From Long to Short: How Interest Rates Shape Life Insurance Markets*

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— Preliminary Draft —

Abstract

This paper investigates how interest rate fluctuations shape life insurance markets, focusing on the liability adjustments insurers employ to manage interest rate risk. Using a combination of theoretical and empirical analysis, we uncover that, after the 2008 Financial Crisis, insurers exposed to high interest rate risk – such as those that offered variable annuities with minimum return guarantees pre-2008 – shifted their product portfolios toward short-duration policies to hedge against rising duration gaps. This liability rebalancing led to sizable contractions in both the supply of long-duration life insurance products and the aggregate life insurance market. Our findings demonstrate that interest rate risk can significantly influence financial intermediaries' liability choices, which in turn shape the composition and availability of financial products.

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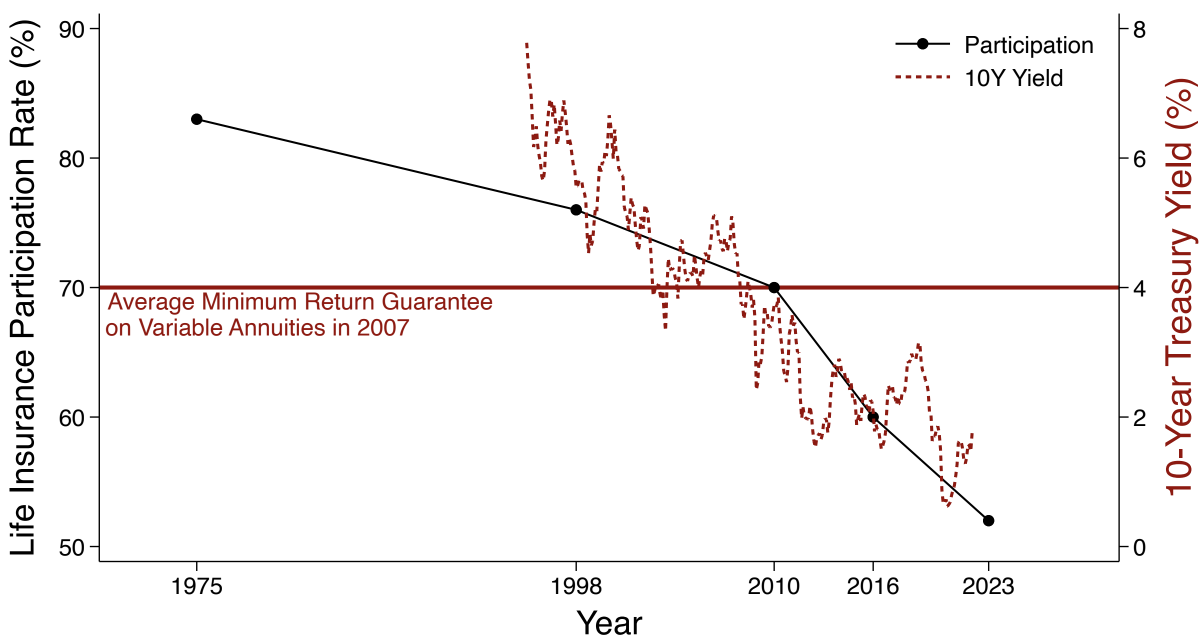
1 Introduction

Life insurance participation has steadily declined for the past half century, and at an accelerating pace (see Figure 1). According to a report by the Guardian Life Insurance Company (Guardian, 2023), life insurance participation declined from 83% in 1975 to 70% in 2010, or 0.37 percentage points per year. Participation continued to decline to 60% just six years later — a magnified rate of 1.67 percentage points per year — and today sits at 52%. The sharp drop in participation has important consequences: among households that experience the loss of an income-earner, 84% that did not have life insurance report living paycheck-to-paycheck as opposed to the 36% that did (Guardian, 2023).

It is therefore reasonable to suspect that the sharp decline in participation was driven by forces beyond household demand. In particular, the post-crisis recovery was accompanied by historically low interest rates, as shown in Figure 1. Life insurers — financial institutions with particularly long-lived liabilities — are generally sensitive to the revaluation effects of

Figure 1: Life Insurance Participation and Treasury Yields



Note: This figure plots life insurance participation rates (left axis) and 10-year treasury yields (right axis) over time. Data on life insurance participation come from Guardian (2023), which is itself derived from LIMRA Barometer reports. The size of the gray triangles represents the size of participation declines between measurement years. Monthly 10-year treasury yields are taken from FRED and cover 1995 to 2022. The average minimum return guarantee is taken from Koijen and Yogo (2022).

interest rate changes. Modern life insurance and annuity products are especially exposed due to their minimum return guarantees, embedded options whose valuation grows dramatically when interest rates are low. In particular, Koijen and Yogo (2022) highlight that the average minimum return guarantee of variable annuities issued in 2007 sat at 4%, approximately 2 percentage points higher than ensuing Treasury yields just a few years later. As a result, the reserve value of the embedded options grew substantially, leaving life insurers exposed to elevated interest rate risk.

This paper explores a new channel through which life insurers may hedge interest rate risk: *liability rebalancing*. As we discuss in Section 2, life insurance product markets are segmented by maturity, and therefore, degrees of interest rate risk. Ordinary life insurance products (term or whole life) provide long-term coverage, while life insurance accessed through employers (group life) typically provides coverage for a single year. Given limits to duration matching through asset rebalancing (Ozdagli and Wang, 2019; Sen, 2023), insurers may naturally transition from ordinary life to group life issuance to reduce their interest rate risk in a low interest rate environment. However, since group life insurance is only accessible through (large) employers, there could be negative consequences for participation at the market level. Moreover, since group life policies typically provide lower levels of coverage than ordinary life policies (Guardian, 2023), life insurance coverage as a whole may shrink.

We explore these insights formally in Section 3. We provide a model of insurance product markets in which risk-averse insurance companies are exposed to interest rate risk. Insurers care about the level of their current period capital as well as their capital returns. However, they carry legacy duration in their capital through their previously issued liabilities, which amplifies the risk of their future asset returns. As a result, insurers trade off current-period profits with future interest rate risk when issuing new policies.

We first show formally that insurers hedge interest rate risk through product markets, consistent with our concept of liability rebalancing. In particular, when interest rate uncertainty rises, insurers issue fewer long-duration policies but increase their issuance of short-duration policies. This effect is especially pronounced for insurers with more negative duration gaps and larger capital convexity: because their capital returns respond more to declines in interest rates, they rebalance toward short-duration policies more greater intensity.

We then cast the model in general equilibrium to study how liability rebalancing affects product markets. In contrast to the partial equilibrium setting, we show that less exposed (but not unexposed) insurers may increase their long-duration product issuance due to the decline in competition. In this sense, less exposed insurers try to fill the gap left by more exposed insurers. However, due to decreasing returns to scale, the substitution across insurers is not enough to stabilize the market and total issuance of long-duration policies declines.

With these predictions in hand, we next turn to our empirical analysis in Section 4. Our data are taken from life insurers' annual statutory filings. For each insurer, we have access to both new issuance and insurance in force for their term life, whole life, and group life businesses from 2005 to 2023. We use information on the account value of insurers' variable annuities in the pre-crisis period to classify them into exposed and non-exposed insurance groups. The exposed insurers are relatively large in terms of assets and capital, but they are 2-3 times more levered. Beyond their exposure to variable annuity guarantees, they also hold a higher share of interest-sensitive life insurance reserves.

We first study the differences in reserve values for ordinary and group life policies. As argued in Section 2, group life policies carry a lower reserve value per dollar of insurance relative to ordinary life. Additionally, at least in the case of exposed insurers, ordinary life reserve values increased after 2010, reflecting their sensitivity to the low-rate environment. However, when we combine the two reserve categories, exposed insurers' overall reserve value remained unchanged. This suggests a rebalancing of their reserves toward group policies.

