer FE			✓			✓			✓
R^2	0.124	0.126	0.674	0.085	0.088	0.650	0.087	0.092	0.643
Observations	16,038	16,038	16,027	22,759	22,759	22,745	20,130	20,130	20,125

Note: The table estimates equation (2). The dependent variable is net premiums into non-unit-linked business, scaled by total assets. The Slope Shock is the monetary policy shock to the slope of the yield curve, defined as the difference between the ten-year and one-year shocks. The interacted characteristic X_i differs across blocks of columns: the share of profit-participation contracts in 2016 in columns (1)–(3), an indicator for pure life undertakings in columns (4)–(6), and a standardized measure of interest rate exposure in columns (7)–(9), constructed by regressing each insurer's net asset value on changes in interest rates and normalized to have mean zero and unit standard deviation. Standard errors, double clustered at the insurer and quarter level, in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Source: EIOPA Regulatory Filings, 2016-2024.

the slope of the yield curve fell by approximately 2.5 percentage points, turning sharply negative, households responded actively by surrendering existing contracts. This pattern is consistent with the same interest-rate mechanism operating through existing positions when movements in interest rates become sufficiently large and salient, and is difficult to reconcile with a purely slow-moving structural explanation.

Using data from EIOPA, which allow us to observe surrenders directly, we document a substantial increase in policy exits. As shown in Figure 8b, overall surrenders rose by 49% between 2020 and their peak in 2023, and remained elevated in 2024.

The cross-country pattern reported in Table F4 provides additional evidence. Surrenders were not uniformly distributed across the Euro area: Germany and the Netherlands recorded no increase and in some cases a decline, while Italy, France, and Luxembourg experienced sharp rises. During 2022–2023, countries experiencing large increases in surrenders were also net sellers of government bonds, illustrating the direct link from household behavior to bond market outcomes.

Surrenders in Italy increased by 108% between 2020 and 2023, more than twice the Euro area increase. The pressure contributed to the failure of Eurovita, a mid-sized Italian life

insurer, which was forced to sell government bonds precisely when rising rates had depressed their prices.[12] IVASS placed the company under special administration in January 2023 and suspended early redemptions until October, and its portfolio was ultimately assumed by a consortium of the largest Italian insurers. This finding is consistent with Section 4.1 and in particular Figure 4a which shows that insurers that faced negative net premiums (e.g., through surrenders) are forced to liquidate their bond positions. The surrender episode provides additional support for our interpretation of our main results. In particular, the sharp response of surrenders during the tightening episode is difficult to explain solely through the slow-moving trends that might confound our regression results. When rates moved sharply, households responded sharply as well. Taken together, the evidence points to a common underlying mechanism: the attractiveness of guaranteed returns relative to outside investment opportunities shapes household allocation to the insurance sector, operating gradually through new subscriptions and more abruptly through policy surrenders.

6. Interest Rates and Franchise Value

In this paper, we have highlighted the importance of interest rates for insurers' ability to sell guaranteed products. A prolonged period of low long-term rates reduced the demand for guaranteed products and induced insurers to shift toward unit-linked contracts. Conversely, higher long-term bond yields allow insurers to offer more attractive guarantees while also improving the margins on these products. This channel is consistent with insurers' own assessments. For instance, a recent Swiss Re report notes that, "After a decade of weak demand driven by low interest rates, profitability is recovering as rises in government bond yields improve returns and margins on life insurance products."

There are two distinct channels, however, through which interest rates affect insurers. The first is a duration channel: insurers hold long-duration liabilities, and when duration gaps are negative, falling rates reduce net asset value (Hartley et al., 2016; Koijen and Yogo, 2022a,b; Li, 2024).[13] The second is a franchise-value channel: low rates compress underwriting margins by limiting insurers' ability to offer attractive guarantees relative to households' outside options, thereby reducing the value of future business. As Koijen and Yogo (2022a) note, existing data have made it difficult to disentangle these two channels. In this paper, we make progress on this distinction by combining market valuations of insurance

[12] As the *Financial Times* reported, "The failure of Eurovita began last year as savers redeemed policies to take advantage of higher rates elsewhere. Eurovita's weakening capital position forced it to sell government bonds that had fallen in price." See "Eurovita/Cinven: flop raises concerns on buyout push into insurance," *Financial Times*, 3 July 2023.

[13] Grochola et al. (2023a); Grochola (2026) provide a detailed analysis of the sensitivity of European insurers' stock returns to interest rates and other market risk factors.

companies with granular regulatory data from EIOPA on the market value of insurers' assets and liabilities.

Our study is closely related to Drechsler et al. (2017), adapted to the insurance sector. When the yield curve is steep, insurers can offer guarantees at positive margins, attracting inflows that expand future balance sheets. When the slope is low, these margins compress, reducing the profitability of new business. Suppose that insurers' stock valuation is given, in logs, by:[14]

$$\log \text{Stock Valuation}_t = \log \text{NAV}_t + \log \text{Franchise Value}_t. \tag{3}$$

Here, NAV_t denotes the insurer's net asset value, defined as the current market value of its assets minus the *market value of liabilities*. Importantly, insurers are required to report the market value of their liabilities and to mark them to market each quarter using updated discount curves linked to Swap rates. NAV therefore captures the market value of the insurer's existing book of business. By contrast, the stock-market valuation also incorporates the value of future business, which we capture through franchise value.

To a first approximation, the interest-rate sensitivity of net asset value measures the duration mismatch between insurers' assets and liabilities, or the so-called duration gap. To some extent, the NAV also reflects new business and other flows occurring within the quarter. By contrast, stock valuations are forward looking and incorporate the discounted value of future business, which we refer to as franchise value.

We then regress stock returns, changes in NAV, and changes in franchise value—defined as the difference between stock returns and changes in NAV—for the set of publicly listed insurers domiciled in the Euro area. We relate these outcomes to changes in the 10-year rate, the one-year Swap rate, and the difference between the two, which we refer to as the slope of the yield curve. The standard specification in the literature regresses insurers' stock returns on changes in the 10-year rate while controlling for broader equity-market returns.[15] We hence estimate the following regression model:

$$\Delta \log y_i = \alpha_i + \beta \Delta \text{Interest Rates}_t + \gamma \text{Market Returns}_t + \varepsilon_t, \tag{4}$$

where y_i is either the insurer stock returns, the insurer NAV or the franchise value. We use insurer fixed effects to control for time-invariant insurer characteristics. We use a specification using quarter-on-quarter changes but also provide the main results for the year-on-year changes. Our sample runs from 2016 to 2024.

Before delving into the details of our regression estimates, it is useful to examine rolling

[14] We assume additivity in logs to simplify the exposition and make the results more intuitive.

[15] We obtain insurer stock returns from Bloomberg and use the STOXX Europe 600 as the market index.

estimates of Equation 4 using weekly data for the EURO STOXX insurance index. The results are shown in Figure F.4. Consistent with the findings in the literature, the sensitivity of insurers' stock returns to changes in 10-year rates became positive after 2010 and, in particular, was clearly positive by 2016. Our sample therefore corresponds to a period in which the stock-market sensitivity of insurers to long-term rates is positive.

Column (1) of Table III reports the results of regressing stock returns on the 10-year rates. We find a positive and statistically significant coefficient of 6.1, implying that a one-percentage-point increase in 10-year interest rates leads to an increase of 6.1% in stock valuation. This has usually been interpreted as evidence that insurers had a negative duration gap of 6.

In Column (2), we add the one-year rate and find that the sensitivity to short-term rates is negative. The coefficient on the 10-year rate increases to 9.3, while the coefficient on the one-year rate is -4.4. Thus, when both rates are included in the regression, insurers' stock returns benefit from higher long-term rates but decline when short-term rates rise. The two coefficients are not identical in magnitude, but they have opposite signs. Consistent with this pattern, when we regress stock returns directly on the slope of the yield curve—the difference between the 10-year and one-year rates—in Column (3), we estimate a positive coefficient of 6.6.

In Column (4), we regress the change in NAV, in logs, on the 10-year rate. We estimate a coefficient of 1.6. This coefficient is much smaller than the corresponding estimate for stock returns and is not statistically different from zero. Importantly, this coefficient provides a more direct approximation of the duration gap, and its magnitude is small. A duration gap of 1.6 is similar to EIOPA's own estimates of insurers' duration gaps (EIOPA, 2019) and to the interest-rate sensitivity of equity reported by insurance companies themselves. In column (5) we also find that the NAV increases with long-term rates but is reduced by an increase in short-term rates.

In Columns (7) and (8), we instead regress franchise value—defined simply as the difference between stock returns and changes in NAV—on interest rates. We find that franchise value increases with the 10-year rate. A one-percentage-point increase in long-term rates raises franchise value by 5.1%. Once we control for the one-year rate, the coefficient on the 10-year rate increases further, to 6.2. By contrast, an increase in the one-year rate reduces franchise value, consistent with the idea that higher short-term rates make households' outside options, such as deposits, more attractive.

We find similar results when we use year-on-year stock returns, changes in NAV, and franchise values, as shown in Columns (9)–(11). Stock returns increase with long-term rates, and their sensitivity is substantially larger than that of NAV. In these specifications,

Table III: Interest Rate Sensitivity of Insurer Valuations

	Quarter-on-Quarter								Year-on-Year		
Dependent Variable	Stock Return			NAV			Franchise		Stock Return	NAV	Franchise
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Δ 10Y Swap Rate	6.09***	9.35***		1.60	4.69*		5.14**	6.20*	4.36***	−0.05	4.91**
	(1.91)	(2.32)		(1.48)	(2.31)		(1.89)	(3.38)	(1.45)	(1.35)	(1.81)
Δ 1Y Swap Rate		−4.43**			−4.07**			−1.41			
		(2.08)			(1.70)			(3.30)			
Δ Slope			6.64**			4.32**					
			(2.83)			(1.93)					
Market Return	1.10***	1.10***	1.06***	0.31***	0.31***	0.30***	0.79***	0.79***	1.08***	0.38***	0.74***
	(0.14)	(0.14)	(0.15)	(0.07)	(0.06)	(0.06)	(0.12)	(0.12)	(0.14)	(0.08)	(0.14)
Insurer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.435	0.443	0.426	0.093	0.107	0.106	0.215	0.216	0.440	0.214	0.239
Observations	573	573	573	572	572	572	554	554	568	513	498

Note: The dependent variable is the insurer stock return, the change in net asset value, or franchise value, as indicated in the column heading. Columns (1)–(8) measure all variables as quarter-on-quarter changes; columns (9)–(11) measure them as year-on-year changes. Δ 10Y Swap Rate and Δ 1Y Swap Rate are the changes in the ten-year and one-year euro Swap rates, and Δ Slope is the change in the slope of the Swap curve; Market Return is the return on the aggregate equity market over the corresponding horizon. All specifications include insurer fixed effects. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

the sensitivity of NAV to long-term rates is even closer to zero and remains statistically insignificant. Thus, also at the annual horizon, most of the sensitivity of insurers' stock valuations to long-term rates appears to operate through franchise value rather than through the valuation of the existing balance sheet.

Evidence from the Universe of Insurers. We also extend the analysis to the universe of individual insurers and ask how much of the variation in net asset values is actually explained by interest rates. For this exercise, we observe NAV but not stock returns. If duration mismatch were the dominant mechanism, changes in interest rates should explain a substantial fraction of NAV fluctuations at the insurer level.

We estimate the regression separately for each insurer, first using only changes in interest rates and then adding sovereign and credit spreads as controls.[16] We find it particularly informative to examine the explanatory power of these regressions. Appendix Figure F.6 plots the distribution of R^2 across insurers, where each observation corresponds to a separate insurer-level regression of NAV on interest rates. Interest rates alone explain only a small fraction of the variation in insurers' NAV, with a median R^2 of approximately 6%. For many insurers, the R^2 is close to zero.

[16]Sovereign spreads are the spread of Italian and Spanish bonds versus German bunds. The credit spread is the spread of BBB Euro area corporate bonds versus AAA corporate bonds.

Adding sovereign and corporate credit spreads raises the explanatory power substantially, with the median R^2 increasing to nearly 30%, consistent with Koijen and Yogo (2023), who show that insurers are effectively levered to credit spreads. By contrast, both the explanatory power of interest rates and the estimated sensitivity of NAV to interest rates remain small, consistent with our findings for the subset of publicly listed insurers.[17]

Overall, the evidence in this section shows that our emphasis on liability flows—and on the role of interest rates in shaping those flows—is consistent with the response of stock-market valuations. In particular, most of the sensitivity of insurers' stock valuations to interest rates appears to operate through franchise value rather than through the mark-to-market value of the existing balance sheet. Importantly, we are not claiming that insurers do not have duration mismatches or duration gaps. Indeed, insurers frequently discuss these mismatches in their own reports. Our findings instead suggest that these duration gaps are relatively small, consistent with insurers' own disclosures.

7. Quantifying the Effects of Interest Rates and Regulation: A Model of Life Insurers

We now develop a model of life insurers that organizes the empirical findings of Sections 3–5 to study how interest rates and regulation jointly shape insurers' product mix and, through it, their demand for long-term bonds. The model builds on Koijen and Yogo (2015) and Koijen and Yogo (2022b), adapting their liability valuation framework to the European context.

The key purpose of the model is to understand how interest rates and regulation shape the decline in insurer bond demand over the last decade. Propositions 2 and 1 deliver closed-form solutions for the total derivatives of the model that help us cleanly calibrate our model to our empirical moments. This framework delivers the lower bond holdings of insurers through two margins: first through a contraction in new business from households, and second through a reallocation of business lines from profit-participation, which is more bond-intensive, to unit-linked products.

7.1 Environment

Time is discrete, indexed by t. The short-term interest rate i_t and the long-term interest rate y_t are exogenous. We define the term spread as $s_t = y_t - i_t$.

[17] The estimated interest-rate sensitivities vary substantially across insurers, with a median coefficient of -1.4 in the univariate regressions. Once we control for sovereign and corporate credit risk, the median coefficient on long-term rates falls to -0.4, and is therefore close to zero. Figure F.5 plots the distribution of these coefficients.

Assets The insurer's general account can invest in two assets: a safe asset with expected return y_t and a risky asset with expected return $y_t + \mu$, where $\mu > 0$ is a constant spread. We can think about the two assets in terms of factor exposure. The safe bond has only interest rate risk, while the risky asset has credit risk or equity risk exposure but earns a risk premium. Let $w_{b,t}$ denote the share invested in safe bonds. The portfolio expected return is:

$$y_t^S(\alpha_t) = y_t + (1 - w_{b,t})\,\mu. \tag{5}$$

We assume that there is a stochastic discount factor $M_{t,t+s}$ that prices payoffs s periods ahead.

Profit Participation (PP) A profit-participation contract is issued at time t and matures at $t + T$. The policyholder pays a one-off premium of 1 (normalized) plus a lump-sum fee f_t^{PP}. The insurer invests the proceeds in its general account and earns a stochastic gross portfolio return $R_{t,t+T}^S$ over $[t, t + T]$. The contract guarantees the policyholder a minimum gross return $(1 + g_t)^T$, where

$$g_t = \phi_g \cdot y_t, \qquad \phi_g \in (0, 1), \tag{6}$$

is set as a fraction of the prevailing long-term yield, reflecting regulatory caps on guarantee rates—such as the German *Höchstrechnungszins* discussed in Section 5—that we assume bind. If the portfolio return exceeds the guarantee, the policyholder receives a share $\delta \in (0, 1)$ of the surplus. The policyholder's payoff at $t + T$ per unit of premium is:

$$L_{t+T} = (1 + g_t)^T + \delta \cdot \max\big(R_{t,t+T}^S - (1 + g_t)^T,\, 0\big)\,. \tag{7}$$

This is the guarantee floor plus δ call options on the portfolio return struck at $(1 + g_t)^T$.

Unit-Linked (UL) In addition to PP, the insurer may offer UL contracts. These are investment products in which the insurer invests fully on behalf of the policyholder. The policyholder bears all market risk, and the insurer earns a fixed fee f_t^{UL} per unit sold. There is no minimum return guarantee.

Liability Valuation The insurer's net liability value per new PP contract is the present value of what the insurer owes beyond what the portfolio delivers:

$$V_{t,t} = P_{t,t} - (1 - \delta) \cdot C_{t,t}, \tag{8}$$

where

$$P_{t,t} = \mathbb{E}_t\big[M_{t,t+T} \cdot \max\big((1+g_t)^T - R^S_{t,t+T},\, 0\big)\big] \tag{9}$$

is the put value—the cost of the guarantee—and

$$C_{t,t} = \mathbb{E}_t\big[M_{t,t+T} \cdot \max\big(R^S_{t,t+T} - (1+g_t)^T,\, 0\big)\big] \tag{10}$$

is the call value—the profit participation. The insurer retains a fraction $(1-\delta)$ of the upside, which offsets the cost of the guarantee.

Standard option pricing implies three properties of $V_{t,t}$ that drive the model's main results. First, $\partial V_{t,t}/\partial y_t < 0$: when yields are high, the portfolio return comfortably exceeds the guarantee floor—the put is out of the money and the insurer retains valuable calls; as yields fall, the put moves into the money and $V_{t,t}$ rises. Second, $\partial^2 V_{t,t}/\partial y_t^2 > 0$: this relationship is convex, so that low-rate environments amplify the effect of any further rate decline on guarantee costs. Third, $V_{t,t}$ depends on the portfolio allocation: a higher risky share α_t raises both the put and call values, with the net effect on $V_{t,t}$ pinned down by the insurer's asset allocation condition in equilibrium.

7.2 Household Demand

There is a unit mass of insurance customers in each period. Households decide whether to purchase a PP contract, buy UL, or exit the insurance sector altogether, holding their savings in bank deposits that yield the constant short-term rate i. We model this choice with a nested logit: the two insurance products form a nest, with nesting parameter $\lambda^N \in (0, 1]$, and deposits are the outside option. The deterministic indirect utilities are

$$v_t^{PP} = \delta_{PP} - \alpha_{PP} f_t^{PP} + \alpha_r\, y_t, \qquad v_t^{UL} = \delta_{UL} - \alpha_{UL} f_t^{UL}, \tag{11}$$

with the outside option normalized to zero. The long rate enters PP utility through the guarantee rule (6): a higher y_t raises the guaranteed return g_t relative to the deposit rate, so the slope of the yield curve governs the attractiveness of PP relative to the outside option—the mechanism documented empirically in Section 5. The nesting parameter λ^N regulates how much closer substitutes PP and UL are for each other than for deposits; $\lambda^N = 1$ recovers the standard multinomial logit.

Demand for the two products is

$$Q_t^{PP} = Q^{PP}(f_t^{PP}, f_t^{UL}, y_t), \qquad Q_t^{UL} = Q^{UL}(f_t^{PP}, f_t^{UL}, y_t),$$

and we summarize its local behavior with semi-elasticities. We adopt the convention $\varepsilon_k^{f^j} \equiv |\partial \log Q_t^k / \partial f_t^j|$ for fee elasticities and $\varepsilon_y^j \equiv \partial \log Q_t^j / \partial y_t$ for rate elasticities

For the fee elasticities we adopt the convention $\varepsilon_k^{f^j} \equiv |\partial \log Q_t^k / \partial f_t^j|$, and for the rate elasticities $\varepsilon_y^{PP} \equiv \partial \log Q_t^{PP} / \partial y_t$ and $\varepsilon_y^{UL} \equiv \partial \log Q_t^{UL} / \partial y_t$. Own-price and cross-price semi-elasticities are positive, reflecting substitutability between PP and UL, and $\varepsilon_y^{PP} > 0$ through the guarantee channel. Under the maintained assumption that each insurance product represents a modest fraction of household savings, a small-share approximation delivers *constant* semi-elasticities, which is what allows the comparative statics below to be solved in closed form (Appendix D states the approximation and the exact nested-logit formulas). [18]

7.3 Balance Sheet

The insurer's balance sheet has two accounts. The separate UL account evolves as:

$$B_t = R_{B,t}\, B_{t-1} + Q_t^{UL}, \tag{12}$$

where $R_{B,t}$ is the gross return on the risky asset. The general account backs PP liabilities and insurer equity. Policyholders pay a lump sum invested in the general account portfolio, so assets evolve as:

$$A_t = R_t^S\, A_{t-1} + (1 + f_t^{PP}) Q_t^{PP} + f_t^{UL}\, Q_t^{UL}, \tag{13}$$

where $\mathbb{E}_{t-1}\left[R_t^S\right] = 1 + y_{t-1} + \alpha_{t-1}\mu$ is the expected gross return on the general account portfolio. The UL fee $f_t^{UL} \cdot Q_t^{UL}$ accrues to the insurer with no corresponding liability. Equation (13) connects directly to the bond demand of insurers: holding fixed the bond portfolio share $\omega_{b,t}$, a decline in new PP business contracts the stock of assets A_t and so bond demand.

Liabilities have two components. The first, L_t^{PP}, is the policyholder's claim on the portfolio:

$$L_t^{PP} = R_{A,t}\, L_{t-1}^{PP} + Q_t^{PP}, \tag{14}$$

where $R_{A,t}$ is the return credited to existing policyholders, which embeds legacy guarantee rates and lapsation and is taken as given by the insurer. New contracts enter at face value.

The second component, L_t^G, is the market-consistent value of existing minimum return

[18] The nested structure disciplines the demand system in two ways that we exploit heavily in the calibration. First, the four fee semi-elasticities are generated by only three demand parameters $(\alpha_{PP}, \alpha_{UL}, \lambda^N)$, which implies that one cross-price elasticity depends on the other three elasticities and the product mix (see Appendix D.3). Second, because the long rate enters only PP utility, the two rate semi-elasticities are tied together by $\varepsilon_y^{UL} = -(\varepsilon_{UL}^{f^{PP}} / \varepsilon_{PP}^{f^{PP}})\, \varepsilon_y^{PP}$. Intuitively, a steeper curve draws customers into PP partly out of deposits and partly out of UL.

guarantees net of the participation offset:

$$L_t^G = \frac{V_{t-1,t}}{V_{t-1,t-1}} L_{t-1}^G + V_{t,t}\, Q_t^{PP}. \tag{15}$$

The existing guarantee stock is revalued each period by the ratio $V_{t-1,t}/V_{t-1,t-1}$—the change in the market-consistent option value of the legacy book—and new contracts contribute $V_{t,t}$ per unit of new business.