Consistent with the trend in total reserve value, we then show that the average exposed insurer reduced their issuance of ordinary life insurance by approximately 40% between the end of the financial crisis and the subsequent decade. Non-exposed insurers doubled their issuance on average, consistent with our theory's predictions on insurer substitution. However, exposed insurers' group life issuance remained stable until 2019 and then sharply increased. Non-exposed insurers' group life issuance remained flat. These trends validate our model's mechanism: insurers whose duration gap became negative due to their minimum return guarantees rebalanced their liabilities toward short-duration products to hedge their elevated exposure to interest rate risk.

We then aggregate policy issuance across insurers to explore product market trends. We document that total issuance of ordinary life insurance as a percentage of GDP declined by 48% between 2005 and 2023, with two thirds of the decline stemming from exposed insurers.[1] Group life insurance issuance also declined as a percentage of GDP, but to a lesser

[1]This does not imply that nominal issuance of non-exposed insurers declined; in fact, total non-exposed

extent. The results suggest that both supply-side and demand-side effects were responsible for the reduction in life insurance issuance, but that the supply-side effects exacerbated the demand-side effects in ordinary life markets.

Despite the decline in issuance rates, the size of the insurance market could remain stable if new issuance exceeded claims and lapsation. We show that this was not the case: from peak to trough, ordinary life insurance in force as a percentage of GDP declined from 150.4% to 107%, three quarters of which stemmed from exposed insurance groups. Group life insurance in force only declined from 64% to 53% of GDP, the bulk of which came after the COVID-19 crisis. Due to the relative market sizes, total insurance in force declined from 213% to 160% of GDP, a contraction of nearly a quarter.

Our results suggest that the interest rate risk exposure of variable annuity issuers had severe consequences for life insurance markets. While we cannot yet disentangle the demand-side effects from the supply-side consequences, our work highlights a growing need for regulation to address insurers' risk exposures and mitigate the resulting cross-product spillovers.

Related Literature

Our work relates most closely to the literature on variable annuities and insurers' hedging behavior. In terms of market risk, Barbu and Sen (2024) document that insurers have begun selling long-dated short put products in an attempt to reduce exposure to downside market risk. Ellul et al. (2022) shows both theoretically and empirically that insurers only partially hedge their variable annuity guarantee exposures by rebalancing their bond portfolios, but in doing so, exacerbate systemic risk. In terms of interest rate risk, Ozdagli and Wang (2019) shows that illiquidity and transaction costs make it difficult for insurers to fully hedge their duration gap. Sen (2023) conducts a detailed study of variable annuity hedging and finds that differences in accounting methods used for assets and liabilities can further lead to imperfect hedging. We offer a new channel — liability rebalancing — through which insurers can reduce their exposure to variable annuities and interest rate risk by issuing shorter-duration products such as group life insurance and reducing their issuance of long-duration products.

We also contribute to the literature on how the financial health of life insurance companies spills over into their product markets.[2] Koijen and Yogo (2015) document that the wedge

insurer issuance increased by 34% by the end of the sample period. The discrepancy is due to relative changes in real GDP. See Section 4.4 for more details.

[2] In the context of P&C insurance, Gron (1994), Froot (2001), and Zanjani (2002) show that insurers'

between actuarial and statutory reserve valuation methods affects pricing behavior. Barbu et al. (2024) show that the introduction of risk-based capital accounting affects both the prices of, the supply of, and the demand for life insurance. Ge (2022) further shows that for insurance groups with both P&C and life divisions, P&C losses worsen their financial health, spilling over to their life insurance division and leading to nuanced pricing behavior. Knox and Sørensen (2024) show that insurance prices reflect the gains and losses stemming from insurers' asset performance. Verani and Yu (2024) show that interest rate risk management plays a role in annuity pricing, and the cost of interest rate risk hedging has pushed up annuity premia post-2008. Our contribution highlights the long-term effects on product markets when interest rate risk cannot be perfectly hedged.

Our paper builds on earlier works on the interest rate risk of U.S. life insurance companies. Since Berends et al. (2013), a large literature has established that the duration gap of U.S. life insurers switched from positive to negative after the 2007-2008 Financial Crisis (e.g., Hartley et al., 2016; Ozdagli and Wang, 2019; Koijen and Yogo, 2021, 2022; Huber, 2022; Sen, 2023; Kirti and Singh, 2024; Li, 2024). The majority of existing works identify the insurers' duration gap by using two-factor regression models to estimate the sensitivity of US life insurers' excess stock returns with respect to 10-year Treasury yields. In addition, Huber (2022) and Sen (2023) provide more direct evidence from insurers' balance sheets showing that insurers hedge their long-term liabilities imperfectly post-2008. We relegate a more detailed discussion on insurers' duration gaps to Section 2.3. Kirti and Singh (2024) and Li (2024) further show that interest rate risk has important asset pricing implications through insurers' asset demand.

Last, our paper connects to the literature on the industrial organization of insurance markets, particularly life insurance. Koijen and Yogo (2015, 2022) estimate demand for life insurance and variable annuities, respectively, and use their framework to understand how regulation affects product markets. Tang (2022) uses a structural model to evaluate the effects of regulatory competition across U.S. state insurance regulators and the establishment of captive reinsurance. Wenning (2024) estimates a model of life insurance agent distribution across a rich geography to explore the consequences of national price-setting behavior. While we have not yet done so, our model is amenable to estimation and will be used to carry out counterfactual analyses in future work.

capital constraints can affect their insurance supply and demand.

2 Institutional Setting

We begin with a broad description of insurance product markets. We then discuss the interaction between insurance reserves and interest rates. We end with a discussion of the regulatory and economic motives for life insurance companies to hedge interest rate risk and highlight why product markets are a feasible outlet for hedging.

2.1 An Overview of Life Insurance Products

Life insurance markets have evolved considerably since their inception. The earliest forms of life insurance were short-duration policies with minor payouts. Prominent insurers by today's standards often began with such policies (Knight, 1920): for example, at its inception in 1875, Prudential Financial, which today has over $1.4 trillion in assets under management, primarily sold industrial life insurance — small policies with maturities of about a week that targeted laborers in poor urban neighborhoods (Carr, 1975).

Since then, life insurance products have evolved considerably. The closest category to the traditional industrial life policy is what is known as group life insurance.[3] Insurers write group contracts with firms rather than individuals, and the firm itself issues insurance certificates to their workers. These certificates function primarily as yearly-renewable policies with premium rates that are renegotiated at renewal. Employer-sponsored group policies are especially small, typically covering only one to two years of an employee's salary (Guardian, 2023), and are less accessible, since not all employers offer group life insurance as a benefit. Group life coverage totaled about 55% of GDP in 2005.

Ordinary life insurance departs from group life insurance in both the coverage and the time dimension. On the coverage dimension, policyholders are free to choose their desired level of coverage rather than being fixed at one year's wage.[4] On the time dimension, products can be split into two broad categories: term life policies and whole or permanent policies. Term life policies pay out a pre-specified benefit upon the death of the insured, conditional on the death happening during a set number of years.[5] For example, a 10-year

[3]Industrial life insurance still exists today but the market is minuscule: as of 2023, it only accounts for 0.016% of gross life insurance coverage in force.

[4]In our data that we discuss in Section 4, the average ordinary life insurance policy covers $144,281 in 2023, while the average group life policy covers $67,185.