7.4 Regulation

We define statutory capital as equity minus required capital. Required capital has three components, reflecting the sources of risk on the insurer's balance sheet under Solvency II.

First, the minimum return guarantee exposes the insurer to interest rate risk. This generates a capital charge proportional to the minimum return guarantee liability L_t^G, with risk weight $\phi_1 > 0$, which is present regardless of portfolio allocation.

Second, the risky asset share α_t exposes the insurer to spread risk on assets backing L_t^{PP}. This generates a capital charge proportional to $(1 - \omega_{b,t})L_t^{PP}$, with risk weight $\phi_2 > 0$. The safe asset carries no spread risk charge, so an insurer fully invested in safe bonds faces only the first component.

Third, unit-linked business is not capital-free under risk-based regulation. Although the policyholder bears the market risk, UL contracts attract charges for lapse, expense, and operational risk, which scale with the size of the UL book. We capture these with a charge $\phi_L \geq 0$ per unit of UL liabilities.

Statutory capital is therefore:

$$K_t = \underbrace{A_t + B_t - (L_t^{PP} + L_t^G + B_t)}_{\text{equity}} - \underbrace{\big(\phi_1\, L_t^G + \phi_2\, \alpha_t\, L_t^{PP} + \phi_L\, B_t\big)}_{\text{required capital}}, \tag{16}$$

The risk weights (ϕ_1, ϕ_2, ϕ_L) are exogenous regulatory parameters; an increase in any of them represents a tightening of regulation. Low statutory capital can trigger a rating downgrade or regulatory action, and equity issuance is costly due to financial frictions. We model these costs through a cost function $C_t = C(K_t)$, which is continuous, twice continuously differentiable, strictly decreasing, and strictly convex. In other words, the marginal cost of capital $c_t = -\partial C/\partial K_t > 0$ increases as the stock of regulatory capital falls, reflecting the convexity of $C(\cdot)$.

7.5 The Insurer's Problem

The insurer optimises over the pricing and allocation of *new* contracts each period, taking the existing book of business as given. The return on legacy statutory capital, $R_{K,t}$, is determined by realised returns on the existing asset portfolio and the mark-to-market evolution of legacy guarantee liabilities—both of which embed inherited guarantee rates, lapsation, and past allocation decisions that are outside the insurer's current control.[19]

The insurer therefore chooses fees f_t^{PP}, f_t^{UL} and the safe asset share $\omega_{b,t} \in [0,1]$ to maximise current-period profits from new business, net of the cost of financial frictions:

$$J_t = \underbrace{(f_t^{PP} - V_{t,t})\, Q_t^{PP}}_{\text{PP net margin}} + \underbrace{f_t^{UL}\, Q_t^{UL}}_{\text{UL fee income}} - \underbrace{C(K_t)}_{\text{friction cost}} . \tag{17}$$

The first term is the net margin on new PP business: the fee collected minus the market-consistent cost of the guarantee liability being issued. The second term is fee income on UL, with no corresponding liability. Statutory capital reflects the legacy book plus the contribution of new business:

$$K_t = R_{K,t}\, K_{t-1} + \left(f_t^{PP} - (1+\phi_1)\, V_{t,t} - (1-\omega_{b,t})\right) Q_t^{PP} + \left(f_t^{UL} - \phi_L\right) Q_t^{UL}. \tag{18}$$

New PP business contributes the fee net of the regulation-inflated guarantee cost $(1+\phi_1)V_{t,t}$ and the spread risk charge $\phi_2\alpha_t$; new UL business contributes fee income net of the unit-linked charge ϕ_L. This last term is the point of departure from Koijen and Yogo (2022b) and from the earlier version of our model: unit-linked business now consumes regulatory capital, so regulation reaches both product lines directly.

7.6 Equilibrium Pricing

The first-order conditions for the two fees and the risky share characterize the equilibrium (derivations in Appendix D.1). Our focus in this paper is on the equilibrium selection of fees. We abstract from optimal portfolio choice precisely because, in the data, this channel is of second-order importance in explaining the bond holdings of insurers: what matters most is deriving model-implied household inflows, driven by the prices that insurers offer in equilibrium.

[19] We abstract from the effect of current decisions on future capital K_{t+1}, following Koijen and Yogo (2022b); this retains the key within-period trade-off between profitability and capital costs without requiring a fully dynamic solution.

Define the shadow cost of capital

$$\lambda_t = \frac{1 + c_t(1+\phi_1)}{1+c_t} > 1, \tag{19}$$

and the two per-customer surpluses

$$\Pi_t \equiv f_t^{PP} - \lambda_t V_{t,t} - \frac{c_t}{1+c_t}\phi_2\alpha_t, \qquad \Pi_t^{UL} \equiv f_t^{UL} - \frac{c_t}{1+c_t}\phi_L. \tag{20}$$

Π_t is the margin on a new PP contract net of the regulation-inflated guarantee cost and the spread-risk surcharge; Π_t^{UL} is the UL fee net of the marginal capital absorbed by a unit of UL business. The optimal PP fee is:

$$f_t^{PP} = \underbrace{\frac{1}{\varepsilon_{PP}^{f^{PP}}}}_{\text{mark-up}} + \underbrace{\lambda_t V_{t,t} + \frac{c_t}{1+c_t}\phi_2(1-\omega_{b,t})}_{\text{marginal cost}} + \underbrace{\Pi_t^{UL}\frac{\varepsilon_{UL}^{f^{PP}}}{\varepsilon_{PP}^{f^{PP}}}\frac{Q_t^{UL}}{Q_t^{PP}}}_{\text{cross-demand effect}}. \tag{21}$$

There are three components to the fee. First, there is the standard constant-elasticity mark-up. Second, the marginal cost of selling the product has two parts: $\lambda_t V_{t,t}$ is the cost of providing the guarantee, where $\lambda_t > 1$ reflects the additional cost from using up capital to satisfy regulatory requirements, whose cost rises with both c_t (the degree of capital constraint) and ϕ_1 (the stringency of regulation); and $\frac{c_t}{1+c_t}\phi_2(1-\omega_{b,t})$ is the spread risk surcharge, since each additional PP customer increases the capital charge on risky assets. Third, the cross-demand effect captures the gain from diverting customers to UL: raising f_t^{PP} shifts some households toward UL, where the insurer earns the capital-adjusted surplus Π_t^{UL} per diverted customer.

The optimal UL fee mirrors this structure:

$$f_t^{UL} = \underbrace{\frac{1}{\varepsilon_{UL}^{f^{UL}}}}_{\text{mark-up}} + \underbrace{\frac{c_t}{1+c_t}\phi_L}_{\text{marginal cost}} + \underbrace{\Pi_t\frac{\varepsilon_{PP}^{f^{UL}}}{\varepsilon_{UL}^{f^{UL}}}\frac{Q_t^{PP}}{Q_t^{UL}}}_{\text{cross-demand effect}}. \tag{22}$$

The key difference here is that the UL fee carries a marginal cost of its own: each unit of UL absorbs ϕ_L of capital, valued at the marginal cost of capital $\frac{c_t}{1+c_t}$. The cross-demand effect works in the opposite direction to the PP equation: raising f_t^{UL} diverts customers toward PP, where the insurer earns surplus Π_t per customer, which compresses the UL markup when PP is profitable.

The rest of our analysis will rely heavily on these two first-order conditions. First, when we calibrate our model, we will be using total derivatives derived from perturbing each of these conditions. Second, when we run experiments that consider various evolutions of interest rates and/or regulation, the first step is to understand the equilibrium effect on fees that are pinned down by these optimality conditions. This is what we turn to next.

8. Calibration

We now take the model to the data to quantify the relative importance of low long-term rates and risk-based regulation in explaining the decline in profit-participation (PP) business. We proceed in two steps. First, we calibrate the household demand system and capital-cost channel so that the model exactly reproduces a set of reduced-form empirical moments: the response of PP and unit-linked (UL) issuance to regulatory reform estimated by Barbu et al. (2025b), together with our estimates of how aggregate insurance flows and the PP–UL product mix respond to interest rates from Section 5. Second, we feed the calibrated model the observed changes in long-term rates and regulatory charges over 2016–2024 and compute the resulting counterfactual paths of PP and UL business. This nonlinear decomposition allows the two forces to interact rather than simply adding their separate effects. As we show below, this interaction is quantitatively important: tighter regulation becomes substantially more costly when low interest rates make guarantees expensive to provide, materially amplifying the contraction in guaranteed business and aggregate insurance inflows.

8.1 Targeted Moments

Regulatory moments We exploit the work of Barbu et al. (2025b) who use a natural experiment that introduces risk-based capital regulation for UK life insurers: they obtain estimates of how fees and new business by product lines respond to an increase in the capital charge on guaranteed business. Expressed per unit of z, their responses are:

$$\frac{df_t^{PP}}{dz} = 1.20, \qquad \frac{df_t^{UL}}{dz} = 0.63, \qquad \frac{d\log Q_t^{PP}}{dz} = -7.31, \qquad \frac{d\log Q_t^{UL}}{dz} = -1.33. \tag{23}$$

A tighter charge raises both fees and lowers issuance of both products, with the guaranteed line responding far more strongly. These four moments are matched exactly to the model's total derivatives expressed in Propositions 1 and 2.

Interest-rate moments For the interest-rate block we target two quantity moments: total flows (Q_t^I) and the product mix $m_t^{UL} = Q_t^{UL}/(Q_t^{PP} + Q_t^{UL})$:

$$\frac{dQ_t^I}{dy_t} = 0.12, \qquad \frac{dm_t^{UL}}{dy_t} = -0.135 \tag{24}$$

These moments imply that[20]

$$\frac{d\log Q_t^{PP}}{dy_t} = 0.6025, \qquad \frac{d\log Q_t^{UL}}{dy_t} = -0.0050 :$$

essentially all of the flow response loads on the guaranteed line, consistent with the micro evidence in Table I that unit-linked inflows are far less sensitive to the slope than non-unit-linked inflows.

Imposed levels The remaining parameters are disciplined outside the calibration. We set the marginal cost of capital to $c_t = 1.53$ and the net liability value of a new PP contract to $V_{t,t} = 0.05$, consistent with Koijen and Yogo (2022b). We set the guarantee risk weight to $\phi_1 = 1.4$, implying a regulatory wedge of $z \equiv \phi_1 V_{t,t} = 0.07$, matching the size of the Barbu et al. (2025b) experiment. We set the pre-regulation savings shares to $(s_{PP}, s_{UL}) = (0.20, 0.10)$, implying total insurance penetration of $s_I = 0.30$ and a PP–UL mix consistent with Section 3. The remaining regulatory input is $\tau \equiv \phi_L/z$, which we set to 2.0 in the baseline, so that $\phi_L = 0.14$; in Appendix D.5, we show that admissible calibrations restrict τ to a narrow range around this value. Finally, we anchor the calibration at $y_0 = 1.5$, the 2016 long-term rate in percentage points, so that the local empirical moments and the starting point of the counterfactual experiment coincide.[21]

8.2 Calibration Results

Table IV reports the calibrated parameters, distinguishing those imposed externally from those chosen to match the empirical moments above. Appendix D.5 and Appendix D.6 provide details on the calibration procedure and implementation.

Three features of the calibration are worth highlighting. First, as an untargeted check

[20] One can show that:

$$\frac{dQ_t^I}{dy_t} = Q_t^{PP}\,\frac{d\log Q_t^{PP}}{dy_t} + Q_t^{UL}\,\frac{d\log Q_t^{UL}}{dy_t}$$

and that

$$\frac{dm_t^{UL}}{dy_t} = m_t^{UL}(1-m_t^{UL})\left(\frac{d\log Q_t^{UL}}{dy_t} - \frac{d\log Q_t^{PP}}{dy_t}\right)$$

.

[21] This choice also matters for equilibrium existence. Anchoring instead at the pre-QE rate $y_0 = 4$ would require extrapolating the calibrated demand system through a 2.5-percentage-point decline before the experiment begins. Along this path, $V_{t,t}(y)$ roughly doubles and the static equilibrium reaches a fold and ceases to exist. Anchoring at the 2016 rate keeps the experiment within the region where the equilibrium is well defined.

Imposed / hand-set			*Calibrated*		
c_t	marginal cost of capital	1.53	a	$\varepsilon_{PP}^{f^{PP}}$	6.478
$V_{t,t}$	net liability value	0.05	b	$\varepsilon_{UL}^{f^{UL}}$	5.727
ϕ_1	MRG risk weight	1.4	u	$\varepsilon_{UL}^{f^{PP}}$	1.893
$z = \phi_1 V_{t,t}$	regulatory wedge	0.07	v	implied by nested logit	0.730
$\tau = \phi_L / z$	UL charge ratio	2.0	$\Gamma_t X$	capital feedback	1.588×10^{-2}
ϕ_L	UL capital charge	0.14	λ^N	nesting parameter	0.944
s_{PP}, s_{UL}	pre-reg. shares	0.20, 0.10	α_{PP}, α_{UL}	utility slopes	7.90, 6.10
y_0	anchor long rate (pp)	1.5	α_r	rate slope	0.0793
dQ^I/dy	flow moment	0.12	δ_{PP}, δ_{UL}	intercepts	0.857, −0.014
$x = dm^{UL}/dy$	mix moment (chosen)	−0.135	$\partial V_{t,t}/\partial y$	liability slope (per pp)	−0.0230
T, ϕ_g	maturity, guarantee frac.	20, 0.6	ε_y^{PP}, ε_y^{UL}	rate semi-elast.	0.065, −0.019
δ, σ	participation	0.9	η	cost-of-capital curvature	171.5
K_0	capital normalisation	1.0	f_t^{PP}, f_t^{UL}	implied fee levels	0.279, 0.307

Table IV: Calibrated Model Parameters

on levels, the model implies a lump-sum PP fee of $f^{PP} = 0.279$ per unit of premium. The observed fee of roughly 0.0065 is quoted annually; over a contract with an average duration of around thirty years, this corresponds to a lump-sum equivalent of approximately 0.23, placing the model-implied fee in the right range. Second, the baseline value of ϕ_L is relatively high. This is needed for the regulatory tightening to generate a sufficiently strong contraction in UL issuance; otherwise, substitution away from PP toward UL dominates the direct effect of tighter regulation. Third, the capital cost function is specified as $C(K) = Ae^{-\eta K}$, with an implied curvature of $\eta = 171.5$. At this value, the marginal cost of capital changes by a factor of e for every 0.006 change in statutory capital. This strong convexity is central to the model's amplification mechanism: once regulation pushes insurers into a more capital-scarce region, the effect of low interest rates on marginal capital costs becomes substantially larger.

8.3 The Transition Experiment, 2016–2024

We now use the calibrated model to trace the transition from 2016 to 2024, subjecting insurers to two forces: (i) a gradual decline in long-term interest rates and (ii) the phase-in of tighter regulatory capital requirements under Solvency II.[22] We focus on flows of new business in each period. These flows feed back into the insurer's capital position, so the regulatory cost of issuing new contracts evolves endogenously along the transition.

Table V reports the results. New PP business falls sharply, by 68%, while UL business declines by a more modest 22%. As a result, the UL share of new business rises from 0.42 to 0.64. The asymmetry is intuitive. Both products become more expensive as tighter

[22]The transition paths are provisional. For now, both shocks are phased in linearly, with the long rate declining from 1.5 to 0.5 percentage points and ϕ_1 rising from 0 to 1.4. In a later draft, we will replace these with the observed interest-rate path and the regulatory phase-in schedule.

year	y_t	$\phi_{1,t}$	$\phi_{L,t}$	Q_t^{PP}	Q_t^{UL}	Q_t^{I}	m_t^{UL}	f_t^{PP}	f_t^{UL}	c_t	K_t
2016	1.50	0.00	0.000	0.227	0.165	0.392	0.422	0.249	0.209	0.007	1.031
2017	1.38	0.17	0.017	0.216	0.169	0.385	0.439	0.255	0.208	0.020	1.025
2018	1.25	0.35	0.035	0.205	0.172	0.377	0.456	0.262	0.208	0.056	1.019
2019	1.12	0.52	0.052	0.192	0.172	0.363	0.472	0.271	0.211	0.154	1.013
2020	1.00	0.70	0.070	0.175	0.166	0.341	0.487	0.285	0.222	0.386	1.008
2021	0.88	0.88	0.087	0.153	0.155	0.308	0.502	0.307	0.242	0.859	1.003
2022	0.75	1.05	0.105	0.129	0.142	0.270	0.525	0.335	0.267	1.765	0.999
2023	0.62	1.22	0.122	0.102	0.132	0.234	0.563	0.372	0.292	3.488	0.995
2024	0.50	1.40	0.140	0.073	0.129	0.201	0.639	0.426	0.315	6.662	0.991

Table V: The baseline transition. In 2016 regulation is absent, statutory capital is slack, and $c_t \approx 0$; by 2024 the joint shock has pushed c_t to 6.7 even though K_t falls by less than 4% of its level—the calibrated curvature $\eta = 171.5$ at work.

regulation reduces statutory capital and raises the marginal cost of capital, which insurers pass through into higher fees. PP contracts, however, face an additional adverse effect from falling long-term rates. Lower rates reduce the guaranteed return offered to households while simultaneously increasing the value, and hence the regulatory cost, of the guarantee borne by the insurer. PP therefore becomes less attractive from both sides of the market: households receive a less attractive guarantee, while insurers must charge more to provide it. UL contracts are affected by the common increase in capital scarcity, but do not bear this additional guarantee channel, so their issuance falls much less. The final columns of Table V make this mechanism explicit: Solvency II progressively tightens the capital constraint, while lower rates raise the regulatory burden of guaranteed business, causing the two shocks to reinforce one another.

8.3.1 Interaction Effects

Because interest rates and regulation changed simultaneously, we next ask whether their effects simply add up or instead reinforce one another. We therefore re-run the transition with each shock in isolation and compare the sum of the two responses with the full transition.

Table VI shows that the interaction is quantitatively important. Of the total decline in PP business, 52% is explained by lower long-term rates alone and 11% by regulation alone, while the remaining 37% arises from their interaction. The intuition is straightforward: each shock reduces statutory capital and raises its marginal cost, so when both occur together they push the insurer into a more capital-scarce region where the effect of each shock is amplified.

The interaction is weaker for UL business because the two forces partly offset one another. Lower rates shift households from PP toward UL, while tighter regulation raises the cost of

	Total	Yield	Regulation	Interaction
$\Delta \log Q^{PP}$	-1.136	-0.596	-0.125	-0.415
$\Delta \log Q^{UL}$	-0.248	$+0.263$	-0.501	-0.010
Δm^{UL}	$+0.217$	$+0.211$	-0.088	$+0.095$
Δf^{PP}	$+0.177$	$+0.080$	$+0.030$	$+0.067$
Δf^{UL}	$+0.105$	-0.016	$+0.098$	$+0.024$
Δc_t	$+6.65$	$+0.02$	$+1.52$	$+5.12$

Table VI: Decomposition of 2016–2024 changes. "Yield" freezes regulatory parameters at their 2016 values; "Regulation" freezes y_t at 1.5; Interaction is the residual effect to obtain the Total.

supplying UL. As a result, regulation ultimately dominates and UL issuance falls, but the opposing effects limit the amplification.

9. Back-of-the-Envelope Calculation: Effect on Bond Yields

The previous sections established that household flows into the insurance sector contracted sharply after 2015 and that declining interest rates and regulation are important drivers of this shift. In equilibrium, however, these flows are not lost: they are reallocated to, for example, mutual funds or bank deposits. Whether this reallocation matters for bond markets depends on whether insurance companies differ meaningfully from other investors in their exposure to long-duration assets.

To estimate the asset pricing implications of contracted insurance flows, we build on the insights of Koijen and Yogo (2019) and Gabaix and Koijen (2021) that provide a simple mapping from changes in investor demand to asset prices. The mechanism is simple: households reallocate savings across intermediaries that differ in their portfolio exposures. Because insurance companies hold far more long-term bonds than the mutual funds and banks absorbing the redirected flows, the reallocation generates a net reduction in demand for duration, even though aggregate flows sum to zero. The resulting price impact is governed by the demand elasticity of the remaining long-term bond investors.

We formalize this idea using a simple sufficient-statistic representation that maps flows into price changes. We provide a brief summary here and refer to Appendix E for details. The effect of flows on equilibrium yields depends on three sufficient statistics: the magnitude of flows, the degree of market segmentation, and the elasticity of demand for long-term bonds.

We now quantify these objects to provide a back-of-the-envelope calculation. First, we measure flows into the insurance sector. Relative to a counterfactual in which households

maintain their pre-QE allocation to insurance products, we estimate a cumulative shortfall of €1.7 trillion between 2015 and 2025.[23] These flows are economically large, particularly relative to the stock of long-term bonds, which constitutes insurers' primary asset class. Second, we quantify differences in portfolio exposures across intermediaries. Insurance companies allocate about 31% of their assets to long-term bonds, compared with 16% for other investors (see Appendix Figure E.1). As a result, when one euro flows out of the insurance sector and is reallocated to other intermediaries, approximately 15 cents are withdrawn from long-term bonds in equilibrium. This reflects a structural difference in maturity preferences across investor sectors. Third, we adopt a conservative estimate of the price multiplier, consistent with Chaudhary et al. (2024) and related studies. This value reflects the relatively low elasticity of demand for long-duration bonds, particularly at maturities where close substitutes are limited.

Combining these estimates gives an increase in yields of approximately 50 basis points. Across alternative calibrations—varying flows, segmentation, and elasticities—the implied effect ranges between 40 and 100 basis points (see Table E2).

The key insight is that reallocations of household savings across intermediaries have first-order effects on asset prices when intermediaries differ in their portfolio composition. In our setting, the contraction of the insurance sector reduces the presence of a key preferred-habitat investor in long-term bond markets. As a result, equilibrium demand for duration declines and yields increase.