[5]Some policies allow for yearly renewals with adjusted premiums, but policyholders are not permitted to renew for the full term. Other provisions may allow the policies to be converted to permanent contracts.

term life policy pays out if the insured dies between the time of issuance and 10 years. Whole life policies, on the other hand, do not expire unless premiums are not paid.[6]

Whole life policies are notable due to their embedded savings components. These policies typically have lower coverage but redirect a fraction of the premium revenue toward a savings vehicle that accrues interest. This is referred to as the cash value of the policy. Traditionally, the cash value is invested in fixed income assets whose investment returns are fairly stable. New innovations in whole life policies have emerged over time, such as variable, indexed, and universal life products, that invest the cash value in a variety of non-fixed-income assets and may come with additional embedded options, such as minimum return guarantees.

Life insurers also issue annuities, products that insure longevity as opposed to mortality. Standard annuity products are paid for upfront and provide a fixed stream of payments until the death of the insured. The payments can either start alongside the initial payment (immediate annuities) or after a set number of years (deferred annuities). Similar to whole life insurance, insurers have innovated on annuity products by allowing the payments to fluctuate with an underlying mutual fund. These are known as variable annuities. A key similarity with variable life insurance is that the returns often come with a minimum return guarantee. For example, if the return guarantee is 4% per year and the mutual fund only returns 2% in a given year, the insurance company must pay the remaining 2% out of pocket.

2.2 Insurance Reserves and Interest Rate Risk

Insurance companies must hold reserves to ensure available payment for policyholders. The value of the reserves for traditional policies directly accounts for mortality risk conditional on the age, gender, and health status of the policyholder. Since many policies have a time component, the value of a given policy's reserves may change over time due to a higher loading on a higher mortality risk or due to changes in the discounted value of future payouts (Koijen and Yogo, 2015; Huber, 2022). As such, these policies, especially whole life and long maturity term life, carry implicit interest rate risk. Group policies, which are often yearly renewable, typically have a low reserve requirement and are not sensitive to interest rate risk due to their short maturities.

Insurers hold non-traditional policy reserves in their separate accounts rather than their

[6] These policies technically expire at a very old age, such as 100 or 121. Since most individuals do not live this long or lapse well before this, the restriction is typically not binding.

general accounts (Koijen and Yogo, 2022). This is due to the fluctuating nature of the savings components. However, when these policies are bundled with minimum return guarantees, the value of the separate account does not cover the residual returns between the underlying mutual fund and the minimum return guarantee when the guarantee is in the money. Insurers therefore hold reserves in their general accounts to account for these options.

Variable annuity and life insurance reserves are therefore convex. When interest rates and stock market returns are high, the likelihood that the minimum return guarantee will be exercised is low. Reserve positions are therefore small since insurers are less likely to have to cover the gap in returns. However, when rates and stock returns are low and declining, the guarantees are more likely to be exercised, and the reserve valuations increase substantially. For example, as discussed in Huber (2022), Metlife's "5 Year Ratchet & ROP-d, GMIB w/ 10y, 7 to 8" variable annuity had a reserve value that increased 4-fold between 2009 and 2011. In general, Sen (2023) estimates that the duration of minimum return guarantees is between 9 and 17 years.

2.3 Duration Matching Motives in the Life Insurance Industry

Insurers that specialize in ordinary life insurance hold reserves with long maturities, often spanning more than 30 years. Minimum return guarantees on their variable liabilities add both duration and convexity to their total reserve positions. Given the sensitivity of their reserves to interest rates, a natural interest rate risk management strategy is to hold assets that match the duration of their reserves.

However, duration matching is not always a successful or even feasible strategy. Market incompleteness may prevent insurers from perfectly matching the duration between their assets and liabilities. Corporate bonds, which account for the majority of insurers' asset portfolios (Koijen and Yogo, 2023), have an average duration of only around 7-8 years. While Treasury bonds can have a longer duration, their maturities are also capped at 30 years, and insurers in general dislike Treasuries for their relatively low returns.

Beyond market incompleteness, insurers also face a variety of other frictions that push against duration-matching motives. First, insurance regulations might inadvertently distort insurers' hedging motives. Sen (2023) argues that the mismatch in the accounting methods used for assets and liabilities discourages insurers from using interest rate derivatives to hedge variable annuities. Second, Ozdagli and Wang (2019) finds that illiquidity and transaction costs in the corporate bond market are potentially important factors preventing insurers from closing their duration gaps, as doing so requires insurers to turn over large fractions of their bond holdings, which could be prohibitively expensive.[7] This is consistent with the evidence in Huber (2022), which shows that the asset duration of individual life insurers did increase somewhat after the financial crisis, but not substantially.

Consequently, life insurers' duration gaps became negative after the financial crisis. Several existing studies (e.g., Berends et al., 2013; Hartley et al., 2016; Ozdagli and Wang, 2019; Koijen and Yogo, 2022; Kirti and Singh, 2024; Li, 2024) arrived at this conclusion by examining how insurers' stock returns co-moves with interest rates. After carefully studying insurers' balance sheets, Sen (2023) finds direct evidence that many insurers failed to hedge a significant proportion of their variable annuity liabilities. By calculating the duration gap at the individual insurance company level, Huber (2022) finds that the aggregate gap switched from positive to negative after 2010.[8] Additionally, Li (2024) shows that after the financial crisis, the market leverage of life insurance companies co-moved negatively with long-term Treasury yields.

Given the limits to duration matching through asset rebalancing, we explore an alternative channel: *liability rebalancing*. Insurers can reduce the duration of their liabilities by allowing their legacy reserves to expire and shifting new issuance toward shorter-duration policies. In the following section, we present a model of insurance product markets in the presence of interest rate risk to explore how liability rebalancing can be used as a risk management strategy.

3 A Model of Product Markets and Interest Rate Risk

We first present a simple model of duration matching to organize the empirical exploration. We discuss the structure of the model in Section 3.1. We then explore how duration mismatch affects product pricing and liability rebalancing in Section 3.2. We end with a discussion on the cross-market equilibrium outcomes in Section 3.3.

[7]Furthermore, Domanski et al. (2017) and Greenwood and Vissing-Jorgensen (2018) suggest that, due to their large scale, the reach-for-duration by insurers could lead to a substantial increase in the total demand for long-term assets, which could further push down long-term interest rates, resulting in a vicious cycle.

[8]Note that despite the duration estimation of minimum return guarantees by Koijen and Yogo (2022) and Sen (2023), Huber (2022) sets the duration of the minimum return guarantees for variable annuities and life insurance policies to zero. Incorporating these liabilities would likely lead to an even stronger decline in duration gaps.

3.1 Setup

Time is discrete, $t \in \mathbb{N}$. There are a large number of insurance companies, $j \in \mathcal{J}$, that sell a variety of insurance and annuity products, $i \in \mathcal{I}$, to a unit measure of households. Insurers have two functions. First, they sell insurance to households, strategically setting prices and the extent of their market penetration for each product. Second, they manage a portfolio of assets with exogenous insurer-specific returns. These two activities shape the behavior of insurers' capital.