10. Conclusion

Euro area life insurers have retreated sharply from long-term bond markets: their ownership share of ten- to fifteen-year government bonds fell from 34% in 2016 to 19% in 2024. Using confidential EIOPA data covering the universe of Euro area insurers, we show that this retreat reflects changes in the size and composition of their liabilities rather than active portfolio rebalancing. Households channelled a declining share of savings into insurance, and insurers shifted from bond-intensive guaranteed contracts toward unit-linked products invested mainly in equities. Because insurers pass roughly seventy cents of every euro of net premiums directly into bonds, these liability-side margins account for most of the decline.

Two forces drove this adjustment: the prolonged decline in long-term rates, which made guaranteed products unattractive relative to households' outside options, and the introduction of risk-based capital regulation. Our model attributes about half of the collapse in guaranteed business to low rates, a tenth to regulation alone, and the remainder to their

[23] With total household wealth of approximately €30 trillion, this corresponds to a net reallocation of about −5.6% of wealth away from the insurance sector.

interaction, as Solvency II arrived when the cost of existing guarantees was near its peak.

The contraction of the sector removed a key source of stable demand for duration, raising long-term yields by roughly 50 basis points. More broadly, our results point to a distinction between horizons: over short windows policy shifts how intermediaries allocate a given balance sheet, but over longer horizons it changes which intermediaries households invest through—and that margin dominates.

References

(2013): *European System of Accounts (ESA 2010)*, Luxembourg: Eurostat, European Commission, see Chapter 16, esp. §§16.10–16.14, 16.31–16.33, 16.52, and 16.70–16.71.

Adrian, T., R. K. Crump, and E. Moench (2013): "Pricing the term structure with linear regressions," *Journal of Financial Economics*, 110, 110–138.

Agnew, J., P. Balduzzi, and A. Sundén (2003): "Portfolio Choice and Trading in a Large 401(k) Plan," *American Economic Review*, 93, 193–215.

Albertazzi, U., B. Becker, and M. Boucinha (2021): "Portfolio rebalancing and the transmission of large-scale asset purchase programs: Evidence from the Euro area," *Journal of Financial Intermediation*, 48, 100896.

Altavilla, C., L. Brugnolini, R. S. Gürkaynak, R. Motto, and G. Ragusa (2019): "Measuring euro area monetary policy," *Journal of Monetary Economics*, 108, 162–179.

Andersen, S., J. Campbell, K. Meisner-Nielsen, and T. Ramadorai (2014): "Inattention and inertia in household finance: Evidence from the Danish mortgage market," .

Andonov, A., K. A. Jansen, and J. D. Rauh (2025): "When Cash Flows Turn Negative: Liquidity-Driven Selling by Pension Funds," *Available at SSRN 5498920*.

Aquilina, M., F. Garavito, G. Gelos, U. Lewrick, F. Packer, G. Pinter, V. Sushko, and K. Todorov (2025): "The transformation of the life insurance industry: systemic risks and policy challenges," *BIS Papers*.

Banque de France (2024): "National Financial Accounts: Methodology Note (ESA 2010 base 2014)," Tech. rep., Banque de France, see p. 11 for F.62 treatment of premiums, supplements, benefits, and exclusion of holding gains/losses.

Barbu, A. (2023): "Ex-post loss sharing in consumer financial markets," *Available at SSRN 4079524*.

Barbu, A., D. Humphry, and I. Sen (2025a): "The evolution of insurance markets: Insurance provision and capital regulation," Tech. rep., Working Paper.

Barbu, A., I. Sen, and D. Humphry (2025b): "The Evolution of Insurance Markets: Capital Regulation and Insurance Provision," Tech. rep., Working Paper, preliminary.

Becker, B. and V. Ivashina (2015): "Reaching for Yield in the Bond Market," *The Journal of Finance*, 70, 1863–1902.

Becker, B., M. M. Opp, and F. Saidi (2022): "Regulatory Forbearance in the U.S. Insurance Industry: The Effects of Removing Capital Requirements for an Asset Class," *The Review of Financial Studies*, 35, 5438–5482.

Begenau, J., M. Piazzesi, and M. Schneider (2015): "Banks' risk exposures," Tech. rep., National Bureau of Economic Research.

Breckenfelder, J. and V. De Falco (2023): "Investor heterogeneity and large-scale asset purchases," *Available at SSRN 4719227*.

Bretscher, L., L. Schmid, I. Sen, and V. Sharma (2022): "Institutional corporate bond pricing," *Swiss Finance Institute Research Paper*.

Brunnermeier, M. K. and S. Nagel (2008): "Do Wealth Fluctuations Generate Time-Varying Risk Aversion? Micro-evidence on Individuals," *American Economic Review*, 98, 713–36.

Chaudhary, M., Z. Fu, and J. Li (2023): "Corporate bond multipliers: Substitutes matter," *Available at SSRN*.

Chaudhary, M., Z. Fu, and H. Zhou (2024): "Anatomy of the Treasury Market: Who Moves Yields?" *Available at SSRN*.

Coppola, A. (2025): "In safe hands: The financial and real impact of investor composition over the credit cycle," *The Review of Financial Studies*, hhaf017.

Corell, F., F. Holm-Hadulla, M. Leombroni, L. Mota, and M. Papoutsi (2025): "The Liquidity Promises of QE," .

——— (2026): "Drivers of Convenience Yields," SSRN Working Paper 4656963.

Corradin, S., A. Fontana, C. Kubitza, and A. Maddaloni (2025): "Insurance Companies in the Euro Area: Asset Allocation and Impact on Financial Markets," ECB Discussion Paper 28, European Central Bank.

Darmouni, O., K. Siani, and K. Xiao (2022): "Nonbank fragility in credit markets: Evidence from a two-layer asset demand system," *Available at SSRN*, 4288695.

Domanski, D., H. S. Shin, and V. Sushko (2017): "The hunt for duration: Not waving but drowning?" *IMF Economic Review*, 65, 113–153.

Drechsler, I., A. Savov, and P. Schnabl (2017): "The Deposits Channel of Monetary Policy*," *The Quarterly Journal of Economics*, 132, 1819–1876.

Du, W., A. Fontana, P. Jakubik, R. S. J. Koijen, and H. S. Shin (2023a): "International Portfolio Frictions," BIS Working Papers 1137, Bank for International Settlements, presented at the 22nd BIS Annual Conference, Basel, June 2023.

Du, W., A. Fontana, P. Jakubik, R. S. J. Koijen, and H.-S. Shin (2023b): "International Portfolio Frictions," Tech. rep., BIS Working Paper 1137.

EIOPA (2019): "Report on Insurers' Asset and Liability Management in Relation to the Illiquidity of Their Liabilities," Tech. Rep. EIOPA-BoS-19-593, EIOPA, Frankfurt.

Ellul, A., C. Jotikasthira, and C. T. Lundblad (2011): "Regulatory pressure and fire sales in the corporate bond market," *Journal of Financial Economics*, 101, 596–620.

Ellul, A., C. Jotikasthira, C. T. Lundblad, and Y. Wang (2015): "Is Historical Cost Accounting a Panacea? Market Stress, Incentive Distortions, and Gains Trading," *The Journal of Finance*, 70, 2489–2538.

Fang, C. and K. Xiao (2025): "What Do 40 Trillion of Portfolio Holdings Say about Monetary Policy Transmission?" Tech. rep., Working Paper, Columbia.

Favero, C. A. and R. Fernandez-Fuertes (2023): "Modelling the Term Structure with Trends in Yields and Cycles in Excess Returns," BAFFI CAREFIN Working Paper 23210, BAFFI CAREFIN, Centre for Applied Research on International Markets Banking Finance and Regulation, Universita' Bocconi, Milano, Italy.

Gabaix, X. and R. S. Koijen (2021): "In search of the origins of financial fluctuations: The inelastic markets hypothesis," Tech. rep., National Bureau of Economic Research.

Gagnon, J., M. Raskin, J. Remache, and B. Sack (2011): "The financial market effects of the Federal Reserve's large-scale asset purchases," .

Greenwood, R. M. and A. Vissing-Jorgensen (2018): "The impact of pensions and insurance on global yield curves," *Harvard Business School Finance Working Paper*, 19–59.

Grochola, N. (2026): "The influence of negative interest rates on European life insurance companies," *Journal of Risk and Insurance*, n/a.

Grochola, N., M. J. Browne, H. Gründl, and S. Schlütter (2023a): "Exploring the market risk profiles of US and European stock insurers," *Risk Management and Insurance Review*, 26, 287–341.

Grochola, N., H. Grundl, and C. Kubitza (2023b): "Life Insurance Convexity," Tech. rep., ECB Working Paper.

Haddad, V., A. Moreira, and T. Muir (2024): "Asset purchase rules: How QE transformed the bond market," Tech. rep., Working paper, UCLA, Rochester, and USC.

Hartley, D., A. Paulson, and R. J. Rosen (2016): "Measuring interest rate risk in the life insurance sector," *The economics, regulation, and systemic risk of insurance markets*, 124.

Hombert, J. and V. Lyonnet (2022): "Can Risk Be Shared across Investor Cohorts? Evidence from a Popular Savings Product," *The Review of Financial Studies*, 35, 5387–5437.

Jansen, K. (2023): "Long-Term Investors, Demand Shifts, and Yields," Tech. rep., DNB Working Paper.

Jansen, K. A., W. Li, and L. Schmid (2024): "Granular treasury demand with arbitrageurs," Tech. rep., National Bureau of Economic Research.

Jiang, Z. and J. Sun (2024): "Quantitative tightening with slow-moving capital," Tech. rep., National Bureau of Economic Research.

Kaminska, I. and G. Zinna (2020): "Official demand for US debt: Implications for US real rates," *Journal of Money, Credit and Banking*, 52, 323–364.

Koijen, R. S., F. Koulischer, B. Nguyen, and M. Yogo (2017): "Euro-area quantitative easing and portfolio rebalancing," *American Economic Review*, 107, 621–627.

Koijen, R. S. and M. Yogo (2021): "The evolution from life insurance to financial engineering," Tech. rep., National Bureau of Economic Research.

——— (2022a): "Global life insurers during a low interest rate environment," in *AEA Papers and Proceedings*, American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203, vol. 112, 503–508.

Koijen, R. S. J., F. Koulischer, B. Nguyen, and M. Yogo (2021): "Inspecting the Mechanism of Quantitative Easing in the Euro Area," *Journal of Financial Economics*, 140, 1–20.

Koijen, R. S. J. and M. Yogo (2015): "The Cost of Financial Frictions for Life Insurers," *American Economic Review*, 105, 445–475.

——— (2016): "Shadow Insurance," *Econometrica*, 84, 1265–1287.

——— (2019): "A Demand System Approach to Asset Pricing," *Journal of Political Economy*, 127, 1475–1515.

——— (2022b): "The Fragility of Market Risk Insurance," *Journal of Finance*, 77, 815–862.

——— (2023): "Understanding the ownership structure of corporate bonds," *American Economic Review: Insights*, 5, 73–91.

Krishnamurthy, A., S. Nagel, and A. Vissing-Jorgensen (2018): "ECB policies involving government bond purchases: Impact and channels," *Review of Finance*, 22, 1–44.

Krishnamurthy, A. and A. Vissing-Jorgensen (2012): "The aggregate demand for treasury debt," *Journal of Political Economy*, 120, 233–267.

Kubitza, C. (2025): "Investor-Driven Corporate Finance: Evidence from Insurance Markets," *Review of Financial Studies*, earlier versions include ICIR Working Paper No. 43/21; ECB Working Paper Series No. 2816.

Leombroni, M., A. Vedolin, G. Venter, and P. Whelan (2021): "Central bank communication and the yield curve," *Journal of Financial Economics*, 141, 860–880.

Li, Z. (2024): "Long Rates, Life Insurers, and Credit Spreads," Available at SSRN: https://ssrn.com/abstract=4465485 or http://dx.doi.org/10.2139/ssrn.4465485.

Li, Z. and D. Wenning (2025): "From Long to Short: How Interest Rates Shape Life Insurance Markets," SSRN Working Paper.

Lou, D. (2012): "A flow-based explanation for return predictability," *The Review of Financial Studies*, 25, 3457–3489.

Mota, L. and K. Siani (2023): "Financially sophisticated firms," *Available at SSRN 4613366*.

Sen, I. (2023): "Regulatory limits to risk management," *The Review of Financial Studies*, 36, 2175–2223.

A. Portfolio Rebalancing

We now ask how directly these flows translate into bond demand: If insurers allocated new inflows in the same proportions as their existing portfolio, the pass-through would be one-for-one. In practice, however, new premiums need not mirror the existing allocation: insurers may temporarily park inflows in cash as a liquidity buffer, direct them toward equities or alternative assets, or adjust portfolio weights in response to changing market conditions. We estimate a pass-through of approximately €0.70 per euro of net premiums confirming that the bulk of new inflows reaches the bond market. This is the key link in the chain: because insurers invest incoming premiums on profit participation products predominantly in bonds, then the contraction in these flows maps almost one-for-one into a contraction in bond demand. We show that this is indeed the case, and that liability-driven flows dwarf portfolio rebalancing as a driver of insurers' bond purchases.

A.1 Flows versus Portfolio Rebalancing

To organize our discussion, it is convenient to decompose investor demand for bonds (in euros) as the product of portfolio weights and assets under management:

$$\text{Bond Demand}_t \;=\; w_{b,t} \;\cdot\; A_t. \tag{25}$$

Insurers trade for two main reasons: portfolio rebalancing on the asset side and liability-driven flows. Portfolio rebalancing reflects shifts across asset classes that leave the overall size of the balance sheet unchanged. By contrast, liability flows arise from premiums received, claims paid, and investment income, and they expand or contract the balance sheet depending on whether they are positive or negative. When inflows occur, insurers can either hold the additional resources in cash or allocate them to securities such as bonds. Thus, while rebalancing changes the composition of the portfolio, liability flows directly affect its scale. In terms of the decomposition (25), rebalancing operates through $w_{b,t}$ while liability flows operate through A_t.

The existing literature has primarily emphasized the rebalancing channel, documenting how regulatory capital constraints shape insurers' cross-sectional portfolio allocations. When constraints tighten (Ellul et al., 2011; Becker et al., 2022) or when increases in equity value make them less binding (Li, 2024), the resulting change in the "optimal" allocation generates bond trading. By contrast, the role of liability flows in driving insurers' bond

purchases has received much less attention.[24] Importantly, Mota and Siani (2023) and Kubitza (2025) construct flow-induced trading by insurance companies as demand shocks for corporate bonds. While Kubitza (2025) focus on flows from paid insurance premiums only for non-life insurance companies, Mota and Siani (2023) use flows from operating income. We show that, economically, flows from operating income are considerably smaller than flows from net premiums, which are the key driver of insurance companies' bond demand, both in the cross-section of insurers and in the aggregate time series.

A.2 Net-Premium Induced Trading

Despite the magnitude of capital in- and outflows, these may simply be absorbed by insurers' cash positions without necessarily affecting their security portfolios. To test this, we examine to what extent insurers adjust their aggregate bond holdings (corporate and government) in response to net premium flows. We refer to this adjustment as net-premium-induced trading. Specifically, we estimate the following pooled regression over all insurers and quarters from 2016 to 2024:

$$\Delta q^B_{i,t} = \alpha + \beta\, np_{i,t} + \epsilon_{i,t}, \tag{26}$$

where $\Delta q^B_{i,t}$ denotes bond purchases relative to lagged bond holdings, and $np_{i,t}$ is net premiums relative to lagged total assets.[25]

If insurers reinvest net premiums proportionally across their existing portfolio—keeping the relative weights of bonds, cash, and other asset classes constant—the scaling coefficient β should equal one. In that case, a 1% net premium relative to total assets translates into a 1% increase in bond holdings. By contrast, if inflows are parked as cash buffers, or if outflows are financed by drawing down cash rather than selling bonds, we would expect $\beta = 0$. Figure A.1 reports the estimated coefficient.

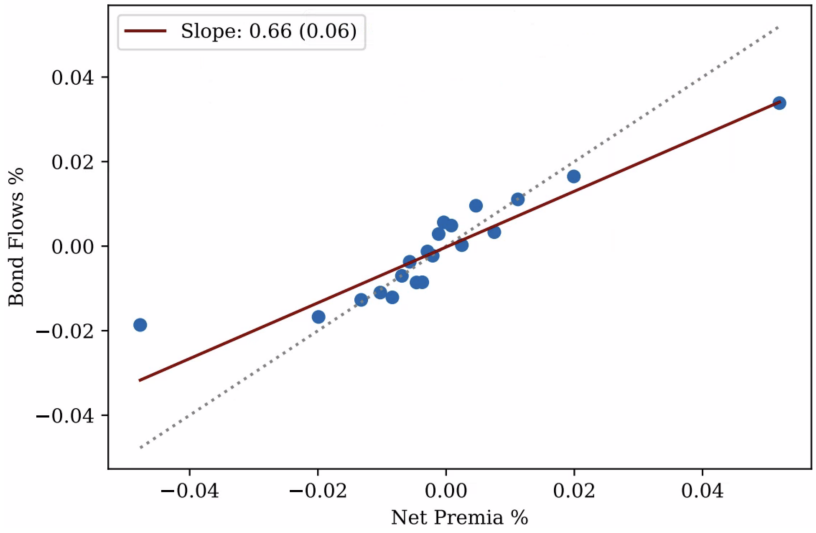
On average, a net premium of 1% of assets is associated with a 0.7% increase in bond holdings. Rather than absorbing flows into cash, insurers scale their bond positions almost one-for-one with inflows and redemptions. In Appendix Figure A.2, we split the sample into net-premium inflows and outflows and find significant downscaling of bond holdings when net premiums are negative and upscaling when they are positive.

The combination of large net premiums and near-proportional portfolio adjustments underscores the importance of net premiums for understanding insurers' role in bond markets. Next, we assess the economic importance of net premiums relative to equity capital in driving

[24] There is, however, a large literature on mutual funds' trading in response to flows. Lou (2012) find that equity mutual funds scale their equity positions by 0.62% for every 1% inflow. Similarly, Chaudhary et al. (2023) report a passthrough of 0.59 for corporate bond mutual funds.

[25] Formally, $\Delta q^B_{i,t} = \frac{F^B_{i,t}}{A^B_{i,t-1}}$, where $F^B_{i,t} = \sum_{n\in \text{CB,GB}} \Delta Q_{i,t}(n) P_{t-1}(n)$ are dollar flows into corporate and government bonds and $A^B_{i,t} = \sum_{n\in \text{CB,GB}} Q_{i,t}(n) P_t(n)$ are total holdings in corporate and government bonds.

Figure A.1: Net Premium-Induced Bond Trading

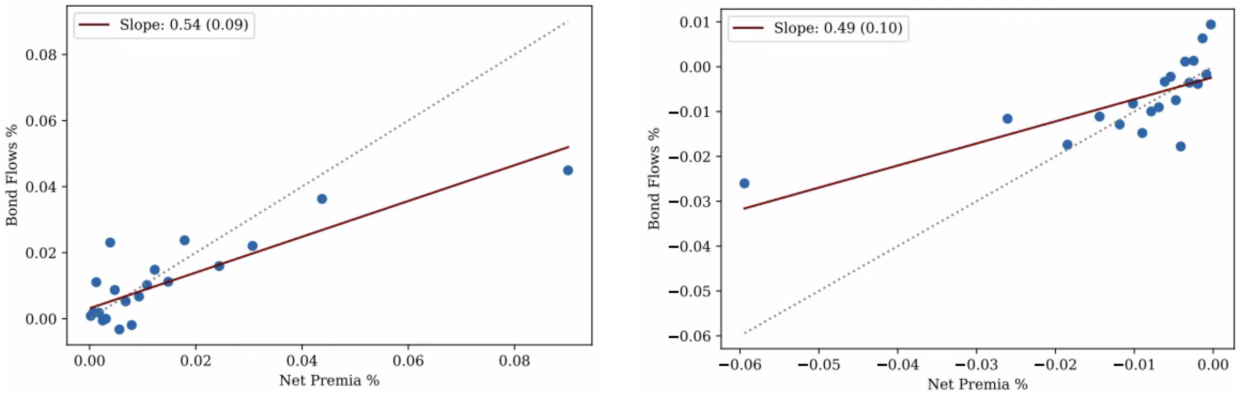


Note: We regress percentage changes in bond holdings $\Delta q^B_{i,t}$ on net premiums $np_{i,t}$ at the quarterly horizon over the panel of insurer-quarter observations via WLS, weighting by lagged bond holdings to reduce the influence of outliers. Standard errors of the partial scaling coefficients (in parentheses) are clustered by quarter. Source: EIOPA Regulatory Filings.

Figure A.2: Net Premia In- and Outflows

(a) Net Premia Inflows

(b) Net Premia Outflows



Note: We regress % changes in bond holdings $\Delta q^B_{i,t}$ onto net premia $np_{i,t}$ at the quarterly horizon over the panel of insurer-quarter dates via WLS, where we weight observations by lagged bond holdings to reduce the effect of outliers. Panel (a) tests inflow scaling and uses only investor-quarter observations with $np_{i,t} > 0$. Panel (b) tests outflow scaling and uses only investor-quarter observations with $np_{i,t} < 0$. The standard errors of the partial scaling coefficients (in parentheses) are clustered by quarter.

insurance companies' bond holdings.