Insurers take their portfolio's return, R^A_{jt}, as given.[9] They can expand their balance sheets and increase their assets by selling new insurance policies. When selling new products, insurers can attract more demand by setting lower prices, P_{ijt}, or by hiring more agents to market their products, T_{ijt}. We assume demand for each product-insurer pair takes the form

$$Q_{ijt} \equiv \overline{Q}_{ijt} \kappa(T_{ijt}) P_{ijt}^{-\varepsilon_{it}}, \tag{1}$$

where $\overline{Q}_{ijt}$ is a insurer-product-specific component that we elaborate on in Section 3.3, $\kappa(T_{ijt})$ is an increasing function of T_{ijt} that varies between 0 and 1, and ε_{it} is the demand elasticity for policy i at time t. We assume for simplicity that the total number of agents attracted to sell the insurer's products is linear in the commissions paid, $T_{ijt} = \eta_{it}^{-1} F_{ijt}$, for some constant η_{it}. Hence, their assets evolve according to the law of motion

$$A_{jt} = R^A_{jt} A_{jt-1} + \sum_{i \in \mathcal{I}} \left(P_{ijt} Q_{ijt} - F_{ijt} \right). \tag{2}$$

When issuing products, insurers add to their existing liabilities, L_{jt}, through the creation of reserves. We refer to V_{it} as product i's reserve value. The total reserves created through the issuance of policy i at time t is then $V_{it} Q_{ijt}$.[10] We denote the return on an insurer's stock of existing reserves as R^L_{jt}, which governs the speed of increase of existing reserves. We then refer to the return on a particular product's reserves as R_{it}, which we assume is fixed constant across insurers.[11] Insurers' liabilities therefore evolve according to

[9] In practice, insurers hold 60-70% of their asset portfolios in corporate bonds and, therefore, have asset returns close to the average return of the bond market (Koijen and Yogo, 2023). This assumption can in principle be relaxed to allow for reaching-for-duration by insurers (Ozdagli and Wang, 2019).

[10] Statutory values for insurance policies are typically more conservative than their actuarial value, which can also affect pricing (Koijen and Yogo, 2015). For our purposes, this distinction is not necessary.

[11] This implies that R^L_{jt} is determined through the insurer's portfolio of outstanding insurance policies.

$$L_{jt} = R^L_{jt} L_{jt-1} + \sum_{i \in \mathcal{I}} V_{it} Q_{ijt}. \tag{3}$$

Combining (2) and (3) therefore gives us the evolution of insurers' capital:

$$K_{jt} = \overline{K}_{jt} + \sum_{i \in \mathcal{I}} \Big[(P_{ijt} - V_{it}) \, Q_{ijt} - F_{ijt} \Big], \tag{4}$$

where $\overline{K}_{jt} \equiv \overline{A}_{jt} - \overline{L}_{jt} \equiv R^A_{jt} A_{jt-1} - R^L_{jt} L_{jt-1}$ is insurer j's legacy capital (i.e., the level of capital without new policy issuance). Current period capital therefore has two components: financial returns that depend on their legacy capital and its returns, and operating profits that depend on new policy issuance.

Legacy returns themselves also have two components: a guaranteed component (e.g., coupon payments, policy claims, and lapsation) and a revaluation component due to changes in market interest rates, R_t.[12] We assume returns take the form

$$\begin{aligned} R^A_{jt} &= \overline{R}^A_{jt} - D^A_{jt} \Delta R_t, \\ R^L_{jt} &= \overline{R}^L_{jt} - D^L_{jt} \Delta R_t, \\ R_{it} &= \overline{R}_{it} - D_{it} \Delta R_t, \end{aligned}$$

where the guaranteed components of returns $\overline{R}^A_{jt}, \overline{R}^L_{jt}$ and $\overline{R}_{it}$ are assumed to be exogenous, reflecting the characteristics of the underlying securities. We further refer to D^A_{jt} as insurer j's asset duration, D^L_{jt} as insurer j's liability duration, and D_{it} as policy i's duration, as they measure the sensitivities of the returns to the market rate. Here, R_t, R^A_{jt}, R^L_{jt} and R_{it} are gross returns. We denote the net market interest rate as r_t. Net returns for assets and liabilities have similar definitions and are referred to as r^A_{jt}, r^L_{jt}, and r_{it}, respectively.

Insurers have two objectives. First, they maximize current period capital, which is equivalent to maximizing their operating profits. Second, they maximize their capital returns. We assume insurers are risk averse, and capture their risk management motives through an increasing and concave function $\Lambda(\overline{K}_{jt+1}/\overline{K}_{jt})$.[13] Therefore, their objective function can be

[12]One could argue that claims and lapsation rates themselves are both inherently random (e.g., Gottlieb and Smetters, 2021; Koijen et al., 2024). Since our framework considers atomistic households, after aggregating, we treat the idiosyncratic components of such risks as diversified. We let the returns be time-dependent, which allows for aggregate claim and lapsation risks.

[13]One can interpret $\Lambda(\cdot)$ as the insurer's utility function. Alternatively, if the insurer has a growth rate

summarized as

$$\max_{\{P_{ijt},F_{ijt}\}} \underbrace{\sum_{i\in\mathcal{I}} \Big[(P_{ijt} - V_{it})\, Q_{ijt} - F_{ijt} \Big]}_{\text{Operating Profits}} + \underbrace{\mathbb{E}_t \left[\Lambda \left(\frac{\overline{K}_{jt+1}}{\overline{K}_{jt}} \right) \right]}_{\text{Risk Management}}.$$

In what follows, we will use a first-order approximation of $\Lambda(\overline{K}_{jt+1}/\overline{K}_{jt})$ around legacy returns, $R^K_{jt+1} \equiv (R^A_{jt+1}\overline{A}_{jt} - R^L_{jt+1}\overline{L}_{jt})/\overline{K}_{jt}$, which is the return on capital without any new policy issuance:

$$\Lambda\left(\frac{\overline{K}_{jt+1}}{\overline{K}_{jt}}\right) \approx \Lambda(R^K_{jt+1}) + \frac{\Lambda'(R^K_{jt+1})}{\overline{K}_{jt}} \left[\sum_{i\in\mathcal{I}} \Big(R^A_{jt+1} P_{ijt} - R_{it+1} V_{it} \Big) Q_{ijt} - \sum_{i\in\mathcal{I}} R^A_{jt+1} F_{ijt} \right]. \quad (5)$$

The first term only depends on characteristics of insurer j prior to the current period, and therefore is taken as given. The second term captures the marginal value of risk management from the issuance of new products, and is the relevant piece of our model. For notational convenience, we denote $\lambda_{jt+1} \equiv \Lambda'(R^K_{jt+1})/\overline{K}_{jt}$. Formally, insurer j solves

$$\begin{aligned} \max_{\{P_{ijt},F_{ijt}\}} & \overbrace{\sum_{i\in\mathcal{I}} \Big[\Big(P_{ijt} - V_{it}\Big) Q_{ijt} - F_{ijt} \Big]}^{\text{Operating Profits}} \\ & + \underbrace{\mathbb{E}_t \left[\lambda_{jt+1} \left(\sum_{i\in\mathcal{I}} \Big(R^A_{jt+1} P_{ijt} - R_{it+1} V_{it} \Big) Q_{ijt} - \sum_{i\in\mathcal{I}} R^A_{jt+1} F_{ijt} \right) \right]}_{\text{Expected Value of Risk Management}}. \quad (6) \end{aligned}$$

The insurer trades off its immediate profits and, therefore, higher capital today with its expected return on its capital in the next period. The expectation is taken over the distribution of market rate innovations, ΔR_t. The choice of product prices and agent distribution in the current period will therefore depend on the insurer's *interest rate risk* and, in particular, the sensitivity of an insurer's legacy capital to interest rates, λ_{jt+1}.

3.2 Duration Gaps and Liability Rebalancing

Given the trade-off between profits and return risk, how should an insurer design its product portfolio? To study this question, we first need to understand the determinants of pricing

target r^*, we can set $\Lambda(x) = -a(x - r^*)^2$, in which case $\Lambda(\cdot)$ is the penalty for deviations from the target.

and agent distribution and, therefore, their product issuance. We begin by characterizing the optimal decisions of a given insurer in the following lemma.