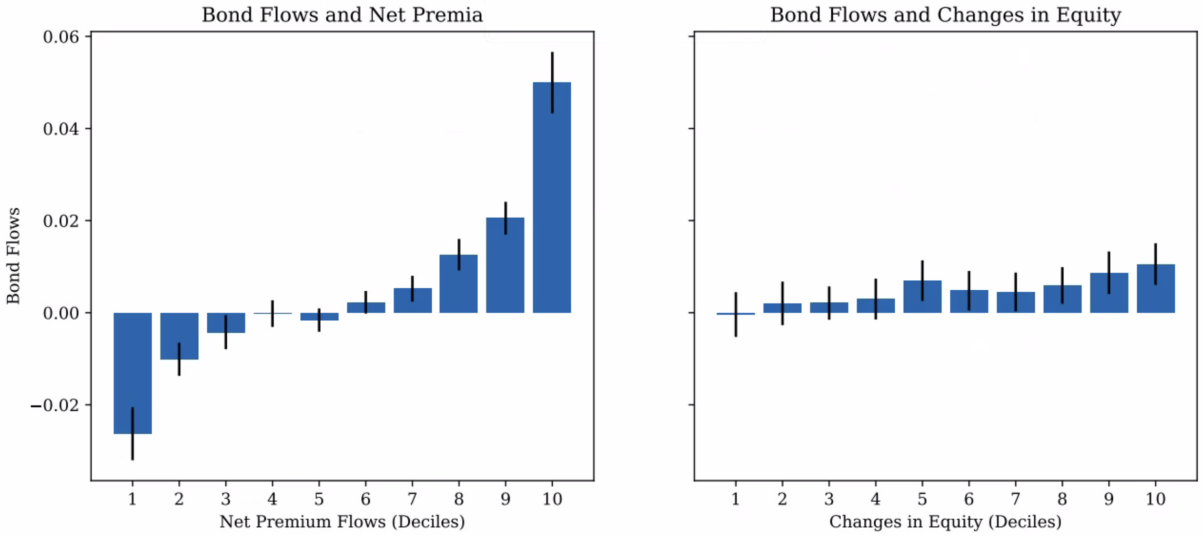
A.3 Economic Importance of Net Premiums versus Net Equity

To highlight the *economic* importance of net premiums in driving insurance companies' bond demand, we benchmark the impact of net premiums against that of net equity, which has received considerable attention in the literature (see, e.g., Sen (2023); Haddad et al. (2024)).

As for net premiums, we compute net equity flows as $ne_{i,t} = \frac{\Delta NAV_{i,t}}{A_{i,t-1}}$. Net equity flows capture changes in leverage arising from shifts in net equity, holding total assets constant. Since quarterly changes in net equity are small, and to give net equity the best chance of explaining bond rebalancing, we aggregate both net premiums and net equity flows to the annual horizon.

Simple Double Sort We sort all insurance companies into deciles based on their past annual net premiums $np_{i,t}$ and net equity flows $ne_{i,t}$. Note that net premiums may mechanically increase net equity due to accounting conventions. Therefore, we first sort based on net premiums and then, within each net premiums bucket, sort insurers into deciles by net equity flows. This is conceptually similar to orthogonalizing net equity changes with respect to net premiums. For each decile, we compute the average bond flow.[26] Figure A.3 reports the results. The economic importance of net equity for explaining bond purchases is negligible

Figure A.3: Bond Flow Drivers: Net Premiums versus Net Equity



Note: We sort insurance companies into deciles by annual net premiums (left panel) and changes in net equity (right panel), and plot average annual bond flows relative to total assets, $F^B_{i,t}/A_{i,t}$, by decile. Changes in net equity are orthogonalized with respect to net premiums. Source: EIOPA Regulatory Filings.

compared to net premiums. Across deciles, the difference in bond flows between the top and bottom of the net premium distribution is 7.5% of total assets, whereas for changes in net equity it is less than 1%.

[26] We scale by total assets, which allows interpreting the coefficient as a dollar allocation relative to total assets. This is more robust than $\Delta q^B_{i,t}$, as it avoids dividing by potentially small previous bond holdings, but does not yield an interpretable scaling coefficient as in Figure A.1. Using $\Delta q^B_{i,t}$ delivers noisier but qualitatively equivalent results.

Regression Results The double sorting is only chosen for visual exposition. Table A1 reports ordinary regressions of annual bond flows on annual net premiums and annual changes in net equity. A one standard deviation higher inflow from net premiums leads to 1.67% additional bond flows. This dwarfs the economic importance of net equity: a one standard deviation net equity flow leads to a mere 0.2% higher bond flows. Furthermore, net premiums explain a large fraction (15%) of the variation in total bond flows, while the incremental explanatory power of net equity on top of net premiums is virtually zero. The relative importance of net premiums holds across different bond subgroups such as corporate bonds, government bonds, long-term bonds, and low-rated bonds. For example, net premiums are eight times more important for explaining government bond flows, and seven times more important for explaining flows to high-risk bonds than changes in net equity.

Table A1: Bond Flow Drivers: Net Premiums versus Net Equity

	All Bonds		Bonds by Subgroup			
	(1)	(2)	Corp.	Gov. Bonds	Long-Term	Low-Rated
Constant	0.57***	0.53***	0.28***	0.24**	0.29**	1.85***
	(0.11)	(0.13)	(0.09)	(0.10)	(0.12)	(0.18)
$\Delta NAV_{i,t}$		0.32***	0.21***	0.12*	0.20**	0.10
		(0.09)	(0.04)	(0.07)	(0.09)	(0.06)
Net Premium$_{i,t}$	1.67***	1.62***	0.69***	0.92***	0.96***	0.67***
	(0.09)	(0.08)	(0.09)	(0.05)	(0.08)	(0.08)
N	4006	4006	4006	4006	3709	3815
R^2	0.15	0.15	0.07	0.08	0.10	0.05

Note: We estimate pooled regressions at the insurer-year level of annual bond flows on annual net premiums and annual net equity (relative to total assets). Net premiums and changes in net equity are standardized. The first two columns use total flows into all bonds; the remaining columns use flows into subgroups. Long-maturity bonds are bonds with maturities greater than eight years. Low-rated bonds are those rated below BBB. Standard errors are clustered by year. * p<0.10, ** p<0.05, *** p<0.01.

A.4 Portfolio Rebalancing Based on Net Equity and Net Premiums

The previous subsections show that liability flows (A_t channel) are the dominant driver of total bond demand. We now examine the portfolio weight channel ($w_{b,t}$). Proposition 2 predicts $dw_{b,t}/dy_t < 0$ (lower rates push toward safe bonds) and Proposition 1 predicts $\partial w_{b,t}/\partial \phi_2 > 0$ (tighter regulation pushes toward safe bonds). Both operate through rebalancing conditional on the balance sheet. We show that while these rebalancing effects are statistically detectable, they are economically small relative to the A_t channel.

Net premiums are the primary driver of total bond demand and are economically more

important than variations in net equity. We now examine how net premiums and changes in net equity shape insurers' cross-sectional portfolio choices across different segments of the bond market. In particular, we focus on two key dimensions of bond demand: credit rating and maturity.

Let $A^L_{i,t}$ denote insurer i's holdings of long-term bonds—defined as securities with maturities greater than eight years—and let $A^R_{i,t}$ denote holdings of risky bonds, defined as those with credit ratings of BBB or lower. We scale these positions by total bond holdings $A^B_{i,t}$ to obtain the corresponding portfolio weights $w^L_{i,t} = \frac{A^L_{i,t}}{A^B_{i,t}}$ and $w^R_{i,t} = \frac{A^R_{i,t}}{A^B_{i,t}}$

To isolate active portfolio rebalancing, we compare observed flows into each bond category with the flows that would occur mechanically if insurers simply expanded their portfolios in proportion to existing weights. Formally, we define active rebalancing as

$$\Delta a^k_{i,t} = \frac{F^k_{i,t} - w^k_{i,t-1} F^B_{i,t}}{A_{i,t-1}},$$

where $k \in \{L, R\}$; $F^L_{i,t}$ denotes flows into long-term bonds, $F^R_{i,t}$ denotes flows into risky bonds, and total flows satisfy $F^B_{i,t} = F^L_{i,t} + F^R_{i,t}$. This decomposition allows us to distinguish between passive expansion of existing positions—driven by the size of net premiums—and active changes in the composition of bond portfolios along maturity and credit-risk dimensions. For example, $\Delta a^L_{i,t}$ is flows toward long-term bonds in excess of proportionally scaling existing bond weights. We regress the cross-section of rebalancing toward long maturity $\Delta a^L_{i,t}$ and low credit rating $\Delta a^R_{i,t}$ respectively onto net premiums and changes in net equity. We study active rebalancing from 1 quarter up to 3 years via Fama–MacBeth regressions.

Table A2 reports the estimated rebalancing for high-risk bonds (with lower credit ratings). Increases in net equity lead to a significant active rebalancing toward riskier bonds. This echoes the findings in Ellul et al. (2011) and Li (2024). Improvements in net equity alleviate potential risk-based capital constraints and lead to higher allocations to riskier bonds. However, despite their statistical significance, the economic magnitudes are extremely small. A one standard deviation increase in net equity increases the weight to high-risk bonds (within the total bond portfolio) by 0.22% over a three-year horizon.

Table A3 reports the estimates for the demand for long-maturity bonds. Net premium inflows lead to significant active rebalancing toward longer-maturity bonds. While we cannot decompose the underwritten premiums by their maturity (e.g., selling life policies to older versus younger people), we suspect that this relationship points to the mechanical effect of new policies being of longer maturity than expiring or surrendered policies. We also find that increases in net equity lead to a significant active rebalancing toward shorter-maturity

Table A2: Demand for Lower-Rated Bonds

	Rebalancing to Lower-Rated Bonds			
	1Q	4Q	8Q	12Q
$\Delta NAV_{i,t}$	-0.01	0.02	0.09*	0.22***
	(0.01)	(0.03)	(0.05)	(0.07)
Net Premium$_{i,t}$	-0.01	0.00	-0.05	−0.19**
	(0.01)	(0.03)	(0.05)	(0.08)
Avg. R^2	0.01	0.01	0.01	0.01
Avg. N	435	418	398	377

Note: We estimate the portfolio rebalancing toward lower-rated bonds versus investment-grade bonds via Fama–MacBeth regressions of $\Delta a^{R}_{i,t}$ onto net premiums and changes in net equity. We scale both net premiums and changes in equity by total lagged assets and estimate the rebalancing regression over 1, 4, 8, and 12 quarter horizon changes. * p<0.10, ** p<0.05, *** p<0.01.

bonds. However, despite the statistical significance of the rebalancing activity, the economic magnitudes are small. For example, a one standard deviation higher net premium leads an insurer to increase the weight on long-term bonds by 0.60% over a three-year horizon.

Table A3: Demand for Long Maturity

	Rebalancing to Long-Term Bonds			
	1Q	4Q	8Q	12Q
$\Delta NAV_{i,t}$	0.00	−0.06*	−0.13**	−0.31***
	(0.01)	(0.03)	(0.06)	(0.09)
Net Premium$_{i,t}$	0.03**	0.23***	0.40***	0.60***
	(0.02)	(0.06)	(0.10)	(0.13)
Avg. R^2	0.01	0.02	0.02	0.01
Avg. N	447	430	410	390

Note: We estimate the portfolio rebalancing toward long versus short maturity bonds via Fama–MacBeth regressions of $\Delta a^{L}_{i,t}$ onto net premiums and changes in net equity. We scale both net premiums and changes in equity by total lagged assets and estimate the rebalancing regression over 1, 4, 8, and 12 quarter horizon changes. * p<0.10, ** p<0.05, *** p<0.01.

Appendix Tables A5 and A4 repeat the portfolio rebalancing results on credit rating and maturity choice for alternative specifications. We use dummy variables equal to 1 for the top decile of insurers with the highest net premiums and net equity changes as opposed to the raw net premiums and net equity changes. The qualitative patterns are unchanged and the economic importance of net equity for the cross-sectional portfolio choice remains small.

Overall, the portfolio rebalancing results confirm that the channel emphasized by the existing literature—net equity relaxing capital constraints and shifting portfolio composition—

Table A4: Demand for High Credit Rating: Dummy Specification

	Rebalancing to Lower-Rated Bonds			
	1Q	4Q	8Q	12Q
NAV-Dummy	-0.08	0.04	0.15	0.36
	(0.05)	(0.10)	(0.19)	(0.22)
NP-Dummy	-0.02	-0.21^{**}	-0.44^{**}	-0.78^{***}
	(0.04)	(0.09)	(0.18)	(0.24)
Avg. R^2	0.01	0.01	0.01	0.01
Avg. N	435	418	398	377

Note: We estimate the portfolio rebalancing towards investment grade versus high yield bonds via Fama–MacBeth regressions of $\Delta a^{\mathrm{C}}_{i,t}$ onto net premia dummies and changes in net equity dummies. The dummy variables are equal to one if net premia or changes in net equity are in the top decile. We scale both net premia and changes in equity by total lagged assets and estimate the rebalancing regression over 1, 4, 8, and 12 quarter horizon changes. * p<0.10, ** p<0.05, *** p<0.01.

Table A5: Demand for Long Maturity: Dummy Specification

	Rebalancing to Long-Term Bonds			
	1Q	4Q	8Q	12Q
NAV-Dummy	-0.01	-0.07	-0.78^{***}	-1.19^{***}
	(0.04)	(0.12)	(0.26)	(0.37)
NP-Dummy	0.15^{***}	0.66^{***}	1.43^{***}	2.37^{***}
	(0.04)	(0.15)	(0.28)	(0.29)
Avg. R^2	0.01	0.01	0.02	0.02
Avg. N	447	430	410	390

Note: We estimate the portfolio rebalancing towards long versus short maturity bonds via Fama–MacBeth regressions of $\Delta q^{\mathrm{LS}}_{i,t}$ onto net premia dummies and changes in net equity dummies. The dummy variables are equal to one if net premia or changes in net equity are in the top decile. We scale both net premia and changes in equity by total lagged assets and estimate the rebalancing regression over 1, 4, 8, and 12 quarter horizon changes. * p<0.10, ** p<0.05, *** p<0.01.

is statistically present but economically negligible. A one standard deviation improvement in net equity shifts the weight toward risky bonds by 0.22% and toward long-maturity bonds by 0.60% over a three-year horizon. These magnitudes are an order of magnitude smaller than the effect of net premiums on total bond demand. The rebalancing channel affects the *composition* of bond portfolios at the margin; it does not move the *scale*. The scale is determined by flows. Returning to the decomposition (25): changes in $w_{b,t}$ (portfolio rebalancing) are economically small, while changes in A_t (driven by net premiums) are large. The decline in insurers' bond market share documented in Figure 1 is therefore overwhelmingly a balance-sheet phenomenon, not a portfolio-weight phenomenon.

A.5 Decomposition of Changes in Bond Holdings

An insurer's total bond holdings are given by

$$B_t \ = w_{b,t} A_t.$$

For each insurer, business is split into a profit-participation division (PP) and a unit-linked division (UL). Let A_t^{PP} and A_t^{UL} denote assets under management in each division at time t, and let w_t^{PP} and w_t^{UL} denote the share of each division's assets held in government bonds. Total government bond holdings can therefore be decomposed as $B_t = \ w_{b,t}^{PP} A_t^{PP} + w_{b,t}^{UL} A_t^{UL}$. Let $s_t = A_t^{PP}/A_t$ be the PP share of total assets. We decompose the change in holdings between the first and last year an insurer is observed, $\Delta B_t = B_t - B_0$, into four intuitive pieces: money coming in or out of the insurer (*flows*), business moving between the PP and UL divisions (*shift*), active trading in bonds (*rebalancing*), and the mechanical effect of market returns (*valuation*).

Start from the identity above and take the difference between $t = 0$ and t. Adding and subtracting the counterfactual holdings that would obtain if weights had stayed fixed at their initial values, ΔB_t splits into three pieces:

$$\Delta B_t \ = \ \underbrace{w_{b,0}\, \Delta A_t}_{\text{Flows}} \ + \ \underbrace{\left(w_{b,0}^{PP} - w_{b,0}^{UL}\right) A_t\, \Delta s_t}_{\text{UL Shift}} \ + \ \underbrace{\Delta w_{b,t}^{PP}\, A_t^{PP} + \Delta w_{b,t}^{UL}\, A_t^{UL}}_{\text{Rebalancing}}. \tag{27}$$

- **Flows**: if the insurer's overall bond weight had stayed exactly at its initial level $w_{b,0}$, how much would bond holdings have changed purely because total assets grew or shrank? This is the effect of net contributions and withdrawals.
- **UL Shift**: holding both divisions' bond weights fixed, how much did bond holdings change purely because business moved from PP to UL (or vice versa)? Since PP and UL typically hold different bond weights, a shift in the mix mechanically changes aggregate bond holdings even with no trading.
- **Rebalancing**: the change in bond holdings coming from actually changing the bond weight within each division, i.e. active buying or selling.

Part of ΔA_t and Δw_t is mechanical: assets grow with market returns even absent flows, and bond weights drift on their own whenever bonds and the rest of the portfolio earn different returns. Let r_t^A and r_t^B denote cumulative returns on total assets and on the bond

portfolio. The mechanical weight drift is

$$\delta^j \;=\; w^j_{b,0}\,\frac{r^B_t - r^A_T}{1 + r^A_t}, \qquad j \in \{PP, UL\}.$$

Netting this out of Flows and Rebalancing and collecting it into a fourth term yields

$$\Delta B_t \;=\; \underbrace{w_{b,0}\big(\Delta A_t - A_0 r^A_t\big)}_{\text{Flows}} \;+\; \underbrace{\big(w^{PP}_{b,0} - w^{UL}_{b,0}\big)\,A_t\,\Delta s_t}_{\text{UL Shift}}$$
$$+\; \underbrace{\big(\Delta w^{PP}_{b,t} - \delta^{PP}\big)A^{PP}_t + \big(\Delta w^{UL}_{b,t} - \delta^{UL}\big)A^{UL}_t}_{\text{Rebalancing}} \;+\; \underbrace{\bar{w}_{b,0}A_0 r^A_t + \delta^{PP}A^{PP}_t + \delta^{UL}A^{UL}_t}_{\text{Valuation}}. \qquad (28)$$

Flows and Rebalancing now net out mechanical return effects; Valuation captures the change in holdings that would occur with no flows and no trading at all.

B. QSA Description

B.1 Flows into Insurance Liabilities

Aggregate. In the ESA 2010 financial accounts, instrument category F6 captures all entitlements arising from insurance, pensions, and standardised guarantee schemes. It is composed of three subcomponents:

$$F6 = F62 + F6M + F6O.$$

F62: Life insurance and annuity entitlements. These are policyholders' claims on life insurers, including both unit-linked and non-unit-linked products. Transactions are derived from premiums earned and premium supplements (investment income attributed to policyholders), net of benefits due and changes in technical reserves (ESA, 2013, ESA 2010, §16.52, p. 384). The full flow identity is reported in equation (29).

F6M: Pension entitlements and related items. This block consolidates three ESA 2010 categories: (i) pension entitlements (F63), i.e. accrued claims on employment-related pensions; (ii) claims of pension funds on pension managers (F64), which arise when the legal sponsor and the fund are separate units; and (iii) entitlements to non-pension benefits (F65), such as post-employment health schemes. Together these cover all pension-related liabilities not classified as life insurance.

F6O: Non-life insurance and standardised guarantees. This item comprises the reserves of non-life insurers for claims not yet settled, and provisions for calls under standardised guarantee schemes (e.g. deposit insurance or export credit guarantees). It reflects

expected obligations from contracts other than life insurance and pensions.

B.1.1 Life Insurance (F62)

Instrument. F62 records policyholders' claims on life insurers and annuity providers. In ESA 2010, life insurance is treated as saving with risk coverage, with entitlements representing liabilities of insurers and assets of policyholders (ESA, 2013, ESA 2010, §§16.10–16.14, pp. 348–379; §16.31, p. 382).

Transactions vs. revaluations. To measure inflows "available to invest," we use *transactions* in F62, which exclude holding gains or losses from changes in interest rates or asset prices. These valuation effects are recorded separately under revaluations/other changes (ESA, 2013, ESA 2010, §§16.31–16.33, p. 382). National methodologies make this explicit: "nominal holding gains and losses on entitlements are not recorded as flows" (Banque de France, 2024, p. 11).

Flow identity. ESA 2010 defines the net transaction in AF.62 as:

$$\Delta \mathrm{F62}_t^{(\text{transactions})} = \underbrace{\text{premiums earned}_t}_{\text{accrual basis}} + \underbrace{\text{premium supplements}_t}_{\text{investment income attributed to policyholders}} - \underbrace{\text{benefits due}_t}_{\text{claims/benefits on an accrual basis}} - \underbrace{\Delta\text{technical reserves}_t}_{\text{increase (decrease) in life reserves}} . \tag{29}$$

Here, *premium supplements* are investment income on reserves attributed to policyholders; *benefits due* are obligations payable during the period; and *technical reserves* cover actuarial and with-profits components. Equation (29) corresponds to ESA 2010 §16.52 (p. 384), with definitions in §§16.31–16.33 (p. 382).

Recording in the accounts. Life-insurance premiums and claims are not recorded as separate transfers; instead, their net effect appears as a financial transaction in AF.62 (ESA, 2013, ESA 2010, §§16.70–16.71, p. 388).

B.1.2 Pension Entitlements and Related Items (F6M)

Instrument. F6M aggregates pension entitlements (F63), claims of pension funds on pension managers (F64), and entitlements to non-pension benefits (F65). These are assets of households and liabilities of pension funds, employers, or social security schemes (ESA, 2013, ESA 2010, §§17.95–17.106, pp. 410–412).

Transactions vs. revaluations. Transactions in F6M reflect contributions (actual and imputed) and premium supplements, net of pension benefits paid and changes in reserves. Valuation changes due to discount-rate movements are excluded and recorded as revaluations

(ESA, 2013, ESA 2010, §17.99, p. 411).

Flow identity. The net transaction in F6M can be written as:

$$\begin{aligned}\Delta \text{F6M}_t^{(\text{transactions})} = {} & \text{contributions received}_t + \text{premium supplements}_t \\ & - \text{benefits paid}_t - \Delta\text{pension reserves}_t. \end{aligned} \tag{30}$$

Recording in the accounts. Contributions and benefits are recorded in the secondary distribution of income account, with their net impact on accrued entitlements recorded as transactions in AF.6M (ESA, 2013, ESA 2010, §17.106, p. 412).

B.1.3 Non-life Insurance and Standardised Guarantees (F6O)

Instrument. F6O covers non-life insurance technical provisions and provisions for calls under standardised guarantee schemes. These are liabilities of insurers or guarantors, and assets of policyholders or beneficiaries (ESA, 2013, ESA 2010, §§16.85–16.92, pp. 389–391).

Transactions vs. revaluations. Transactions in F6O consist of premiums earned and premium supplements, net of claims due and changes in technical reserves. As with F62 and F6M, valuation effects are excluded (ESA, 2013, ESA 2010, §§16.89–16.90, p. 390).

Flow identity. The net transaction in F6O is:

$$\begin{aligned}\Delta \text{F6O}_t^{(\text{transactions})} = {} & \text{premiums earned}_t + \text{premium supplements}_t \\ & - \text{claims due}_t - \Delta\text{non-life technical reserves}_t. \end{aligned} \tag{31}$$

Recording in the accounts. Non-life premiums and claims are treated as current transfers in the allocation of primary income account. The adjustment for changes in technical reserves ensures that only the service charge is recorded as output; the corresponding financial transaction is in AF.6O (ESA, 2013, ESA 2010, §§16.85–16.92, pp. 389–391).

C. Household Participation Rate in Life Insurance Policies

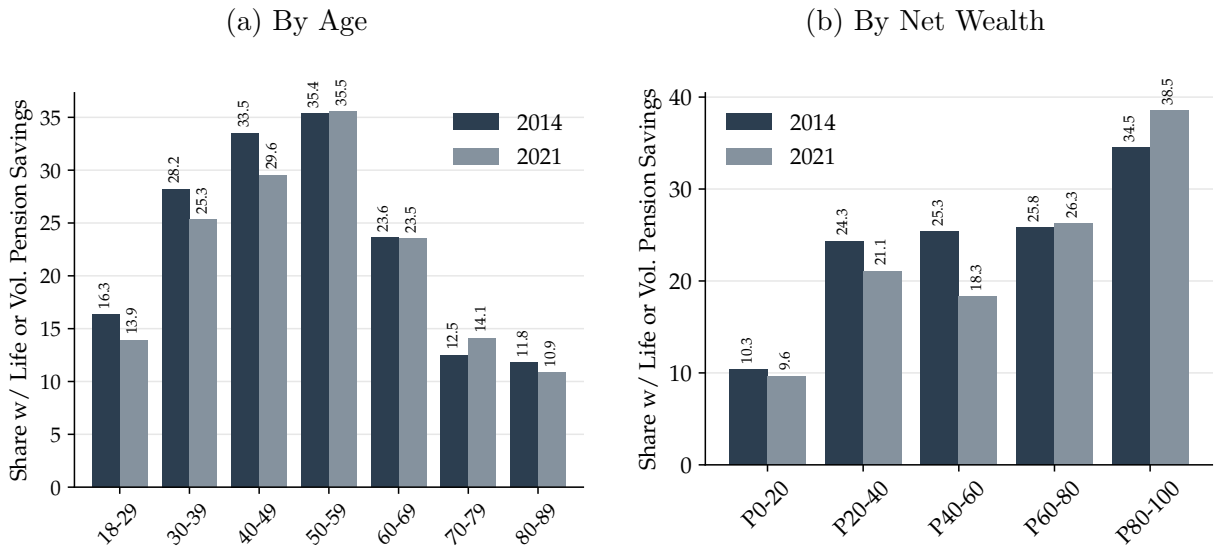
We use data from the ECB Household Finance and Consumption Survey (HFCS) to analyze changes in households' holdings of life insurance and retirement products. Specifically, we focus on households' participation in voluntary private pension plans and life insurance policies, which largely correspond to the instruments administered by life insurers in our study. Figure C.1 illustrates the change in participation rates by age group between 2014 and 2021.

The figure shows that younger households experienced the largest decline in participation in voluntary retirement products, with participation rates falling by 2.4 percentage points for those aged 18–29, 2.9 percentage points for those aged 30–39, and 4.0 percentage points for those aged 40–49. This suggests that younger cohorts are increasingly refraining from allocating any funds to voluntary retirement policies.

When we split the sample by net wealth, we find that the decline in retirement policy participation is concentrated among households in the bottom 60th percentile of the wealth distribution. In contrast, households in the top 20% experienced a significant increase in participation, rising by about 4 percentage points.

Overall, these findings are important both for understanding the underlying mechanism and for assessing the implications of low interest rates. The decline in participation among younger households suggests that the reduction in inflows to insurance companies largely reflects lower demand for these products during the low-rate period. Consequently, a growing share of households now hold neither life insurance nor voluntary pension plans, with significant implications for their exposure to longevity risk.

Figure C.1: Participation in Voluntary Pension and Life Insurance Products



Note: The figure shows the share of individuals holding voluntary pension savings or life insurance with savings components across age and wealth groups, using HFCS 2014 and 2021. Panel (a) highlights the decline in participation among younger adults and a mild increase among older cohorts. Panel (b) illustrates a widening wealth gap, with participation rising among the top quintile and falling for the bottom 60%. All values are weighted using individual survey weights.

D. Model Appendix

This appendix collects the derivations behind Sections 7 and 8: the first-order conditions of the insurer's problem (D.1), the comparative-statics system (D.2), the nested-logit demand block (D.3), the proofs of Propositions 2 and 1 (D.4), and the details of the calibration (D.5 and D.6).

D.1 First-Order Conditions

Optimal PP Fee

Differentiating the objective (17) with respect to f_t^{PP}, using $c_t = -C'(K_t)$:

$$\frac{\partial J_t}{\partial f_t^{PP}} = \underbrace{Q_t^{PP} + (f_t^{PP} - V_{t,t})\frac{\partial Q_t^{PP}}{\partial f_t^{PP}} + f_t^{UL}\frac{\partial Q_t^{UL}}{\partial f_t^{PP}}}_{\text{direct profit}} + c_t \frac{\partial K_t}{\partial f_t^{PP}}, \tag{32}$$

where, from the capital identity (18),

$$\frac{\partial K_t}{\partial f_t^{PP}} = Q_t^{PP} + \left(f_t^{PP} - (1+\phi_1)V_{t,t} - \phi_2\alpha_t\right)\frac{\partial Q_t^{PP}}{\partial f_t^{PP}} + \left(f_t^{UL} - \phi_L\right)\frac{\partial Q_t^{UL}}{\partial f_t^{PP}}. \tag{33}$$

The capital channel has the same structure as the direct profit channel, with three differences. First, the guarantee cost is inflated from $V_{t,t}$ to $(1+\phi_1)V_{t,t}$, reflecting the regulatory capital charge on MRG liabilities. Second, each additional PP customer absorbs spread risk capital $\phi_2\alpha_t$. Third, each customer diverted toward UL now contributes fee income *net of* the unit-linked charge ϕ_L. Setting $\partial J_t/\partial f_t^{PP} = 0$, collecting the direct and capital channels, and dividing through by $(1+c_t)$:

$$Q_t^{PP} + \Pi_t \frac{\partial Q_t^{PP}}{\partial f_t^{PP}} + \Pi_t^{UL}\frac{\partial Q_t^{UL}}{\partial f_t^{PP}} = 0, \tag{34}$$

where the per-customer surpluses are as defined in (20):

$$\Pi_t = \frac{(f_t^{PP} - V_{t,t}) + c_t\left(f_t^{PP} - (1+\phi_1)V_{t,t} - \phi_2\alpha_t\right)}{1+c_t} = f_t^{PP} - \lambda_t V_{t,t} - \frac{c_t}{1+c_t}\phi_2\alpha_t,$$

$$\Pi_t^{UL} = \frac{f_t^{UL} + c_t(f_t^{UL} - \phi_L)}{1+c_t} = f_t^{UL} - \frac{c_t}{1+c_t}\phi_L,$$

and the shadow cost of capital $\lambda_t = \left(1 + c_t(1+\phi_1)\right)/(1+c_t) > 1$ is the direct analogue of the shadow cost of capital in Koijen and Yogo (2022b). When regulatory capital requirements

tighten (ϕ_1 rises) or the insurer is poorly capitalised (c_t is high), λ_t rises, making guarantees more expensive relative to their actuarial value. Rearranging (34) using the semi-elasticity notation of Section 7.2 delivers the pricing equation (21) in the main text.

Optimal UL Fee

Differentiating (17) with respect to f_t^{UL}:

$$\frac{\partial J_t}{\partial f_t^{UL}} = Q_t^{UL} + (f_t^{PP} - V_{t,t})\frac{\partial Q_t^{PP}}{\partial f_t^{UL}} + f_t^{UL}\frac{\partial Q_t^{UL}}{\partial f_t^{UL}} + c_t\frac{\partial K_t}{\partial f_t^{UL}}, \tag{35}$$

with

$$\frac{\partial K_t}{\partial f_t^{UL}} = \left(f_t^{PP} - (1+\phi_1)V_{t,t} - \phi_2\alpha_t\right)\frac{\partial Q_t^{PP}}{\partial f_t^{UL}} + Q_t^{UL} + \left(f_t^{UL} - \phi_L\right)\frac{\partial Q_t^{UL}}{\partial f_t^{UL}}. \tag{36}$$

Collecting terms, setting the derivative to zero, and dividing by $(1 + c_t)$:

$$Q_t^{UL} + \Pi_t\frac{\partial Q_t^{PP}}{\partial f_t^{UL}} + \Pi_t^{UL}\frac{\partial Q_t^{UL}}{\partial f_t^{UL}} = 0. \tag{37}$$

Rearranging delivers (22): relative to a model in which UL is capital-free, the marginal-cost term $\frac{c_t}{1+c_t}\phi_L$ appears because each unit of UL business absorbs ϕ_L of statutory capital at the margin.

Optimal Risky Share

Differentiating (17) with respect to α_t, and noting that demand depends on fees and interest rates but not directly on α_t:

$$\frac{\partial J_t}{\partial \alpha_t} = -\frac{\partial V_{t,t}}{\partial \alpha_t}Q_t^{PP} + c_t\frac{\partial K_t}{\partial \alpha_t}, \qquad \frac{\partial K_t}{\partial \alpha_t} = -(1+\phi_1)\frac{\partial V_{t,t}}{\partial \alpha_t}Q_t^{PP} - \phi_2 Q_t^{PP}. \tag{38}$$

Collecting terms and dividing by $(1 + c_t)\, Q_t^{PP}$, the first-order condition becomes

$$\lambda_t\frac{\partial V_{t,t}}{\partial \alpha_t} + \frac{c_t}{1+c_t}\phi_2 = 0, \tag{39}$$

Note that ϕ_L does not enter: unit-linked business carries no spread risk on the general account. In the absence of the spread charge ($\phi_2 = 0$), the insurer sets α_t such that $\partial V_{t,t}/\partial \alpha_t = 0$—the point where the participation benefit and the MRG cost exactly cancel—and the portfolio condition decouples from the pricing conditions, which is the case studied in Propositions 2–1. A tighter spread risk requirement (higher ϕ_2) or a more capital-constrained insurer (higher c_t, hence λ_t) pushes the optimal α_t downward.

D.2 The Comparative-Statics System

The three first-order conditions defining the equilibrium $(f_t^{PP}, f_t^{UL}, \alpha_t)$ are

$$F_t \equiv Q_t^{PP} + \Pi_t \frac{\partial Q_t^{PP}}{\partial f_t^{PP}} + \Pi_t^{UL} \frac{\partial Q_t^{UL}}{\partial f_t^{PP}} = 0, \tag{40}$$

$$G_t \equiv Q_t^{UL} + \Pi_t \frac{\partial Q_t^{PP}}{\partial f_t^{UL}} + \Pi_t^{UL} \frac{\partial Q_t^{UL}}{\partial f_t^{UL}} = 0, \tag{41}$$

$$H_t \equiv \lambda_t \frac{\partial V_{t,t}}{\partial \alpha_t} + \frac{c_t}{1+c_t}\phi_2 = 0. \tag{42}$$

Totally differentiating all three with respect to a shock $x_t \in \{y_t, \phi_1, \phi_2, \phi_L\}$ yields a 3×3 system; we split it, assessing the effects on fees holding the portfolio share fixed, and vice versa. For the fee block, total differentiation of (40)–(41) at fixed α_t gives the 2×2 linear system

$$\underbrace{\begin{pmatrix} F_{f^{PP}} & F_{f^{UL}} \\ G_{f^{PP}} & G_{f^{UL}} \end{pmatrix}}_{J} \begin{pmatrix} df_t^{PP}/dx_t \\ df_t^{UL}/dx_t \end{pmatrix} = - \begin{pmatrix} F_x \\ G_x \end{pmatrix}, \tag{43}$$

solved by Cramer's rule with $\Delta \equiv F_{f^{PP}} G_{f^{UL}} - F_{f^{UL}} G_{f^{PP}} > 0$:

$$\frac{df_t^{PP}}{dx_t} = \frac{-F_x G_{f^{UL}} + G_x F_{f^{UL}}}{\Delta}, \qquad \frac{df_t^{UL}}{dx_t} = \frac{-G_x F_{f^{PP}} + F_x G_{f^{PP}}}{\Delta}. \tag{44}$$

The capital gradient and the regulatory wedges Both surpluses depend on the fees only through c_t, and c_t only through K_t. Substituting the equilibrium conditions (40)–(41) into the derivative of the capital identity (18), the response of statutory capital to either fee is

$$\frac{\partial K_t}{\partial f_t^j} = -\frac{1}{1+c_t}\left[\omega_t^P \frac{\partial Q_t^{PP}}{\partial f_t^j} + \omega_t^L \frac{\partial Q_t^{UL}}{\partial f_t^j}\right], \qquad j \in \{PP, UL\}, \tag{45}$$

where the two *regulatory wedges*

$$\omega_t^P \equiv \phi_1 V_{t,t} + \phi_2 \alpha_t, \qquad \omega_t^L \equiv \phi_L \tag{46}$$

are the capital absorbed per unit of PP and of UL business respectively. Defining

$$\Theta_t \equiv \frac{C''(K_t)}{(1+c_t)^3} > 0, \qquad \begin{aligned} \psi_{PP} &\equiv \omega_t^P \, \varepsilon_{PP}^{f^{PP}} Q_t^{PP} - \omega_t^L \, \varepsilon_{UL}^{f^{PP}} Q_t^{UL}, \\ \psi_{UL} &\equiv \omega_t^L \, \varepsilon_{UL}^{f^{UL}} Q_t^{UL} - \omega_t^P \, \varepsilon_{PP}^{f^{UL}} Q_t^{PP}, \end{aligned} \tag{47}$$

the derivatives of the two surpluses with respect to the fees under constant semi-elasticities are

$$\frac{\partial \Pi_t}{\partial f_t^{PP}} = 1+\Theta_t\,\omega_t^P\,\psi_{PP}, \quad \frac{\partial \Pi_t}{\partial f_t^{UL}} = \Theta_t\,\omega_t^P\,\psi_{UL}, \quad \frac{\partial \Pi_t^{UL}}{\partial f_t^{PP}} = \Theta_t\,\omega_t^L\,\psi_{PP}, \quad \frac{\partial \Pi_t^{UL}}{\partial f_t^{UL}} = 1+\Theta_t\,\omega_t^L\,\psi_{UL}. \tag{48}$$

The terms in Θ_t capture the regulatory capital feedback, proportional to the convexity of the cost function and to the wedges (ω_t^P, ω_t^L). When regulation is absent ($\phi_1 = \phi_2 = \phi_L = 0$) both wedges vanish, so $\partial\Pi_t/\partial f_t^{PP} = 1$ and $\partial\Pi_t/\partial f_t^{UL} = 0$: the per-customer surplus moves one-for-one with the PP fee and is independent of the UL fee, as one would expect without capital constraints; symmetrically for Π_t^{UL}.

The Jacobian Substituting constant semi-elasticities and exploiting $F_t = G_t = 0$ to substitute out Π_t and Π_t^{UL} where possible, the Jacobian elements simplify to

$$F_{f^{PP}} = -\varepsilon_{PP}^{f^{PP}}\,Q_t^{PP} + \Pi_t^{UL}\,\varepsilon_{UL}^{f^{PP}}\,Q_t^{UL}\left(\varepsilon_{PP}^{f^{PP}} + \varepsilon_{UL}^{f^{PP}}\right) - \Theta_t\,\psi_{PP}^2, \tag{49}$$

$$F_{f^{UL}} = G_{f^{PP}} = -\varepsilon_{PP}^{f^{UL}}\,\varepsilon_{UL}^{f^{PP}}\left(\Pi_t Q_t^{PP} + \Pi_t^{UL} Q_t^{UL}\right) - \Theta_t\,\psi_{PP}\psi_{UL}, \tag{50}$$

$$G_{f^{UL}} = -\varepsilon_{UL}^{f^{UL}}\,Q_t^{UL} + \Pi_t\varepsilon_{PP}^{f^{UL}}\,Q_t^{PP}\left(\varepsilon_{UL}^{f^{UL}} + \varepsilon_{PP}^{f^{UL}}\right) - \Theta_t\,\psi_{UL}^2. \tag{51}$$

The two off-diagonal elements are equal, and the capital-convexity terms form the rank-one block $-\Theta_t\,\psi\psi'$ with $\psi = (\psi_{PP}, \psi_{UL})'$—a structure exploited heavily in the proofs. The shock terms are

$$F_x = -\frac{\partial \Pi_t}{\partial x_t}\varepsilon_{PP}^{f^{PP}}\,Q_t^{PP} + \frac{\partial \Pi_t^{UL}}{\partial x_t}\varepsilon_{UL}^{f^{PP}}\,Q_t^{UL} + \Pi_t^{UL}\varepsilon_{UL}^{f^{PP}}\,Q_t^{UL}\left(\varepsilon_x^{UL} - \varepsilon_x^{PP}\right), \tag{52}$$

$$G_x = \frac{\partial \Pi_t}{\partial x_t}\varepsilon_{PP}^{f^{UL}}\,Q_t^{PP} - \frac{\partial \Pi_t^{UL}}{\partial x_t}\varepsilon_{UL}^{f^{UL}}\,Q_t^{UL} - \Pi_t\varepsilon_{PP}^{f^{UL}}\,Q_t^{PP}\left(\varepsilon_x^{UL} - \varepsilon_x^{PP}\right), \tag{53}$$

where $\varepsilon_x^{PP}, \varepsilon_x^{UL}$ are the direct demand semi-elasticities with respect to the shock (zero for regulatory shocks), and the surplus partials with respect to the two shocks of interest are

$$\frac{\partial \Pi_t}{\partial y_t} = -\lambda_t\frac{\partial V_{t,t}}{\partial y_t} + C''(K_t)\frac{\partial K_t}{\partial y_t}\cdot\frac{\omega_t^P}{(1+c_t)^2}, \quad \frac{\partial \Pi_t^{UL}}{\partial y_t} = C''(K_t)\frac{\partial K_t}{\partial y_t}\cdot\frac{\phi_L}{(1+c_t)^2}, \tag{54}$$

$$\frac{\partial \Pi_t}{\partial \phi_1} = -\frac{c_t V_{t,t}}{1+c_t} - \phi_1 C''(K_t)\,Q_t^{PP}\left(\frac{V_{t,t}}{1+c_t}\right)^2, \quad \frac{\partial \Pi_t^{UL}}{\partial \phi_1} = -\,\phi_L\,C''(K_t)\,Q_t^{PP}\,\frac{V_{t,t}}{(1+c_t)^2}, \tag{55}$$

using $\partial K_t/\partial\phi_1 = -V_{t,t}Q_t^{PP}$ (equivalently $\partial K_t/\partial z = -Q_t^{PP}$), and with $\partial K_t/\partial y_t$ given by (64). Expressed per unit of the regulatory wedge $z = \phi_1 V_{t,t}$ (at $\phi_2 = 0$), these are the pass-throughs $\pi_z = -\partial\Pi_t/\partial z$ and $\pi_z^L \equiv -\partial\Pi_t^{UL}/\partial z = \tau(\pi_z - \pi_0)$ of the main text; on the

rate side, $\pi_y = -\partial\Pi_t/\partial y_t$ and $\pi_y^L \equiv -\partial\Pi_t^{UL}/\partial y_t = \tau(\pi_y - \pi_y^0)$. The relation $\pi_x^L = \tau(\pi_x - \pi_x^0)$ thus holds for both shocks, with $\pi_z^0 = \pi_0$ and $\pi_y^0 = \lambda_t \partial V_{t,t}/\partial y_t$.

The portfolio-share margin Differentiating (42) with respect to x_t at fixed fees and solving:

$$\frac{\partial \alpha_t}{\partial x_t} = \frac{-\dfrac{\partial \lambda_t}{\partial x_t}\dfrac{\partial V_{t,t}}{\partial \alpha_t} - \dfrac{\partial \lambda_t}{\partial c_t}\dfrac{\partial c_t}{\partial x_t}\dfrac{\partial V_{t,t}}{\partial \alpha_t} - \lambda_t \dfrac{\partial^2 V_{t,t}}{\partial \alpha_t \partial x_t} - \dfrac{\partial}{\partial x_t}\left(\dfrac{c_t}{1+c_t}\phi_2\right)}{\lambda_t \dfrac{\partial^2 V_{t,t}}{\partial \alpha_t^2}}, \tag{56}$$

with $\partial c_t/\partial x_t = -C''(K_t)\,\partial K_t/\partial x_t$ and the denominator positive by the second-order condition. For $x_t = y_t$ the numerator implies $\partial \alpha_t/\partial y_t > 0$ (equivalently $dw_{b,t}/dy_t < 0$): a higher long rate moves the guarantee out of the money and improves capital, both of which favor the risky asset—so falling rates push the insurer toward safe bonds. For $x_t = \phi_2$ the response is unambiguously negative—a tighter spread risk charge raises the safe-bond share—while for $x_t = \phi_1$ the sign depends on the calibration. For $x_t = \phi_L$ the first and third numerator terms vanish, so the entire effect runs through $\partial c_t/\partial \phi_L = C''(K_t) Q_t^{UL}$. These are the model's portfolio-rebalancing predictions, consistent with Domanski et al. (2017) and Jansen (2023); the empirical evidence of Section 4.3 indicates that this margin, while present, is economically small relative to the liability margin.