LEMMA 1: OPTIMAL ISSUANCE DECISIONS

Insurer j's optimal price for product i and the optimal number of agents hired to sell product i satisfy

$$\frac{P_{ijt}}{V_{it}} = \left(\frac{\varepsilon_{it}}{\varepsilon_{it}-1}\right)\mathcal{M}_{ijt}, \qquad T_{ijt} = \max\left\{(\kappa')^{-1}\left(\frac{\eta_{it}}{\mathcal{E}_{it}\overline{Q}_{ijt}\mathcal{M}_{ijt}^{1-\varepsilon_{it}}}\right),\ 0\right\},$$

where $\mathcal{E}_{it} \equiv \varepsilon_{it}^{-\varepsilon_{it}}(\varepsilon_{it}-1)^{\varepsilon_{it}-1}$ and the risk management markup, $\mathcal{M}_{ijt}$, satisfies

$$\mathcal{M}_{ijt} = \frac{1+\mathbb{E}_t[\lambda_{jt+1}R_{it+1}]}{1+\mathbb{E}_t[\lambda_{jt+1}R^A_{jt+1}]}.$$

Proof: See Appendix A.1.

For a given product, both prices and agent distribution depend explicitly on the returns to that product's reserve value as well as to its interaction with the insurer's marginal value of risk management. Risk management markups, $\mathcal{M}_{ijt}$, are higher when $\mathbb{E}_t[\lambda_{jt+1}R_{it+1}]$ is larger. To examine this case, we consider an approximation of λ_{jt+1} around $\Delta R_t = 0$:

$$\lambda_{jt+1} \approx \underbrace{\frac{\Lambda'(\overline{R}^K_{jt+1})}{\overline{K}_{jt}}}_{\equiv \bar{\lambda}_{jt+1}} - \underbrace{\frac{\Lambda''(\overline{R}^K_{jt+1})}{\overline{K}_{jt}}}_{\equiv \bar{\lambda}'_{jt+1} < 0} D^K_{jt}\Delta R_{t+1}. \tag{7}$$

where $D^K_{jt} \equiv (D^A_{jt}\overline{A}_{jt} - D^L_{jt}\overline{L}_{jt})/\overline{K}_{jt}$ is insurer j's duration gap. Since the function capturing the risk management motive $\Lambda(\cdot)$ is concave, $\bar{\lambda}'_{jt+1} \equiv \Lambda''(\overline{R}^K_{jt+1})/\overline{K}_{jt} < 0$. As highlighted in Section 2.3, many life insurers faced a negative duration gap after the financial crisis. This fact is of first order when analyzing insurers' pricing and issuance patterns. To do so, we use the following lemma to understand how a product's duration affects its pricing.

Lemma 2: Approximate Risk Management Markups

Suppose that the market interest rate R_t follows a martingale process with variance σ_t^2. Then under the approximation (7), risk management markups $\mathcal{M}_{ijt}$ can be written as

$$\mathcal{M}_{ijt} = \frac{1 + \bar{\lambda}_{jt+1}\overline{R}_{it+1} + (\bar{\lambda}'_{jt+1} D^K_{jt} \sigma^2_{t+1}) D_{it}}{1 + \bar{\lambda}_{jt+1}\overline{R}^A_{jt+1} + (\bar{\lambda}'_{jt+1} D^K_{jt} \sigma^2_{t+1}) D^A_{jt}}. \tag{8}$$

Proof: See Appendix A.2.

The lemma highlights an important result: if insurers face a negative duration gap, $D^K_{jt} < 0$, then long duration policies have higher markups, all else equal. Since insurers are risk-averse over capital returns, they put a higher weight on capital losses than they do capital gains. Therefore, when they have a negative duration gap, their value of capital losses due to interest rate declines outweighs their value of capital gains due to interest rate hikes. They therefore set a higher price on long-duration policies when this gap is larger to justify the higher potential losses. Higher prices further translate into reduced agent distribution and commissions as they lower the profitability of long-duration policies. Equipped with this insight, we present our first result.

Proposition 1: Interest Rate Risk and Product Issuance

Consider two interest rate environments, 1 and 2. The interest rate uncertainty in the second environment is higher, $\sigma^2_{2,t+1} > \sigma^2_{1,t+1}$. Let

$$\mathcal{R}_{jt+1} \equiv \frac{1 + \bar{\lambda}_{jt+1} R_{it+1}}{1 + \bar{\lambda}_{jt+1} R^A_{jt+1}}.$$

Then for any insurer j such that $D^K_{jt} < 0$,

$$Q^2_{ijt} > Q^1_{ijt} \qquad \text{if } D_{it} < D^A_{jt}\mathcal{R}_{jt+1}$$

$$Q^2_{ijt} < Q^1_{ijt} \qquad \text{if } D_{it} > D^A_{jt}\mathcal{R}_{jt+1}$$

Proof: See Appendix A.3.

Proposition 1 says that if interest rate uncertainty increases, then relative to their asset duration, insurers with a negative duration gap decrease the issuance of long-duration products and increase the issuance of short-duration products.[14] Since their duration gap is negative, their capital is already exposed to interest rate risk. Therefore, they optimally move away from long-duration products that exacerbate their duration gap in an attempt to hedge additional interest rate risk.

We next explore how this result changes in the cross-section of insurers in different interest rate environments. In particular, we are interested in the role of capital *convexity*. If some insurers have especially convex liabilities — such as insurers that previously issued variable life insurance or annuities with generous minimum return guarantees (Koijen and Yogo, 2022; Sen, 2023) — then in a low rate environment, their duration gap should increase. This makes them especially susceptible to interest rate risk, even if the volatility of interest rates remains unchanged.

Denote the convexity of an insurer's capital as $\gamma^K_{jt} = -\partial D^K_{jt}/\partial R_t$. The following proposition considers how two insurers with different capital convexity respond to a decline in interest rates, holding fixed volatility.

Proposition 2: Capital Convexity and Product Issuance

Consider two interest rate environments, 1 and 2, that are identical except that interest rates are lower in the second environment, $R^2_t < R^1_t$. Additionally, consider two insurers, j and j', that are identical except that insurer j' has more convex capital, $|\gamma^K_{j't}| > |\gamma^K_{jt}|$. Then,

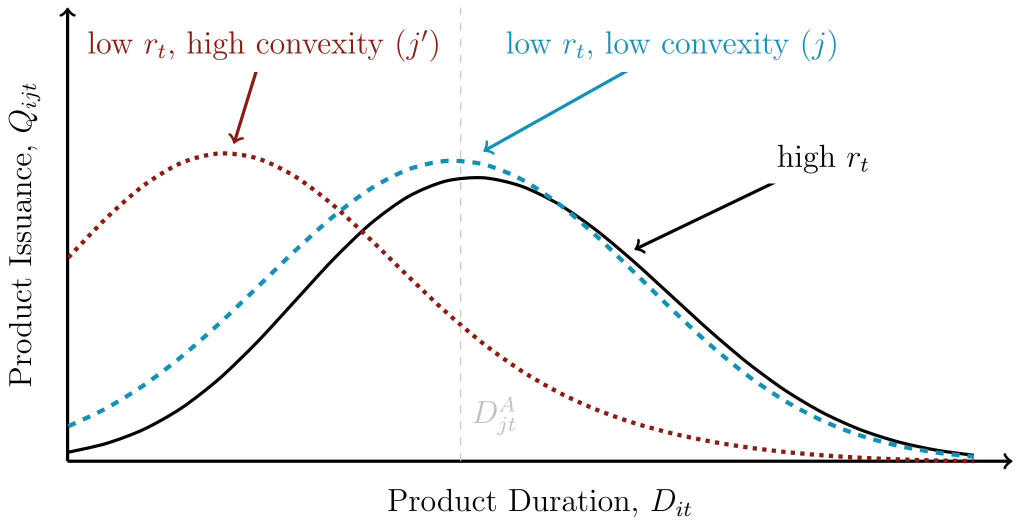
$$\frac{Q^2_{ij't}}{Q^1_{ij't}} > \frac{Q^2_{ijt}}{Q^1_{ijt}} > 1 \qquad \text{if } D_{it} < D^A_{jt}\mathcal{R}_{jt+1}$$

$$\frac{Q^2_{ij't}}{Q^1_{ij't}} < \frac{Q^2_{ijt}}{Q^1_{ijt}} < 1 \qquad \text{if } D_{it} > D^A_{jt}\mathcal{R}_{jt+1}$$

Proof: See Appendix A.4.

[14] This is also conditional on the product's liability returns and the guaranteed component of asset returns. We can keep this interpretation for cases in which $\overline{R}_{it+1} \approx \overline{R}^A_{jt+1}$.

Figure 2: Interest Rate Risk, Capital Convexity, and Product Issuance



Note: This figure presents hypothetical product issuance curves as a function of product duration. The black curve reflects the decisions of two insurers with identical duration gaps in a high interest rate environment. The red dotted and blue dashed line respectively reflect decisions of the more convex and less convex insurer when interest rates decline. The faint dashed gray line represents their shared asset duration.

We summarize Proposition 2 in Figure 2. The Figure plots the product issuance distribution of the two insurers, j and j'. Initially, in a high-interest-rate environment, the two insurers have the same duration gaps and issue products with the same intensity. In the meantime, insurer j' has a higher convexity of capital than insurer j, $|\gamma^K_{j't}| > |\gamma^K_{jt}|$, for example due to previously issuing variable annuities with generous guarantees. Hence, as they transition into an environment with lower rates, the duration gap of j' becomes more negative than the duration gap of j. Both insurers respond to lower rates by shifting their issuance toward low-duration policies, but since insurer j' is especially sensitive, their response is more pronounced.

It is important to note that the results of this section are partial equilibrium results. If a large insurer such as Metlife responds to a decline in rates by no longer selling long-duration policies, less exposed insurers may step in to fill the gap in demand despite also having some exposure to the decline in rates. We therefore turn to an analysis of product market equilibrium to study the market level effects of interest rate risk and duration gaps.

3.3 Duration Mismatch and the Size of Insurance Markets

We begin by zooming in on household purchasing behavior. For simplicity, we assume that households may hold multiple life insurance policies and treat each product market in isolation.[15] We assume households have identical preferences within a product class, but that their preferences may differ across product classes. Household h's indirect utility from purchasing product i sold from insurer j is

$$u_{ijt}^h = \log \alpha_j + \log \kappa_{ijt}(T_{ijt}) - (\varepsilon_{it} - 1) \log \left(\frac{P_{ijt}}{V_{it}} \right) + \nu_{ijt}^h$$

where α_j is an insurer-specific characteristic ("quality") and ν_{ijt}^h is an idiosyncratic taste shock distributed according to an extreme value type I distribution with unit variance.[16] Household h spends a constant amount, Y_{it}^h, on coverage through product i. They therefore purchase $Q_{ijt}^h = Y_{it}^h / P_{ijt}$ units of coverage conditional on buying from insurer j. Households may also choose an outside option 0 (e.g., cash) with preferences satisfying $u_{i0t}^h = \log \alpha_{it}^0$. We normalize the price of the outside option to 1. With these assumptions, insurer j faces the following demand curve

$$Q_{ijt}(P_{ijt}, T_{ijt}) = \kappa(T_{ijt}) \frac{Y_{it}}{P_{ijt}} \left(\frac{P_{ijt}/V_{it}}{\mathcal{P}_{it}} \right)^{1-\varepsilon_{it}},$$

where aggregate expenditures, Y_{it}, and the product market price index, $\mathcal{P}_{it}$, respectively satisfy

$$Y_{it} \equiv \int_0^1 Y_{it}^h dh, \qquad \mathcal{P}_{it}^{1-\varepsilon_{it}} \equiv \alpha_{it}^0 + \sum_{j \in \mathcal{J}} \alpha_j \kappa(T_{ijt}) \left(\frac{P_{ijt}}{V_{it}} \right)^{1-\varepsilon_{it}}.$$

We also introduce a functional form for the market penetration function,

$$\kappa(T_{ijt}) = 1 - \exp(-T_{ijt}).$$

[15] This is not an unrealistic assumption: according to data from the 2018 Health and Retirement Survey, of the 54% of households that hold a life insurance policy, 38% of households hold more than one policy.

[16] We include market penetration explicitly in indirect utility for simplicity. The interpretation is that if insurer j has more agents, they are more accessible, which reduces the cost of search or travel for households. One could alternatively model market penetration as the share of households reached by the insurer, but the resulting price index would only be an approximation when there are a finite number of insurers.

This functional form which allows us to solve for $\mathcal{P}_{it}$ in closed form, which greatly simplifies the analysis.

We begin by addressing the point at the end of Section 3.2: in response to a decline in interest rates, how do insurers adjust within a product market when we account for cross-sectional differences in capital convexity? As highlighted by Huber (2022), some insurers did not see a large decline in their duration gaps post-2008 and should therefore respond differently than insurers whose duration gaps widened. The following result highlights a condition that determines whether or not the competitive effects of reduced issuance by highly exposed firms outweigh the direct effects of additional exposure by other firms.

Proposition 3: Insurer Substitution

Consider two interest rate environments, 1 and 2, that are equivalent except that all insurers face a more severe duration gap in the second environment. Formally, $|D_{jt}^{K,2}| \geq |D_{jt}^{K,1}|$ *for all* j *with a strict inequality for at least one* j. *Let* $\psi_{ijt} = \mathcal{M}_{ijt}^2 / \mathcal{M}_{ijt}^1$ *be the ratio of risk management markups in the two environments.*

If $D_{it} > D_{jt}^A \mathcal{R}_{jt+1}$ *for all* j, *then there exists a threshold* $\overline{\psi}_{it}$ *such that*

$$Q_{ijt}^2 < Q_{ijt}^1 \qquad \text{if } \psi_{ijt} > \overline{\psi}_{it}$$

$$Q_{ijt}^2 > Q_{ijt}^1 \qquad \text{if } \psi_{ijt} < \overline{\psi}_{it}$$

The reverse inequalities are true if $D_{it} < D_{jt}^A \mathcal{R}_{jt+1}$ *for all* j.

Proof: See Appendix A.5.

The partial equilibrium setting of Section 3.2 suggested that even lightly more exposed insurers alter their behavior, and that insurers whose interest rate risk exposure does not change ($D_{jt}^K = 0$) do not adjust their issuance. Instead, in equilibrium, Proposition 3 says that the retreat of the exposed insurers opens up demand for the unexposed insurers, leading them to increase their issuance. This occurs both due to an increase in the number of agents and, therefore, the share of households that they reach, as well as cross-insurer substitution by market participants. We will see in the following section that this pattern holds in the data.

Nevertheless, it is unclear whether unexposed insurers can fully pick up the slack left by the exposed insurers. For example, if lower-quality insurers are the ones with higher exposure, we might expect the higher-quality insurers to easily buy up the policies that they left on the table. However, this may not be sufficient if households' preferences are sufficiently dispersed or if the decreasing returns to scale implied by their market penetration is too strong.

To study this trade-off, note that we can write the share of expenditures that accrue to the outside option as

$$\frac{Q_{it}^{0}}{Y_{it}} = \alpha_{it}^{0}\mathcal{P}_{it}^{\varepsilon_{it}-1} = \frac{\alpha_{it}^{0}}{\alpha_{it}^{0} + \sum_{j\in\mathcal{J}} \alpha_j \kappa_{ijt}(P_{ijt}/V_{it})^{1-\varepsilon_{it}}}. \tag{9}$$

Holding fixed the outside option value α_{it}^{0}, a ubiquitous increase in prices at the market level points to an increase in the outside option share, and therefore, a decline in the expenditures spent on insurance. Since prices are increasing while expenditures are falling, this would immediately imply that total new coverage issued should decline as well. The following result confirms this finding conditional on insurers having the same initial exposure.