D.3 Demand: Nested Logit and Constant Semi-Elasticities

Structure Households choose among $\{PP, UL, 0\}$, where 0 denotes the deposit outside option, with the two insurance products in a nest I with nesting parameter $\lambda^N \in (0, 1]$. Deterministic utilities are as in (11). Writing s_{PP}, s_{UL} for the unconditional shares, $s_I = s_{PP} + s_{UL}$ for the insurance share, $s_{k|I}$ for within-nest shares, and $\theta \equiv 1/\lambda^N - 1 \geq 0$, the four fee semi-elasticities implied by the nested logit are

$$\begin{aligned} a &= \alpha_{PP}\left[(1 - s_{PP}) + \theta(1 - s_{PP|I})\right], & u &= \alpha_{PP}\left[s_{PP} + \theta\, s_{PP|I}\right], \\ b &= \alpha_{UL}\left[(1 - s_{UL}) + \theta(1 - s_{UL|I})\right], & v &= \alpha_{UL}\left[s_{UL} + \theta\, s_{UL|I}\right]. \end{aligned} \tag{57}$$

Note that (57) already carries the $(1 - s)$ factors, so the scaling of product-level elasticities (Koijen and Yogo, 2022b) to bundle-level elasticities is handled by the nesting structure rather than applied by hand. Under the small-share approximation these semi-elasticities are treated as constants, so that demand behaves locally as

$$Q_t^{PP} = s_{PP}\, e^{-a\,\Delta f_t^{PP} + v\,\Delta f_t^{UL} + \varepsilon_y^{PP}\Delta y_t}, \qquad Q_t^{UL} = s_{UL}\, e^{u\,\Delta f_t^{PP} - b\,\Delta f_t^{UL} + \varepsilon_y^{UL}\Delta y_t}, \tag{58}$$

with deviations taken from the calibration point. All second derivatives of demand then reduce to products of first derivatives and semi-elasticities, which is what allows the Jacobian and the shock vectors of Appendix D.2 to be written entirely in terms of (a, b, u, v), the quantities, the surpluses, and the feedback terms. Regulation does not enter demand: households see only the fees, so the charges (ϕ_1, ϕ_2, ϕ_L) operate entirely through the insurer's pricing.

The cross-elasticity restriction Three parameters $(\alpha_{PP}, \alpha_{UL}, \lambda^N)$ generate the four elasticities (57), so one restriction remains, and it has a simple closed form. Writing $\Lambda \equiv 1+\theta/s_I$, the pair (a, u) inverts to $\Lambda = u(1 - s_I)/(a\, s_{PP} - u\, s_{UL})$; substituting into the expressions for b and v and using $s_{UL} = \rho\, s_{PP}$ gives

$$v = \frac{b\, u\, \rho}{a + u\,(1 - \rho)}, \tag{59}$$

v depends only on (a, b, u, ρ)—the share levels drop out entirely. The share levels are needed only afterwards, to recover the underlying demand parameters,

$$\Lambda = \frac{u\,(1 - s_I)}{a\, s_{PP} - u\, s_{UL}}, \qquad \lambda^N = \frac{1}{1 + s_I(\Lambda - 1)}, \qquad \alpha_{PP} = \frac{u}{s_{PP}\Lambda}, \qquad \alpha_{UL} = \frac{v}{s_{UL}\Lambda}, \tag{60}$$

and to check admissibility: $\lambda^N \leq 1$ requires $\Lambda \geq 1$, which bounds the pre-regulation PP share,

$$s_{PP} \;\leq\; \frac{u}{a + u}. \tag{61}$$

An s_{PP} above the bound would require $\lambda^N > 1$, i.e. substitution toward the outside option stronger than substitution within insurance.

The rate elasticities The long rate enters only PP utility, with coefficient α_r. The implied own- and cross-rate semi-elasticities therefore reproduce the formulas (57) with α_{PP} replaced by α_r, so their ratio is independent of α_r and

$$\varepsilon_y^{UL} = -\frac{u}{a}\,\varepsilon_y^{PP}, \qquad \text{hence} \qquad \Delta_\varepsilon \equiv \varepsilon_y^{UL} - \varepsilon_y^{PP} = -\frac{a + u}{a}\,\varepsilon_y^{PP}, \tag{62}$$

Given a calibrated ε_y^{PP}, the utility slope follows as

$$\alpha_r = \frac{\varepsilon_y^{PP}}{(1 - s_{PP}) + \theta\,(1 - s_{PP|I})}.$$

D.4 Propositions 1 and 2

We prove Proposition 1 first: the regulatory shock isolates the supply-side transmission, and the proof of Proposition 2 then adds the demand-shift channel to the same machinery. Throughout, $\phi_2 = 0$ (so $\omega_t^P = z$), demand is the constant-semi-elasticity system (58), and we use the following shortands: $X = Q_t^{PP}$, $Y = Q_t^{UL}$, $\rho = Y/X$, $z = \phi_1 V_{t,t}$, $\tau = \phi_L/z$, $D = ab - uv$, $S = v + \tau u\rho^2$, $\hat{g}_P = a - \tau u\rho$, $\hat{g}_L = \tau b\rho - v$, and $\Gamma_t = \Theta_t z^2$. Finally, define the pass-through coefficients

$$\pi_0 \equiv \frac{c_t}{1+c_t}, \qquad \pi_z \equiv -\frac{\partial \Pi_t}{\partial z} = \pi_0 + \Gamma_t \frac{(1+c_t)X}{z}, \qquad \pi_y^0 \equiv \lambda_t \frac{\partial V_{t,t}}{\partial y_t}, \qquad \pi_y \equiv -\frac{\partial \Pi_t}{\partial y_t}, \tag{63}$$

where

$$\pi_y - \pi_y^0 = -\Gamma_t (1+c_t) \frac{\partial K_t/\partial y_t}{z}, \tag{64}$$

$$\frac{\partial K_t}{\partial y_t} = X \left[-(1+\phi_1)\frac{\partial V_{t,t}}{\partial y_t} + \left(\Pi_t - \frac{z}{1+c_t}\right)\varepsilon_y^{PP} + \left(f_t^{UL} - \phi_L\right)\varepsilon_y^{UL}\rho \right]. \tag{65}$$

Here π_0 is the pass-through of the regulatory wedge into the PP marginal cost when capital costs are linear; π_z adds the capital-feedback term, strictly positive when $\Gamma_t > 0$ because a tightening depletes statutory capital and raises c_t. On the rate side, $\pi_y^0 < 0$ is the direct effect of the long rate on the guarantee cost, and $\pi_y - \pi_y^0$ is the corresponding capital-feedback term.

Setup common to both proofs

With $\phi_2 = 0$ the capital-gradient objects of (47) factor as $\psi_{PP} = zX\hat{g}_P$ and $\psi_{UL} = zX\hat{g}_L$, so that $\Theta_t \psi_i \psi_j = \Gamma_t X^2 \hat{g}_i \hat{g}_j$. Substituting into (49)–(51) and writing $m \equiv \Pi_t X$ and $n \equiv \Pi_t^{UL} Y$ for the total surpluses, the equilibrium conditions (40)–(41) read

$$a\,m - u\,n = X, \qquad -v\,m + b\,n = Y \quad \Longleftrightarrow \quad m = \frac{bX + uY}{D}, \qquad n = \frac{vX + aY}{D}, \tag{66}$$

and the Jacobian takes the rank-one-corrected form

$$J = J_0 - \Gamma_t X^2\, \hat{g}\hat{g}', \qquad J_0 = \begin{pmatrix} u(a+u)\,n - aX & -uv(m+n) \\ -uv(m+n) & v(b+v)\,m - bY \end{pmatrix}, \qquad \hat{g} = \begin{pmatrix} \hat{g}_P \\ \hat{g}_L \end{pmatrix}. \tag{67}$$

Writing $w \equiv (a, -v)'$ and $\tilde{w} \equiv (-u, b)'$, the definitions of $(\hat{g}_P, \hat{g}_L)$ say

$$\hat{g} = w + \tau\rho\,\tilde{w}. \tag{68}$$

The adjugate identities. For a 2×2 matrix the adjugate is linear in the entries, so $\mathrm{adj}(J) = \mathrm{adj}(J_0) - \Gamma_t X^2\,\mathrm{adj}(\hat{g}\hat{g}')$, and $\mathrm{adj}(\hat{g}\hat{g}') = \hat{g}^\perp(\hat{g}^\perp)'$ with $\hat{g}^\perp \equiv (\hat{g}_L, -\hat{g}_P)'$, so that $\mathrm{adj}(\hat{g}\hat{g}')\,x = \big((\hat{g}^\perp)'x\big)\,\hat{g}^\perp$ for any vector x. Since $(\hat{g}^\perp)'\hat{g} = 0$ and, using (68),

$$(\hat{g}^\perp)'\tilde{w} = -u\hat{g}_L - b\hat{g}_P = -u(\tau b\rho - v) - b(a - \tau u\rho) = uv - ab = -D,$$

we obtain

$$\mathrm{adj}(J)\,\hat{g} = \mathrm{adj}(J_0)\,\hat{g}, \qquad \mathrm{adj}(J)\,\tilde{w} = \mathrm{adj}(J_0)\,\tilde{w} + \Gamma_t D X^2\,\hat{g}^\perp. \tag{69}$$

Only the direction $\tilde{w}$ picks up a Γ_t correction.

The four J_0 numerators. Write $J_0 = \begin{pmatrix} A & C \\ C & B \end{pmatrix}$ with $A = u(a+u)n - aX$, $B = v(b+v)m - bY$, $C = -uv(m+n)$, so that $\mathrm{adj}(J_0)w = (aB + vC,\, -aC - vA)'$ and $\mathrm{adj}(J_0)\tilde{w} = (-uB - bC,\, uC + bA)'$. Using $a(b+v) - uv = D + av$, the equilibrium relations $am - un = X$, $bn - vm = Y$, and $Dm = bX + uY$, $Dn = vX + aY$ from (66), direct computation gives

$$\begin{aligned} aB + vC &= v(b+v)X - DY, & -aC - vA &= v(a+u)X, \\ -uB - bC &= u(b+v)Y, & uC + bA &= u(a+u)Y - DX. \end{aligned}$$

For instance,

$$aB + vC = vm\,[a(b+v) - uv] - abY - uv^2 n = vDm + v^2(am - un) - abY = v(b+v)X - DY,$$

and the others are analogous. Forming $\mathrm{adj}(J_0)\hat{g} = \mathrm{adj}(J_0)w + \tau\rho\,\mathrm{adj}(J_0)\tilde{w}$ and using $vX + \tau\rho\,uY = XS$:

$$\mathrm{adj}(J_0)\,\hat{g} = X\begin{pmatrix} (b+v)S - D\rho \\ (a+u)S - \tau\rho D \end{pmatrix}, \qquad \mathrm{adj}(J)\,\tilde{w} = X\begin{pmatrix} u(b+v)\rho + \Gamma_t D X \hat{g}_L \\ u(a+u)\rho - D - \Gamma_t D X \hat{g}_P \end{pmatrix}. \tag{70}$$

The determinant. Substituting (66) into J_0 and expanding, each coefficient of the quadratic form collapses to a power of D, giving

$$\Delta_0 = D\,XY - v(b+v)X^2 - u(a+u)Y^2. \tag{71}$$

For $\Gamma_t > 0$, the matrix determinant lemma applied to (67) gives $\Delta = \Delta_0 - \Gamma_t X^2\, \hat{g}'\, \mathrm{adj}(J_0)\, \hat{g}$. Expanding $\hat{g} = w + \tau\rho\tilde{w}$ and contracting with the four numerators above,

$$w'\mathrm{adj}(J_0)w = D(vX - aY), \qquad w'\mathrm{adj}(J_0)\tilde{w} = D(uY + vX), \qquad \tilde{w}'\mathrm{adj}(J_0)\tilde{w} = D(uY - bX),$$

each step using $a(b+v) - v(a+u) = b(a+u) - u(b+v) = D$. Hence

$$\Delta = \Delta_0 - \Gamma_t X^2 D\left[(vX - aY) + 2\tau\rho\,(uY + vX) + \tau^2\rho^2\,(uY - bX)\right], \tag{72}$$

and dividing (71)–(72) by X^2 delivers $\Omega \equiv \Delta/X^2$. The second-order conditions at an interior optimum are $D > 0$, $F_{fPP} < 0$, and $\Delta > 0$; the first also guarantees, through (66), that both product lines earn positive surplus in equilibrium, which on the UL side requires $f_t^{UL} > \frac{c_t}{1+c_t}\phi_L$.

Proposition 1 (Total derivatives with respect to the regulatory wedge)**.** *Under the assumptions of Proposition 2, and noting that regulation does not enter household demand directly, the equilibrium responses to a tightening of the regulatory wedge $z = \phi_1 V_{t,t}$ (holding $\tau = \phi_L/z$ fixed at its regulatory value and y_t constant) are*

$$\frac{df_t^{PP}}{dz} = \frac{\pi_z}{\Omega}\Big[D\rho - (b+v)S\Big] + \frac{\pi_0\,\tau\rho}{\Omega}\Big[u(b+v)\rho + \Gamma_t DX\hat{g}_L\Big] \tag{73}$$

$$\frac{df_t^{UL}}{dz} = \frac{\pi_z}{\Omega}\Big[\tau\rho D - (a+u)S\Big] + \frac{\pi_0\,\tau\rho}{\Omega}\Big[u(a+u)\rho - D - \Gamma_t DX\hat{g}_P\Big] \tag{74}$$

$$\frac{d\log Q_t^{PP}}{dz} = -\frac{\pi_z}{\Omega}\,D\Big[(a\rho - v) - \tau\rho(u\rho + v)\Big] - \frac{\pi_0\,\tau\rho}{\Omega}\,D\Big[(u\rho + v) + \Gamma_t DX\tau\rho\Big] \tag{75}$$

$$\frac{d\log Q_t^{UL}}{dz} = \frac{\pi_z}{\Omega}\,D\Big[(u\rho + v) + \tau\rho(u\rho - b)\Big] + \frac{\pi_0\,\tau\rho}{\Omega}\,D\Big[(b - u\rho) + \Gamma_t DX\Big]. \tag{76}$$

Proof of Proposition 1 Regulation does not enter demand, so the shock terms (52)–(53) for $x_t = z$ contain no demand-shift component. Using $\pi_z = -\partial\Pi_t/\partial z$ and $\pi_z^L = -\partial\Pi_t^{UL}/\partial z = \tau(\pi_z - \pi_0)$,

$$F_z = \pi_z\, aX - \pi_z^L\, uY, \qquad G_z = -\pi_z\, vX + \pi_z^L\, bY, \tag{77}$$

which resolves in the $(w, \tilde{w})$ basis as

$$-\begin{pmatrix} F_z \\ G_z \end{pmatrix} = -X\left[\pi_z\, w + \pi_z^L\,\rho\,\tilde{w}\right] = -X\left[\pi_z\,\hat{g} - \pi_0\,\tau\rho\,\tilde{w}\right], \tag{78}$$

using (68) in the second equality. The shock therefore has a component along the rank-one direction $\hat{g}$—which, by (69), is annihilated by the Γ_t correction to the adjugate—and a residual $-\pi_0\tau\rho\,\tilde{w}$, which is not. The residual is non-zero precisely when $\phi_L > 0$, and it is what prevents Γ_t from cancelling out of the numerators. By Cramer's rule,

$$\begin{pmatrix} df_t^{PP}/dz \\ df_t^{UL}/dz \end{pmatrix} = -\frac{X}{\Delta}\left[\pi_z \operatorname{adj}(J_0)\,\hat{g} - \pi_0\tau\rho \operatorname{adj}(J)\,\tilde{w}\right], \tag{79}$$

and substituting (70) and $\Delta = \Omega X^2$ delivers the fee rows (73)–(74). For the quantity rows, apply the demand identities (regulation absent from demand):

$$\frac{d\log Q_t^{PP}}{dz} = -a\,\frac{df_t^{PP}}{dz} + v\,\frac{df_t^{UL}}{dz}, \qquad \frac{d\log Q_t^{UL}}{dz} = u\,\frac{df_t^{PP}}{dz} - b\,\frac{df_t^{UL}}{dz}.$$

The π_z brackets combine through $a(b+v) - v(a+u) = b(a+u) - u(b+v) = D$ and $S - a\rho + \tau v\rho = -\left[(a\rho - v) - \tau\rho(u\rho + v)\right]$, and the $\pi_0\tau\rho$ brackets through the two identities

$$a\hat{g}_L + v\hat{g}_P = \tau\rho D, \qquad u\hat{g}_L + b\hat{g}_P = D, \tag{80}$$

which follow directly from the definitions of $(\hat{g}_P, \hat{g}_L)$. Collecting terms delivers (75)–(76). □

Setting $\phi_L = 0$ gives $\tau = 0$, $S = v$, $\hat{g} = w$: the residual vanishes, both the rank-one block and the shock vector collapse onto w, and the four responses reduce to $\frac{\pi_z}{\Omega}\left[D\rho - v(b+v)\right]$, $-\frac{\pi_z}{\Omega}v(a+u)$, $-\frac{\pi_z}{\Omega}D(a\rho - v)$, and $\frac{\pi_z}{\Omega}D(u\rho + v)$, with $\Omega = \Omega_0 + \Gamma_t DX(a\rho - v)$. The UL sign claims in the discussion of Proposition 1 follow from (74) and (76) directly: the UL-fee numerator is a quadratic in τ with positive leading coefficient $(\pi_0\Gamma_t X D u\rho^2)$ and negative intercept $(-\pi_z(a+u)v)$, so $df_t^{UL}/dz > 0$ iff τ exceeds a single threshold; the UL-quantity numerator is linear in τ, and—using $\pi_z - \pi_0 = \Gamma_t(1+c_t)X/z$, so that $\Gamma_t X$ cancels from the relevant bracket—$d\log Q_t^{UL}/dz < 0$ iff $(1+c_t)(b - u\rho) > \pi_0 Dz$ and τ exceeds a second threshold. Both thresholds are infinite at $\Gamma_t = 0$, which proves the linear-cost sign results quoted in the main text.

Proposition 2 (Total derivatives with respect to the long-term rate)**.** *Assume constant semi-elasticities, $\phi_2 = 0$, and normalize $\varepsilon_y^{UL} = 0$. At an interior optimum satisfying $D > 0$*

and $\Omega > 0$, the equilibrium responses of fees and quantities to the long rate are

$$\frac{df_t^{PP}}{dy_t} = \frac{1}{\Omega}\Big\{\pi_y\big[D\rho - (b+v)S\big] + \pi_y^0\,\tau\rho\big[u(b+v)\rho + \Gamma_t DX\hat{g}_L\big] - \varepsilon_y^{PP}\big[u\rho^2 + \Gamma_t SX\hat{g}_L\big]\Big\} \tag{81}$$

$$\frac{df_t^{UL}}{dy_t} = \frac{1}{\Omega}\Big\{\pi_y\big[\tau\rho D - (a+u)S\big] + \pi_y^0\,\tau\rho\big[u(a+u)\rho - D - \Gamma_t DX\hat{g}_P\big] + \varepsilon_y^{PP}\big[v + \Gamma_t SX\hat{g}_P\big]\Big\} \tag{82}$$

$$\frac{d\log Q_t^{PP}}{dy_t} = \underbrace{\varepsilon_y^{PP}}_{direct} + \frac{1}{\Omega}\Big\{-\pi_y D\big[(a\rho - v) - \tau\rho(u\rho + v)\big] - \pi_y^0\,\tau\rho D\big[(u\rho + v) + \Gamma_t DX\tau\rho\big] + \varepsilon_y^{PP}\big[au\rho^2 + v^2 + \Gamma_t SX\tau\rho D\big]\Big\} \tag{83}$$

$$\frac{d\log Q_t^{UL}}{dy_t} = \frac{1}{\Omega}\Big\{\pi_y D\big[(u\rho + v) + \tau\rho(u\rho - b)\big] + \pi_y^0\,\tau\rho D\big[(b - u\rho) + \Gamma_t DX\big] - \varepsilon_y^{PP}\big[bv + u^2\rho^2 + \Gamma_t SXD\big]\Big\}. \tag{84}$$

Proof of Proposition 2 Everything concerning the Jacobian carries over unchanged; only the shock vector differs. For $x_t = y_t$ with $\varepsilon_y^{UL} = 0$, the shock terms (52)–(53) become, using $m = \Pi_t X$, $n = \Pi_t^{UL} Y$,

$$F_y = \pi_y\, aX - \pi_y^L\, uY - \varepsilon_y^{PP}\, u\, n, \qquad G_y = -\pi_y\, vX + \pi_y^L\, bY + \varepsilon_y^{PP}\, v\, m. \tag{85}$$

The first two terms of each are (77) with π_z replaced by π_y, so by (78) and $\pi_y^L = \tau(\pi_y - \pi_y^0)$ they resolve in the same basis, and

$$-\begin{pmatrix} F_y \\ G_y \end{pmatrix} = -X\left[\pi_y\,\hat{g} - \pi_y^0\,\tau\rho\,\tilde{w}\right] + \varepsilon_y^{PP}\,h, \qquad h \equiv \begin{pmatrix} u\,n \\ -v\,m \end{pmatrix}. \tag{86}$$

By Cramer's rule,

$$\begin{pmatrix} df_t^{PP}/dy_t \\ df_t^{UL}/dy_t \end{pmatrix} = \frac{1}{\Delta}\left\{-X\left[\pi_y \operatorname{adj}(J_0)\,\hat{g} - \pi_y^0\,\tau\rho \operatorname{adj}(J)\,\tilde{w}\right] + \varepsilon_y^{PP} \operatorname{adj}(J)\,h\right\}, \tag{87}$$

and the square bracket is already evaluated in (70); only $\mathrm{adj}(J)h$ is new. For the J_0 part, direct computation using $Y = bn - vm$ and $X = am - un$ gives

$$\mathrm{adj}(J_0)\, h = \begin{pmatrix} -u\, Y^2 \\ v\, X^2 \end{pmatrix} = X^2 \begin{pmatrix} -u\rho^2 \\ v \end{pmatrix}.$$

(First component: $unB + vmC = un\,[v(b+v)m - bY] - uv^2 m(m+n) = -u(bn-vm)^2 = -uY^2$; second component analogous.) For the rank-one correction we need the contraction of h with $\hat{g}^{\perp}$, which by (68) and the same equilibrium relations is

$$(\hat{g}^{\perp})' h = un\hat{g}_L + vm\hat{g}_P = \tau\rho\,[u(bn - vm)] + v(am - un) = \tau u\rho^2 X + vX = XS,$$

so that

$$\mathrm{adj}(J)\, h = X^2 \left[\begin{pmatrix} -u\rho^2 \\ v \end{pmatrix} - \Gamma_t S X\, \hat{g}^{\perp} \right]. \tag{88}$$

Note that h is *not* parallel to $\hat{g}$—indeed $(\hat{g}^{\perp})' h = XS > 0$—so this term survives for every $\tau \geq 0$, including $\tau = 0$: capital convexity never cancels from the interest-rate numerators, even without the unit-linked charge. Substituting (70) and (88) into (87), every term carries X^2, and dividing by $\Delta = \Omega X^2$ delivers the fee rows (81)–(82). For the quantity rows, apply

$$\frac{d \log Q_t^{PP}}{dy_t} = \varepsilon_y^{PP} - a\, \frac{df_t^{PP}}{dy_t} + v\, \frac{df_t^{UL}}{dy_t}, \qquad \frac{d \log Q_t^{UL}}{dy_t} = u\, \frac{df_t^{PP}}{dy_t} - b\, \frac{df_t^{UL}}{dy_t}.$$

The π_y and π_y^0 brackets combine exactly as in the proof of Proposition 1, and the ε_y^{PP} brackets combine through the same identities (80):

$$-a\left[-(u\rho^2 + \Gamma_t S X \hat{g}_L)\right] + v\,[v + \Gamma_t S X \hat{g}_P] = au\rho^2 + v^2 + \Gamma_t S X\, \tau\rho D,$$

$$u\left[-(u\rho^2 + \Gamma_t S X \hat{g}_L)\right] - b\,[v + \Gamma_t S X \hat{g}_P] = -\left[u^2\rho^2 + bv + \Gamma_t S X\, D\right],$$

which delivers (83)–(84). For the general case $\varepsilon_y^{UL} = -(u/a)\varepsilon_y^{PP}$ of (62), the shock terms carry $\Delta_\varepsilon = \varepsilon_y^{UL} - \varepsilon_y^{PP}$ in place of $-\varepsilon_y^{PP}$ and the direct term ε_y^{UL} is added to the Q^{UL} row, as stated in the proposition. □

D.5 Calibration Strategy

The regulatory block The unknowns of the regulatory block are the three free semi-elasticities (a, b, u) and the capital-feedback object $\Gamma_t X$—the only combination in which the

curvature $C''(K_t)$ appears. The cross-elasticity v is not free: it is recomputed from the restrictions of the nested logit inside every evaluation of every moment condition. Four moments, four parameters: the block is exactly identified.

The structure of Proposition 1 makes the solve well conditioned. Because regulation does not enter demand directly, the two quantity responses are pure demand identities in the fee responses,

$$\frac{d\log Q_t^{PP}}{dz} = -a\,\frac{df_t^{PP}}{dz} + v\,\frac{df_t^{UL}}{dz}, \qquad \frac{d\log Q_t^{UL}}{dz} = u\,\frac{df_t^{PP}}{dz} - b\,\frac{df_t^{UL}}{dz}. \tag{89}$$

Imposing (89) at the empirical values pins b linearly in u and, after substituting for v using the nested logit, pins a as the positive root of a quadratic, reducing the numerical problem to the two fee equations (73)–(74) in $(u, \Gamma_t X)$; at any root, the quantity moments hold automatically (Appendix D.6). The solution reproduces all four targets to machine precision and is unique in the admissible region across a battery of random starting points. With (a, b, u, v) in hand, the share levels identify the underlying nested-logit primitives $(\alpha_{PP}, \alpha_{UL}, \lambda^N)$ in closed form, with admissibility $\lambda^N \in (0, 1]$ equivalent to a simple bound on the pre-regulation PP share (Appendix D.3).

The admissible window for τ Since τ is an input, we repeat the calibration on a grid $\tau \in [0.5, 4]$. An exact fit to (23) first exists at $\tau \approx 1.10$: below that, u is driven to its zero boundary—without a large enough unit-linked charge the model cannot generate the observed UL responses, the grid counterpart of the sign results in Proposition 1. Admissibility then carves out

$$\tau \in [1.90,\ 2.55] \quad \text{at } (s_{PP}, s_{UL}) = (0.20, 0.10),$$

with the lower edge set by $\lambda^N \leq 1$ and the upper edge by the second-order condition $\Omega > 0$. This window is a finding worth emphasizing: for the model to reproduce the Barbu et al. (2025b) responses, unit-linked business must carry a capital charge of roughly *twice* the wedge on guaranteed business. Within the window, $\Gamma_t X$ is remarkably stable (≈ 1.5–1.8×10^{-2}) while the demand elasticities steepen quickly with τ, so the choice of τ is mostly a statement about demand elasticities rather than about the capital channel. The baseline $\tau = 2.0$ is comfortably interior.

The interest-rate block Everything in the rate derivatives (81)–(84) is pinned by the regulatory block except two objects: the liability-value slope $\partial V_{t,t}/\partial y_t$ and the demand semi-elasticity ε_y^{PP} (the cross rate-elasticity follows from the nested logit). Because π_y is linear in these two unknowns, there is no numerical search anywhere in this block. The solve

imposes no sign restrictions, so the two theoretical signs are genuine tests, and both pass:

$$\frac{\partial V_{t,t}}{\partial y_t} = -0.0230, \qquad \varepsilon_y^{PP} = 0.0650, \qquad \varepsilon_y^{UL} = -0.0190.$$

The implied fee responses are untargeted predictions: $df_t^{PP}/dy_t = -0.0865$ and $df_t^{UL}/dy_t = -0.0310$. Both fees fall when the long rate rises, with the PP fee nearly three times as sensitive—the pattern one would expect if the burden of low rates falls on the guaranteed line, and the external validation of this block.

D.6 Details on Implementation of Calibration

Conditioning the regulatory solve With regulation absent from demand, the two quantity moments are the demand identities (89). Write $m_{f^{PP}}$, $m_{f^{UL}}$, $m_{q^{PP}}$, $m_{q^{UL}}$ for the four empirical values in (23). Imposed at these values, the identities pin

$$b = \frac{u\, m_{f^{PP}} - m_{q^{UL}}}{m_{f^{UL}}}, \tag{90}$$

linearly in u, and, after substituting the nested-logit restriction (59) into the Q^{PP} identity, pin a as the positive root of the quadratic

$$m_{f^{PP}}\, a^2 + \left[m_{f^{PP}}\, u(1-\rho) + m_{q^{PP}}\right] a + m_{q^{PP}}\, u(1-\rho) - m_{f^{UL}}\, b\, u\rho = 0. \tag{91}$$

The numerical solve therefore works on only the two fee equations (73)–(74) in $(u, \Gamma_t X)$, parameterised in logs so that positivity is structural; at any root, the quantity moments hold automatically through (89), and v is recomputed from (59) inside every evaluation. The solution reproduces all four targets to 9×10^{-16} and is unique in the admissible region across 25 random starting points. The fee *levels* then follow from the equilibrium conditions (66): $\Pi_t = (b + u\rho)/D$, $\Pi_t^{UL} = (v + a\rho)/(D\rho)$, and $f_t^{PP} = \Pi_t + \lambda_t V_{t,t}$, $f_t^{UL} = \Pi_t^{UL} + \frac{c_t}{1+c_t}\phi_L$, and serve as untargeted checks.

The interest-rate solve The two rate moments map into the two log-derivatives, as described in a footnote of Section 8 with $m^{UL} = \rho/(1+\rho)$; the flow moment requires the share levels, not just ρ. Everything in (81)–(84) is fixed by the regulatory block except $(\partial V_{t,t}/\partial y_t,\ \varepsilon_y^{PP})$: $\partial K_t/\partial y_t$ is determined by (64), and ε_y^{UL} by (62). Both π_y^0 and π_y are linear

in the two unknowns,

$$\pi_y = A_V \frac{\partial V_{t,t}}{\partial y_t} + A_\varepsilon \, \varepsilon_y^{PP}, \qquad \begin{aligned} A_V &= \lambda_t + (\pi_z - \pi_0)(1+\phi_1), \\ A_\varepsilon &= -(\pi_z - \pi_0)\left[\Pi_t - \frac{z}{1+c_t} - \frac{u}{a}\rho\left(f_t^{UL} - \phi_L\right)\right], \end{aligned} \tag{92}$$

where $\pi_z - \pi_0 = \Gamma_t(1+c_t)X/z$ is already pinned. Since the two quantity rows (83)–(84) are in turn linear in $(\pi_y, \pi_y^0, \varepsilon_y^{PP})$, the two moment conditions form a 2×2 linear system

$$\begin{pmatrix} d\log Q_t^{PP}/dy_t \\ d\log Q_t^{UL}/dy_t \end{pmatrix} = M \begin{pmatrix} \partial V_{t,t}/\partial y_t \\ \varepsilon_y^{PP} \end{pmatrix}, \tag{93}$$

solved in closed form. Writing

$$\begin{aligned} N_1 &= (a\rho - v) - \tau\rho(u\rho + v), \quad N_2 = (u\rho + v) + \Gamma_t DX\tau\rho, \quad E_P = au\rho^2 + v^2 + \Gamma_t SX\tau\rho D, \\ N_3 &= (u\rho + v) + \tau\rho(u\rho - b), \quad N_4 = (b - u\rho) + \Gamma_t DX, \qquad E_L = bv + u^2\rho^2 + \Gamma_t SXD, \end{aligned}$$

the entries are

$$\begin{aligned} M_{11} &= -\left[A_V DN_1 + \lambda_t \tau\rho DN_2\right]/\Omega, & M_{12} &= \left[\Omega - A_\varepsilon DN_1 + \tfrac{a+u}{a}E_P\right]/\Omega, \\ M_{21} &= \left[A_V DN_3 + \lambda_t \tau\rho DN_4\right]/\Omega, & M_{22} &= \left[A_\varepsilon DN_3 - \tfrac{u}{a}\Omega - \tfrac{a+u}{a}E_L\right]/\Omega. \end{aligned} \tag{94}$$

Because the system is linear, the two theoretical sign restrictions—$\partial V_{t,t}/\partial y_t < 0$ and $\varepsilon_y^{PP} > 0$—carve a cone of admissible moment pairs out of M^{-1} *before* any moment is imposed; expressed as an interval for the mix moment at $dQ^I/dy = 0.12$, this is the interval $[-0.161, -0.130]$ reported in Section 8.1. The cone moves with τ and ρ, so any comparative statics will have to select x at the midpoint of the cone's interval whenever the variant moves it.

Demand levels With $(\alpha_{PP}, \alpha_{UL}, \lambda^N)$ recovered from (60) and α_r from (62), the intercepts $(\delta_{PP}, \delta_{UL})$ are exactly identified by requiring the nested logit to reproduce the target shares at the calibrated fees and y_0. Standard share inversion gives

$$IV = \log\frac{s_I}{1 - s_I}, \qquad v_{PP} = IV + \lambda^N \log s_{PP|I}, \qquad v_{UL} = IV + \lambda^N \log s_{UL|I},$$

and hence $\delta_{PP} = v_{PP} + \alpha_{PP} f_t^{PP} - \alpha_r y_0$ and $\delta_{UL} = v_{UL} + \alpha_{UL} f_t^{UL}$. The nesting structure already carries the $(1-s)$ factors of the semi-elasticity formulas (57), so no product-to-bundle rescaling is applied on top.

Cost of capital The exponential $C(K) = Ae^{-\eta K}$ is decreasing and convex everywhere and satisfies $c_t = -C'(K) = A\eta e^{-\eta K}$ and $C'' = \eta\, c$. Matching the calibrated $(c_t, \Gamma_t X)$ gives the closed forms

$$\eta = \frac{C''(K_0)}{c_t} = \frac{\Gamma_t X\,(1+c_t)^3}{c_t\, z^2\, s_{PP}}, \qquad A = \frac{c_t}{\eta}\, e^{\eta K_0}, \tag{95}$$

with the level $K_0 = 1$ a pure normalisation: only $K - K_0$ enters $c(K)$, and the legacy-capital term backs out of the capital identity (18) (at $\phi_2 = 0$) as

$$L \equiv R_K K_{-1} = K_0 - \left(f_t^{PP} - (1+\phi_1)V_{t,t}\right) s_{PP} - \left(f_t^{UL} - \phi_L\right) s_{UL} = 0.9515.$$

The calibrated curvature is $\eta = 171.5$: the marginal cost of capital moves by a factor e for every 0.006 of statutory capital. In the transition experiment, the legacy term is held fixed at L (the flows-only assumption), while statutory capital and c_t are fully endogenous within each period.

The liability value $V_{t,t}(y)$ Globally, $V_{t,t} = P - (1-\delta)C$ with Black–Scholes put and call on the portfolio per unit of premium: strike $(1+g)^T$ with $g = \phi_g\, y$ (in decimals), forward $(1+y)^T$, discount factor $(1+y)^{-T}$, and total volatility $\sigma\sqrt{T}$. The externals are set at $T = 20$, $\phi_g = 0.6$, $\delta = 0.9$, $\sigma = 0.08$. The resulting $V_{BS}(y_0) = 0.0656$ against the targeted 0.05, and $V'_{BS}(y_0) = -0.0344$ against the calibrated -0.0230, constitute the over-identification check reported in Section 8.2. For the transition, which must start exactly at the calibrated point, the affine recentring

$$V(y) = V_{BS}(y) + c_0 + c_1(y - y_0), \qquad c_0 = -0.0156, \quad c_1 = 0.0114,$$

matches the calibrated level and slope exactly while preserving the Black–Scholes convexity in y, which is the substantive global property: as rates fall, both the guarantee cost and the regulatory wedge $z = \phi_1 V(y)$ accelerate.

E. A Framework for Insurance Flows and Long-Term Bond Yields

This appendix presents the framework underlying the quantification of insurers' impact on long-term bond yields.

E.1 A Simplified Framework

To organize the discussion, we begin with a simple static framework that captures the essential mechanism linking insurer flows to long-term bond yields.

The simple model, adapted from Gabaix and Koijen (2021), serves only to connect quantities to prices. Its role is pragmatic: it translates existing elasticity estimates and measured flows into a common set of units, allowing us to make quantitative statements.

The model includes only two asset classes: a long-term bond and an outside asset. Let $F_{\text{Ins},t}$ denote household flows into insurance companies, and let W_t denote total household wealth. Let $w^B_{\text{ins},t}$ be the share of long-term bonds in insurers' portfolios and $w^B_{\text{O},t}$ the corresponding share in the portfolios of all other investors.

Market Segmentation We define the *relative portfolio tilt* (or, equivalently, *market segmentation*) as

$$\Psi_t \equiv \frac{w^B_{\text{ins},t} - w^B_{\text{O},t}}{w^B_t},$$

where w^B_t denotes the weight of long-term bonds in the aggregate market portfolio. When $\Psi_t > 0$, insurers hold disproportionately more long-term bonds than the rest of the market. Note that

$$w^B_t = \alpha_t \, w^B_{\text{ins},t} + (1 - \alpha_t) \, w^B_{\text{O},t},$$

where α_t is the asset share of insurance companies in the economy (i.e., their share of total household wealth).

Market segmentation in the long-term bond market thus measures the relative difference in long-term bond holdings between insurers and other investors. In a representative-agent economy, we would have $\Psi_t = 0$. However, due to their long-term funding structure, insurance companies are naturally positioned to hold long-term bonds in greater proportion than other investors, so that empirically $\Psi_t > 0$. Even though total flows across sectors sum to zero, any household reallocation away from insurance companies—toward deposits, mutual funds, or consumption—generates non-zero net demand for long-term bonds in general equilibrium whenever $\Psi_t \neq 0$.

Price Impact In a partial-equilibrium demand system for long-term bonds, the price impact of a net demand shift is given by

$$\Delta p_t^B = \underbrace{\frac{1}{\zeta}}_{\substack{\text{Price} \\ \text{Multiplier}}} \times \underbrace{\frac{F_{\text{Ins},t}}{W_t}}_{\substack{\text{Magnitude} \\ \text{of Flows}}} \times \underbrace{\Psi_t}_{\substack{\text{Market} \\ \text{Segmentation}}} \tag{96}$$

where $\frac{1}{\zeta}$ is the price multiplier that measures the response of long-term bond prices (relative to short-term bonds) to a 1% change in demand.[27]

Equation (96) summarizes the core logic: in an inelastic long-term bond market, net dollar flows, weighted by insurers' relative portfolio tilt, move prices. Even when total household flows sum to zero, reallocations across sectors affect bond yields whenever investors differ systematically in their maturity preferences.

The framework therefore highlights three factors: (i) the magnitude of insurance flows, (ii) the relative portfolio tilt of insurers toward long-term bonds, and (iii) the price elasticity of long-term bonds.

We now perform a back-of-the-envelope quantification of the three factors in Equation 96.

The Size of Insurance Flows To construct $F_{\text{Ins},t}$, we perform the following counterfactual experiment. Suppose that, throughout 2015–2025, households had continued to allocate the same shares of their financial flows (net savings into financial assets) as in the pre-QE period. We then compare the resulting counterfactual flows into insurance products with the flows observed in the data and define $F_{\text{Ins},t}$ as the difference between the two (counterfactual minus observed). This calculation implies a cumulative shortfall of about \$1.7 trillion in flows into insurance products between 2015 and 2025. Although these flows are measured relative to the pre-QE baseline allocation, we will, for simplicity, refer to them as "insurance flows" $F_{\text{Ins},t}$ whenever there is no ambiguity.

Let W_t denote total household wealth. With W_t averaging around \$30 trillion between 2015 and 2025, the cumulative shortfall corresponds to a *relative* outflow of about 5.6% of wealth (i.e., $F_t/W_t \approx -5.6\%$). These flows are large—not only relative to total household wealth, but especially when compared to the supply of long-term bonds with maturities above 10 years, which totaled \$9.5 trillion in June 2025 and represent the core allocation of insurance companies. Importantly, however, the outflows from insurance companies are reallocated to other intermediaries, such as banks (via deposits) or mutual funds, many of which also demand long-term bonds. What matters for the effect on the bond market is

[27] See Chaudhary et al. (2024) for recent estimates and an overview.

therefore the net equilibrium demand, which is determined by insurers' excess weight in long-term bonds relative to other investor sectors. The next section quantifies this equilibrium net demand effect.

Long-Term Bond Market Segmentation Insurance companies and pension funds are uniquely positioned to invest in long-term securities, given their long-dated liabilities. As a result, they are the primary private holders of long-term government bonds. Panel (a) of Figure E.1 shows the maturity composition of bond portfolios across investor sectors: insurers and pension funds allocate disproportionately to maturities above ten years, far more than mutual funds, banks, or households, which are tilted toward shorter maturities. This already suggests that outflows from insurance companies—unless redirected into pension products—are likely to move toward sectors with much lower long-term bond weights, thereby reducing net demand for long-dated bonds.

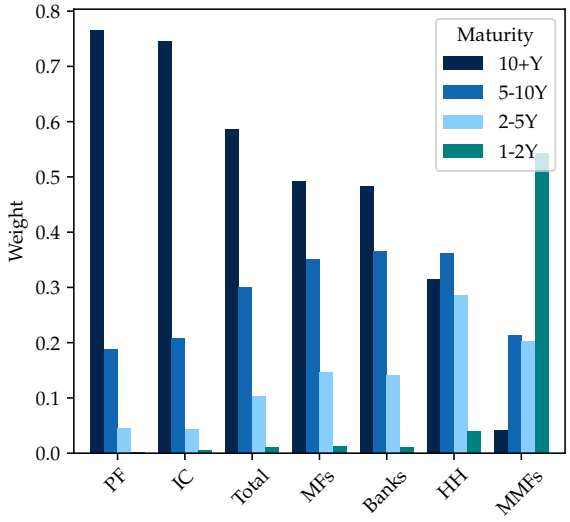
To quantify this, we consider each sector's total long-term bond share, not only its maturity tilt within the bond portfolio. We measure insurers' weight in long-term bonds, $w^B_{\text{ins},t}$, as long-term bond holdings relative to total insurer assets. The corresponding weight for all other investors, $w^B_{\text{O},t}$, is computed as the residual supply of long-term bonds (total supply minus insurer holdings) divided by residual assets (total EU assets minus insurer assets), yielding an asset-weighted average across all non-insurer sectors, including pension funds.

Insurers' preference for long-term bonds is much stronger than that of the rest of the market, with an average market segmentation of $\bar{\Psi} \approx 0.84$. Currently, insurers hold about 31% of their assets in long-term bonds, compared with only 16% for other investors. This implies that when one dollar flows out of the insurance sector and is absorbed by the remaining investors (pension funds, mutual funds, banks, etc.), roughly 15 cents flow out of long-term bonds. Because insurers also invest indirectly in mutual funds with long-duration exposure, this estimate likely understates their effective long-term bond tilt, making the implied net demand effects a strict lower bound.

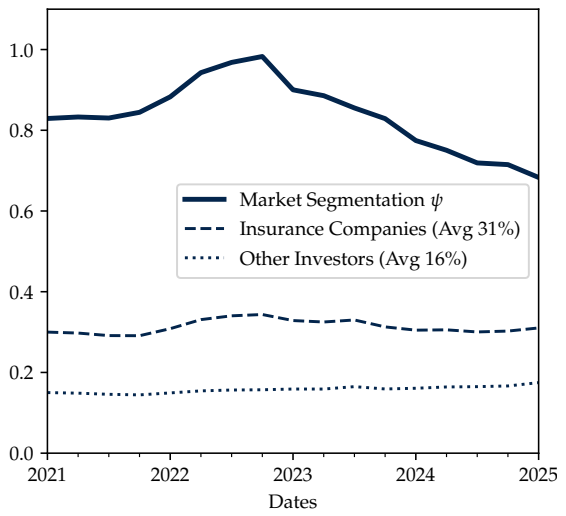
Price Impact of Demand Shifts While the magnitude of flows and market segmentation are directly observable, the impact of demand shifts on the term premium is unobservable. The literature has proposed three ways to estimate the multiplier, $\frac{1}{\zeta}$, which measures the price impact of buying 1% of long-term bond supply on the prices of long-term bonds relative to short-term bonds. First, reduced-form studies (e.g. Krishnamurthy and Vissing-Jorgensen (2012)) estimate the impact via regressions of (changes in) term premia onto plausibly exogenous demand shocks. Second, the semi-structural approach (e.g. Chaudhary et al. (2024)) estimates investor-level regressions of demand onto (changes in) term premia. The multiplier

Figure E.1: Market Segmentation and Insurance Flows

(a) Maturity Habitats



(b) Long-Term Bond Market Segmentation



Note: Panel a) plots the weight in long-term bonds with maturity above 10 years *within* the bond portfolio of different investor sectors. Panel b) plots the portfolio allocation of long-term bonds relative to total assets for insurance companies (dashed line) and other investors (dotted line). The market segmentation measure ψ is given by $(w^B_{\text{Ins.},t} - w^B_{\text{Other.},t})/w^B_t$. Panel b) plots the share of flows into insurance companies $F_{\text{Ins.},t}$ as a fraction of total household flows F_t. Source: EIOPA Regulatory Filings.

is given by the inverse of the weighted average investor-level elasticity.