Proposition 4: Product Market Issuance Dynamics

Consider two interest rate environments, 1 and 2, that are equivalent except that all insurers face a more severe duration gap in the second environment, i.e., $|D_{jt}^{K,2}| \geq |D_{jt}^{K,1}|$ *for all* j *with a strict inequality for at least one* j*. Additionally, assume that* $\mathcal{M}_{ijt}^{1}$ *is constant across insurers. Then the total issuance of product* i *satisfies*

$$Q_{it}^{2} < Q_{it}^{1} \qquad \text{if } D_{it} > D_{jt}^{A}\mathcal{R}_{jt+1} \text{ for all } j$$

$$Q_{it}^{2} > Q_{it}^{1} \qquad \text{if } D_{it} < D_{jt}^{A}\mathcal{R}_{jt+1} \text{ for all } j$$

Proof: See Appendix A.6.

Therefore, according to Proposition 4, a decline in rates that renders all insurers' duration gap more negative leads to a reduction in market issuance for long-duration policies but increases market issuance for short-duration policies. With these results in hand, we now turn to our empirical setting: life insurance markets during the post-GFC, low-interest-rate period.

4 The State of Life Insurance After the Financial Crisis

Equipped with the model predictions, we now turn to our empirical analysis. We begin by discussing our data sources and our method for identifying exposed insurers. We then present results on liability rebalancing and issuance dynamics for exposed and non-exposed insurance groups. We end with an exploration of aggregate issuance dynamics and the evolution of life insurance markets over the last two decades.

4.1 Data Construction

Our data are sourced from life insurers' statutory filings, which we access through S&P Global. Every insurer in the United States must prepare these filings annually for the National Association of Insurance Commissioners (NAIC), who then provides these data to institutions for research purposes.

We pull from a variety of exhibits in the statutory filings. Our primary data is from the Exhibit of Life Insurance, which provides detailed information on policies and coverage issued and in force (gross and net). The exhibit separately identifies ordinary life (term and whole life policies) and group life lines of business. For the latter, there are two policy categories: group contracts and group certificates. Contracts reflect insurer-firm relationships, while certificates are a measure of the number of insured individuals. When using policy-level data, we use certificates.

We complement these data with reserve positions, premiums, and commissions for each product category. Reserves are taken from the Aggregate Reserves for Life Contracts. The filings record the reserve positions (gross and net) for each product category at the end of the fiscal year. Premiums and commissions come from Exhibit 1.

Data on variable annuity issuance and holdings come from the General Interrogatories. These filings record the total related account value for each annuity product sold as well as the reserves held in the general account by the insurer. Note that the account values and reserves only reflect minimum return guarantees since insurers hold the principal of the annuities in their separate accounts.

Finally, we use information on insurers' assets and liabilities, which further allows us to produce leverage ratios. For summary statistics, we use data from the Interest Sensitive Life Insurance Products Report. Data on treasury yields and data on annual GDP are taken from FRED.

Our unit of analysis is an insurance group. We choose to use insurance groups over individual companies for two reasons. First, many insurance groups organize their subsidiaries according to their product specialization. For example, among the subsidiaries of the insurance group Metlife Inc., Brighthouse Financial was a large issuer of variable annuities and variable life insurance. Separating Brighthouse Financial from other subsidiaries, such as the flagship company Metropolitan Life Insurance Company, would paint an incomplete picture of Metlife as a whole. Second, insurers are publicly traded at the insurance group level. Since most public insurers also issued variable annuities, it is consistent with existing evidence on duration gaps and stock returns to use insurance groups (e.g., Hartley et al., 2016; Koijen and Yogo, 2022; Li, 2024).

Our theory predicts that insurers whose liabilities are more convex are more exposed to interest rate risk. Variable annuities are a particularly convex liability due to their minimum return guarantees as discussed in Section 2.2. We therefore split insurance groups by their variable annuities exposure, measured as the total related account value of their variable annuities divided by their total liabilities. We label an insurer as "exposed" if their variable annuity share of liabilities is in the top decile of insurers between 2005 and 2007. Note that only about 25% of insurance groups in our sample issue variable annuities during this time period, so our cutoff corresponds to approximately the top 40% of variable annuity issuers.

Note that we exclude insurers that were not in an insurance group between 2005-2007 for most of the analysis. This is done to provide a clean comparison between exposed and non-exposed insurers prior to the crisis. We bring these insurers back into the sample when we explore aggregate product market trends for completeness.

We also exclude captive reinsurers from our insurance group definitions. This is of little consequence when studying trends in product issuance since reinsurers typically do not issue new policies. However, as we will see later in this section, adding them back into the sample when studying market-level trends does not change the results in the time series. This exclusion also prevents large jumps in the exposed insurers' insurance in force due to the split between Metlife and RGA.

Table 1: Summary Statistics

	Exposed Insurers		Non-Exposed Insurers	
	2005-2008	2009-2023	2005-2008	2009-2023
Number of Groups	26	25	239	198
Assets	94.68	100.30	8.31	14.57
Surplus	5.09	5.39	0.67	1.25
Leverage Ratio	19.62	19.17	6.56	8.97
VA Liability Share	0.57	0.50	0.01	0.01
IS Reserve Share	0.67	0.65	0.24	0.25
Issuance Market Share				
Ordinary	0.43	0.29	0.54	0.61
Group	0.45	0.42	0.54	0.51
In Force Market Share				
Ordinary	0.38	0.29	0.37	0.39
Group	0.48	0.44	0.49	0.47

Note: This table reports summary statistics for our primary sample. Assets and surplus are reported in billions of dollars. All variables except market shares and the number of groups are unweighted averages across insurers. Market shares are calculated across all years within each period.

We provide summary statistics for our primary sample in Table 1. We split the table on two dimensions. First, we report summary statistics for exposed and non-exposed insurance groups separately. Second, we report the statistics for 2005-2008 and 2009-2023 separately. We refer to the first time period as the pre-crisis period and the second time period as the post-crisis period. There are 26 (25) exposed insurers and 239 (198) non-exposed insurers in the pre-crisis (post-crisis) period.

Exposed insurers are systematically larger than non-exposed insurers. In particular, the average exposed insurer is 11.4 times as large as the average non-exposed insurer in the pre-crisis period and 6.88 times as large in the post-crisis period. This is consistent with variable annuity issuance being dominated by large insurers: since variable annuities are among the most complex products issued by life insurers, it is likely that only large insurance groups have adequate resources to manage them. Exposed insurers also have more capital (surplus), though only by an order of 7.6 and 4.3 in the pre- and post-crisis periods, respectively. This difference suggests that exposed insurers are more levered: the average leverage ratio, calculated as liabilities divided by surplus, is 3 and 2.1 times the average leverage of non-exposed insurers in the pre- and post-crisis periods, respectively.

Consistent with our definition of variable annuity exposure, exposed insurers have substantially higher variable annuity liabilities as a share of total liabilities.[17] This is not surprising, as the majority of non-exposed insurers do not issue variable annuities at all. That being said, certain life insurance products are also recorded as interest-sensitive and may be exposed to the low-rate environment in the post-crisis period. The table suggests that insurers exposed to variable annuities also have a substantially higher exposure to interest-sensitive life insurance policies.

Table 1 also preempts our findings across product markets. In the pre-crisis period, exposed insurers, despite being small in number, accounted for 43% of total ordinary life insurance issuance. The remaining 90% of insurance groups accounted for 54% of the issuance, with the remainder being issued by small non-group companies. The numbers for group life issuance are similar. However, in the post-crisis period, exposed insurers only issued 29% of new ordinary life insurance coverage, with non-exposed insurers increasing their share to 61%. On the other hand, group life issuance shares remained relatively stable.