As highlighted extensively in Chaudhary et al. (2024), there is considerable agreement across all three types of evidence on the price impact for 10-year U.S. Treasuries, with $\frac{1}{\zeta}$ estimated at around 1. See their Figure B.4 for a comprehensive overview of multiplier estimates in the literature.[28] Given our focus on maturities exceeding 10 years – where fewer close substitutes are available – we adopt a *conservative lower bound* of $\frac{1}{\zeta} \approx 0.99$. This corresponds to the benchmark estimate of Chaudhary et al. (2024), which we view as the most comprehensive and quantitatively careful study of aggregate bond market multipliers to date.

By contrast, Koijen et al. (2017) report a lower multiplier of 0.3 for EU government bonds. However, their estimate reflects an average across all maturities, making it less representative for the long end of the curve that we study. In addition, their cross-sectional approach relies on variation across EU countries, where government bonds are likely closer substitutes for each other than the aggregate market for long-term versus short-term bonds.

[28] Chaudhary et al. (2023) document a similar multiplier of 1.64 for long-term corporate bonds ($\geq$ 10 years) relative to short-term corporate bonds ($\leq$ 3 years) in the U.S.

Table E1: Price Impact Estimates for Long-Term Bonds

	Methodology	Asset	Multiplier
Jansen et al. (2024)	Structural	Treasuries	1.62
Chaudhary et al. (2024)	Semi-Structural	Treasuries	1.01
Gagnon et al. (2011)	Reduced-Form	Treasuries	1.34
Chaudhary et al. (2023)	Reduced-Form	US Corporate Bonds	1.64
Koijen et al. (2017)	Semi-Structural	EU Government Bonds	0.3

Note: Elasticity of long versus short-term treasuries and corporate bonds from previous studies. All of the papers study long-term treasuries with maturities $\geq$ 10 years, with the exception of Koijen et al. (2017), who estimate maturity weighted averages.

E.2 The Price Impact of Insurance Flows

Table E2 reports the calibration results for the three economic primitives. Our baseline calibration implies that insurance flows lowered long-term yields by about 50 basis points. We assess the sensitivity of this estimate to the three inputs. To highlight the role of each input, we vary them in line with plausible alternative assumptions. For example, we draw on external estimates of price impact, incorporate long-term bond exposures via CIUs, or use more recent household allocation shares as the baseline when computing excess flows relative to the pre-QE period. Across these variations, we find that the equilibrium effect on yields ranges between 40 and 102 basis points.

Table E2: Price Impact, Static Model

	ψ	$\frac{1}{\zeta}$	$\frac{F_{\text{Ins.},t}}{W_t}$	Price Impact	**Yield Impact (bp)**
Alternative Flows					
Baseline	0.84	0.99	-0.06	-0.05	48
Recent Insurance-Share	0.84	0.99	-0.08	-0.06	57
Alternative Market Segmentation					
Excluding Fin. Corporates	1.80	0.99	-0.06	-0.10	102
Include CIU Bond Exposure	1.34	0.99	-0.06	-0.08	76
Alternative Price Impact					
Kaminska and Zinna (2020)	0.84	0.84	-0.06	-0.04	40
Jansen et al. (2024)	0.84	1.62	-0.06	-0.08	77

Note: We report the inputs to several calibrations, with and without financial corporates. Excluding financial corporates affects the portfolio weights of the "Other investors", which results in a different market segmentation parameter ψ. The multipliers $\frac{1}{\zeta}$ are taken from previous studies. Relative flows $\frac{F_{\text{Ins.},t}}{W_t}$ are computed in excess of pre-QE allocation shares using FoF data. Yield impact is computed as the negated price impact divided by 10.

We showed that (i) flows into insurers fell sharply after 2015, (ii) insurers' long-term bond

tilt is large and persistent, and (iii) the price elasticity of long-term bonds is low. Combined, these three facts imply that QE-induced declines in insurer inflows have measurable consequences for the equilibrium term premium.

This static framework also clarifies the role of QE and QT. When the ECB absorbs long-term duration risk, the term premium declines; but the persistent compression in long-term rates also reduces household flows into the insurance sector. Through equation (96), this shrinkage reduces private-sector demand for long-term bonds—an effect that becomes particularly salient once QT increases the supply that private investors must absorb.

The model is intentionally simplified: it omits dynamics and does not explicitly capture the sequence of QE and QT events. We now embed these insights in a fully dynamic Vayanos–Vila framework with endogenous preferred-habitat investors.

E.3 A Static Sufficient-Statistic Representation

We consider a simple economy with two investor types: insurance companies and all other investors, indexed by $i \in \{\text{Ins.}, \text{Other}\}$. Let W_t denote total household wealth, and let $B_t = Q_t^B P_t^B$ denote the market value of long-term bonds (maturity above 10 years). The aggregate portfolio weight of long-term bonds is

$$w_t^B = \frac{B_t}{W_t}.$$

Let $w^B_{\text{Ins.},t}$ and $w^B_{\text{Other},t}$ denote the portfolio weights of insurers and other investors in long-term bonds. Define *market segmentation* as

$$\Psi_t \equiv \frac{w^B_{\text{Ins.},t} - w^B_{\text{Other},t}}{w_t^B}. \tag{97}$$

This object captures differences in maturity preferences across investor sectors. When $\Psi_t > 0$, insurers hold disproportionately more long-term bonds than the rest of the market.

Let $F_{\text{Ins.},t}$ denote flows into the insurance sector. Although total flows across sectors sum to zero, reallocations across intermediaries generate non-zero net demand for long-term bonds whenever $\Psi_t \neq 0$.

Under a partial-equilibrium demand system, the price impact of flows is given by:

$$\Delta p_t^B = \frac{1}{\zeta} \times \frac{F_{\text{Ins.},t}}{W_t} \times \Psi_t, \tag{98}$$

where $\frac{1}{\zeta}$ is the price multiplier. Equation (98) shows that the effect of flows on bond prices

depends on three sufficient statistics: the magnitude of flows, the degree of market segmentation, and the elasticity of demand.

F. Additional Tables and Figures

Figure F.1: Slope and Term-Premium

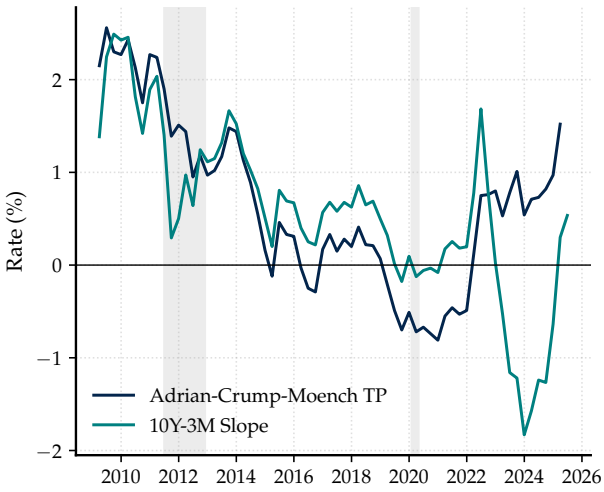
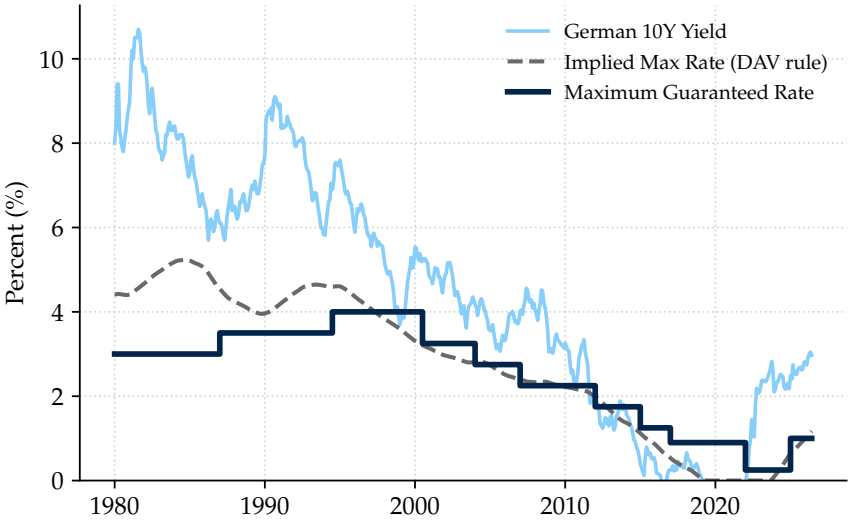
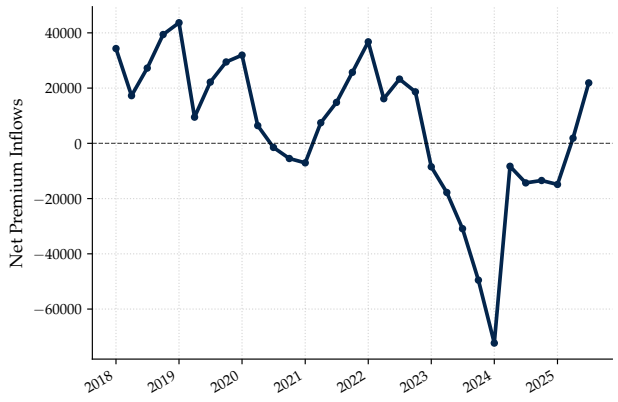


Figure F.2: German Bund Yield and Maximum Guarantee Rate



Note: The figure plots the maximum guaranteed rate for German life insurers (*Höchstrechnungszins*, dark blue), the 10-year German government bond yield (light blue), and the ceiling implied by applying the regulatory formula to that yield (dashed grey), all in percent. The *Höchstrechnungszins* caps the discount rate insurers may apply to technical provisions and hence bounds the return guaranteed on new contracts; it is recommended by the Deutsche Aktuarvereinigung (DAV) and set by the Bundesministerium der Finanzen through the *Deckungsrückstellungsverordnung*, so it changes only discretely. It fell from 4.0% in 1994 to 0.25% in 2022 before rising to 1.0% in 2025, its first increase in three decades. The implied ceiling takes the arithmetic mean of the yield over the preceding five years and subtracts a 40% safety margin, subject to a floor of 0.4 percentage points. The DAV computes this average over a representative new-investment portfolio rather than the Bund yield alone, so the implied series understates the ceiling when credit and equity returns are high. Sources: DAV (guaranteed rate, with values through 1986 from the GDV) and FRED (yield).

Figure F.3: Life Net Premium EIOPA



Note: The figure shows the evolution of net premium inflows for life insurance companies in the Euro Area, based on aggregate public EIOPA data. Net premium is constructed as

Net Premium = Premiums Written (R1500) − Claims Incurred (R1700) − Total Technical Expenses (R2600).

All variables are reported net of reinsurance. The calculation is performed at the country level using EIOPA Solvency II quarterly disclosures, and the resulting series are then aggregated across all Euro Area member states. The plotted time series therefore captures the overall flow of net premiums into the life insurance sector in the Euro Area.

Table F1: Euro Area Insurance Sector Balance Sheet

Assets	**2016Q3**	**2021Q3**	**2024Q4**	**Liabilities**	**2016Q3**	**2021Q3**	**2024Q4**
IL and UL Assets	1,037	1,550	1,831	TP Life excl. UL	4,417	4,603	3,817
Government Bonds	1,989	2,043	1,586	TP UL	1,036	1,542	1,807
Corporate Bonds	1,643	1,577	1,333	TP Non-life	554	718	789
CIUs	680	1,380	1,251	Other Liabilities	782	876	890
Participations	867	824	1,012				
Loans and mortgages	274	340	320				
Equities	131	163	137				
Cash & Deposits	148	136	125				
Structured notes	148	97	97				
Property	95	102	90				
Collateralised securities	30	24	31				
Other Assets	726	875	880				
Total Assets	**7,767**	**9,110**	**8,692**	**Total Liabilities**	**6,790**	**7,739**	**7,304**

Note: The table reports the aggregate balance sheet of insurance companies in the Euro area. Source: EIOPA. Numbers are reported as EUR billions, sorted by 2024-Q4.

Table F2: Asset Allocation by Country (€ bn)

Country	Government Bonds	Corporate Bonds	CIUs	Cash & Deposits	Equity	Total Assets
Austria	23.2	26.1	40.1	4.5	25.6	145.0
Belgium	132.5	59.6	71.1	7.7	25.2	375.1
Germany	390.4	445.4	871.2	74.2	455.2	2555.4
Spain	152.6	56.7	37.7	18.3	21.2	337.1
Finland	3.3	11.7	58.1	5.1	5.3	87.5
France	710.6	661.7	885.4	70.4	292.7	3017.8
Ireland	45.0	48.3	214.9	39.8	70.2	528.1
Italy	426.1	163.8	314.0	22.0	114.8	1115.0
Luxembourg	19.5	37.9	115.8	24.6	34.0	299.5
Netherlands	112.4	66.1	126.7	13.1	32.7	530.5
Portugal	18.7	13.2	11.2	2.4	3.8	53.2

Note: Data as in 2023 Q3. Values are in billions of euros. CIUs denote collective investment undertakings. Totals include all reported asset categories.

Table F3: Insurance Liabilities by Main Product Types (ranked by size)

Country	**Profit Participation** (%)	**IL/UL w/ Guarantees** (%)	**IL/UL w/o Guarantees** (%)	**Total** (€ tn)
France	65.9	13.0	12.6	1.580
Germany	61.2	13.5	0.0	1.302
Italy	66.7	6.0	26.6	0.761
Netherlands	21.3	9.9	20.5	0.298
Belgium	75.4	12.2	5.2	0.203
Luxembourg	24.0	35.9	39.7	0.164
Spain	30.6	1.0	6.5	0.150
Ireland	21.4	10.4	49.5	0.105

Note: The table reports the distribution of contract types across Euro area countries. The last column shows total liabilities, expressed in trillion euros. Source: EIOPA.

Table F4: Insurance Surrenders by Country (2020-2023)

Country	2020 (EUR bn)	2023 (EUR bn)	Change (%)
Portugal	1.0	2.5	+142.6%
Greece	0.5	1.1	+133.7%
Austria	1.2	2.8	+133.3%
Italy	41.6	86.7	+108.3%
Luxembourg	13.6	25.7	+88.1%
France	54.6	81.2	+48.7%
Spain	8.8	12.5	+41.5%
Finland	1.9	2.3	+18.6%
Ireland	17.2	19.5	+13.5%
Belgium	7.8	6.8	-13.5%
Germany	21.8	16.7	-23.2%
Netherlands	4.6	2.8	-38.1%
Euro area	**175.5**	**261.4**	**+49.0%**

Notes: Values represent total amount of surrenders in EUR billions. Change column shows percentage change from 2020 to 2023. Euro area total includes all Euro area countries.

Figure F.4: Rolling Beta of Insurer Stock Returns to Interest Rates

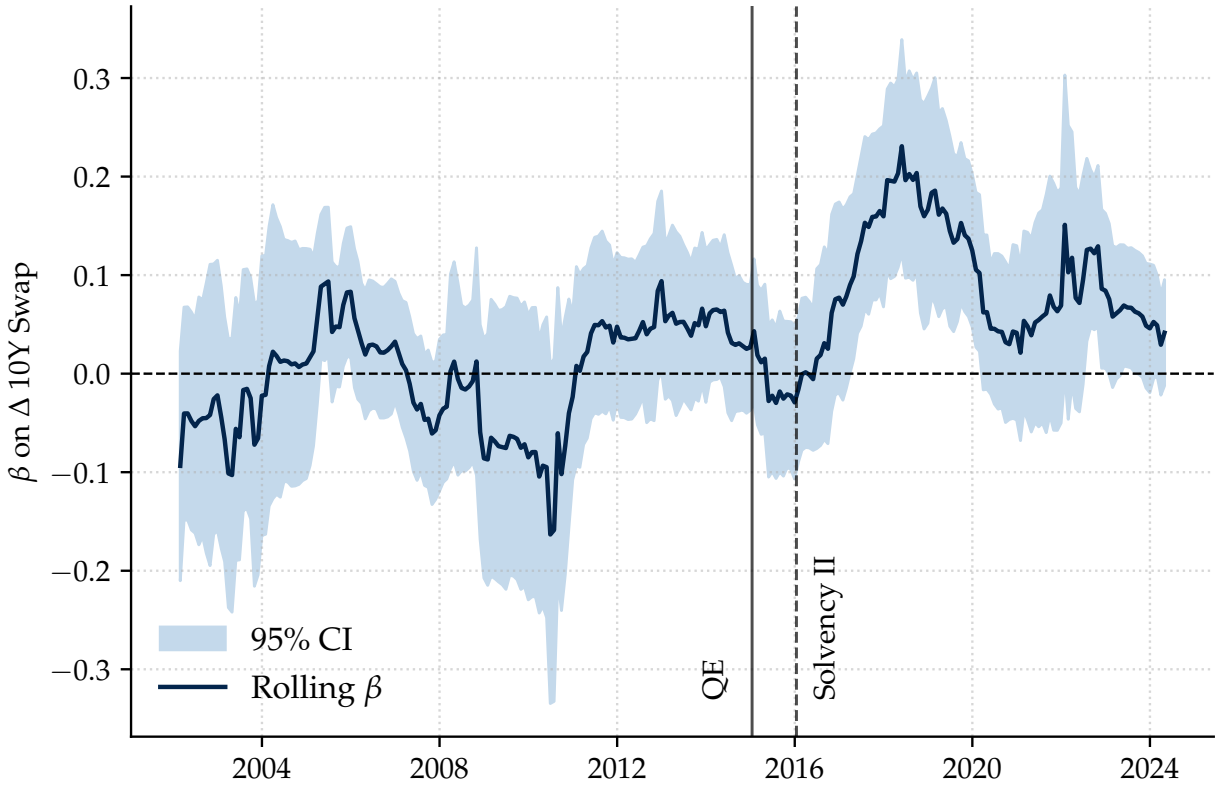
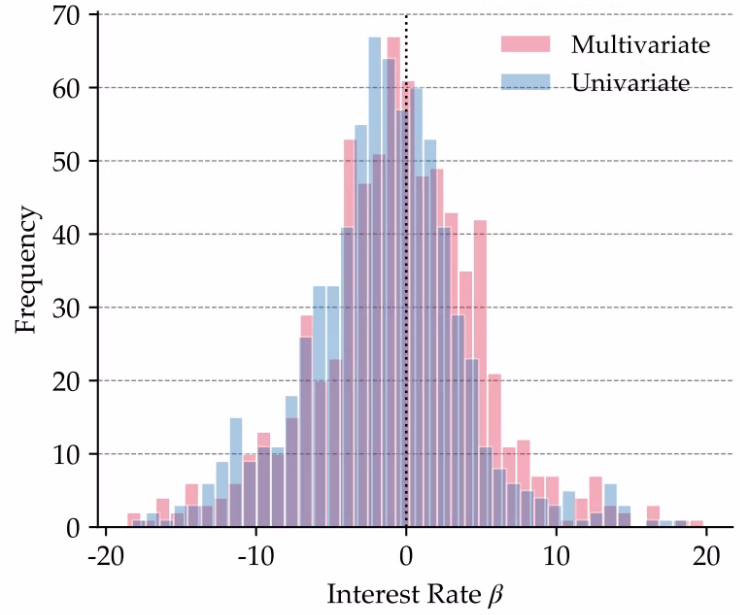
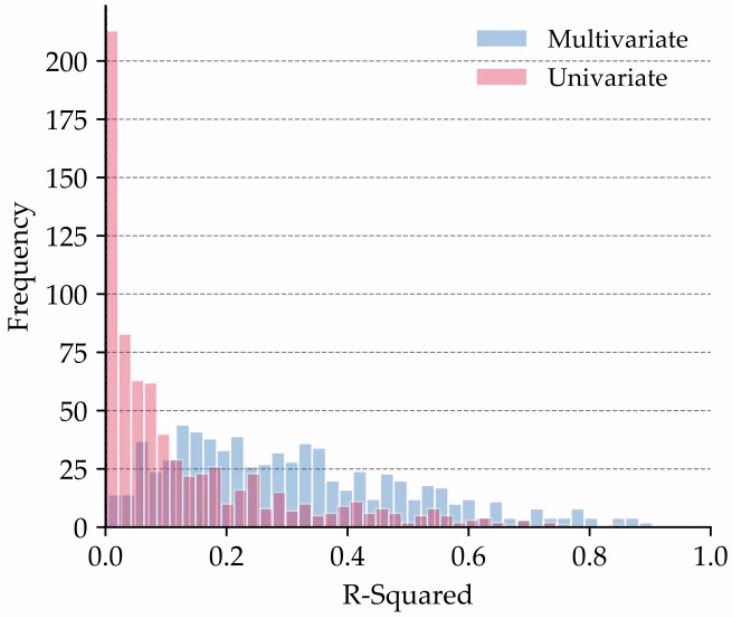


Figure F.5: Loadings of Regressing NAV on Long-Term Rates



Note: The figure reports the results from a set of regressions at the individual insurer level of year-on-year changes in NAV on changes in interest rates, sovereign spreads, and credit spreads. The figure plots the distribution of ceofficient on long-term rates for the univariate (interest rates only) and multivariate regressions (interest rates, sovereign spreads, and credit spreads). The data are quarterly and span the period from Q1 2016 to Q4 2024.

Figure F.6: R-squared of Regressing NAV on Long-Term Rates



Note: The figure reports the results from a set of regressions at the individual insurer level of year-on-year changes in NAV on changes in interest rates, sovereign spreads, and credit spreads. The figure plots the distribution of R^2 for the univariate (interest rates only) and multivariate regressions (interest rates, sovereign spreads, and credit spreads). The data are quarterly and span the period from Q1 2016 to Q4 2024.