The decline in ordinary life issuance is echoed when considering life insurance in force. Exposed insurers decreased their market share of life insurance coverage in force from 38% to 29% between the two periods, while non-exposed insurers' market share increased from 37% to 39%. Group life insurance in force again remained relatively stable. Note that the numbers for ordinary life only add up to 75%; the majority of the remaining insurance was held by reinsurers, and within reinsurers was largely held by RGA, a prior subsidiary of Metlife until their split in 2008.

4.2 Reserve Valuation Across Products

We begin by exploring how the product-level reserve values of exposed insurers changed after the financial crisis. As we showed in Table 1, exposed groups had substantially more exposure to interest-sensitive life insurance policies in addition to their variable annuities, so we should expect their ordinary life insurance reserves to be sensitive to interest rate

[17]Note that insurers' liabilities are calculated differently than variable annuity liabilities. The share reported in the table and used for our classification is merely meant to separate those with high exposure from those with low exposure relative to their size.

changes. Group life insurance, on the other hand, is yearly renewable, so its valuation should not systematically change with interest rates.

Figure 3 confirms this finding. Panel (a) plots the average reserve value of ordinary and group life policies separately for each year in our sample.[18] Three patterns emerge. First, group life policies require substantially fewer reserves than ordinary life policies. This is due to their shorter maturities. Second, average ordinary life reserve values for exposed insurers increased by 34% (0.031 to 0.043) between 2010 and 2023, consistent with the decline in yields and the sensitivity of their reserves to interest rates. Ordinary reserve values also increased over the same time period for non-exposed insurers, but only by 11% (0.047 to 0.052). Third, despite the increase in ordinary life reserve values over the post-crisis period, exposed insurers' total reserve value remained stable. This is suggestive of liability rebalancing: as reserve values increase for ordinary life insurance, the threat of future rate changes incentivizes exposed insurers to shift their issuance away from long-duration policies and toward short-duration policies. We explore liability rebalancing in detail in the following section.

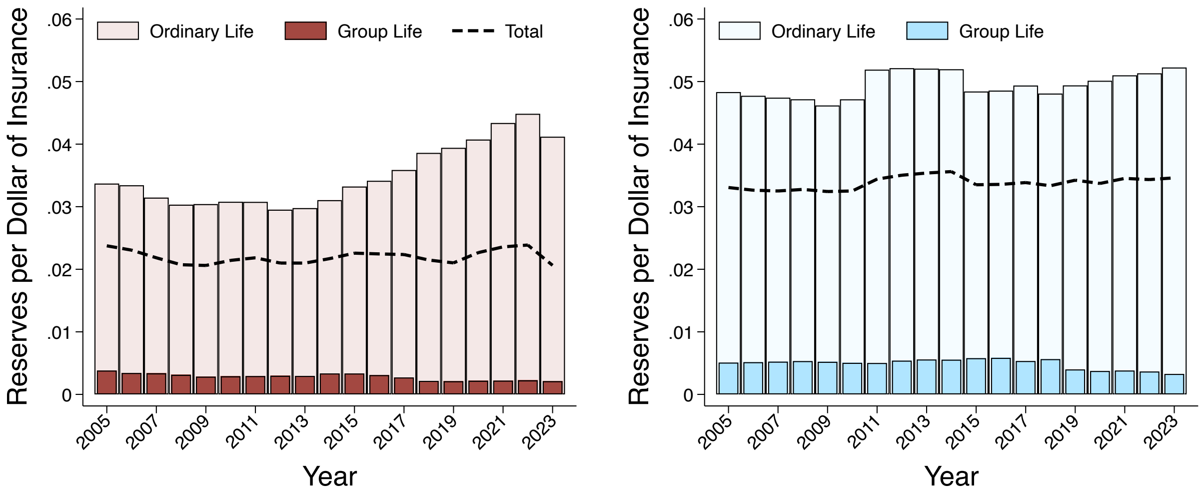
4.3 Liability Rebalancing

As Figure 3 suggests, exposed insurers may have an incentive to shift their product issuance toward low-duration policies in response to interest rate risk. We begin by exploring how average issuance of ordinary and group life product categories changed throughout the post-crisis period in Figure 4. In each panel, we consider the average coverage issued by exposed and non-exposed insurance groups over our sample period. Panel (a) reports the results for ordinary life insurance, and panel (b) reports the results for group life insurance. Units are in billions of nominal dollars.

The figure strongly supports the predictions of the theory. On average, exposed insurance groups strongly reduced their issuance of ordinary life insurance coverage over the sample period from a peak of $32 billion in 2008 to a trough of $18 billion in 2023. Notably, the decline begins after the financial crisis and accelerates after the drop in yields in 2011. At the same time, we see that non-exposed groups began to increase their issuance after 2011:

[18] Note that these averages are weighted by the total amount of insurance in force for each insurer. Insurers who have small positions in a particular category tend to have high reserve values due to a lack of diversification. Additionally, reserve values are inflated when life insurance in force is close to 0, which creates outliers.

Figure 3: Reserve Value Across Products Over Time



(a) Exposed

(b) Non-Exposed

Note: This figure reports average reserve values for ordinary, group, and combined life insurance among exposed insurance groups. Reserve value is calculated as gross reserves divided by life insurance coverage in force. Panel (a) reports reserve values for exposed insurance groups, while panel (b) reports reserve values for non-exposed groups. Dark bars represent average group life reserve values, light bars represent average ordinary life reserve values, and the dashed black line represents the average of the total. Reserve values are weighted by life insurance in force within each category of insurance groups to avoid outliers.

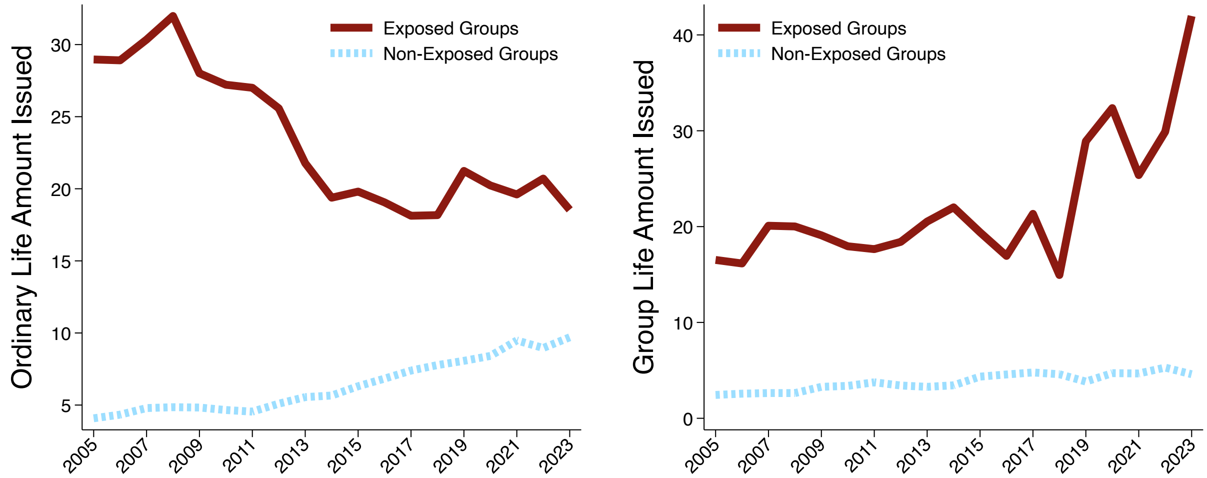
average issuance nearly doubles between 2011 and 2023. This is consistent with non-exposed groups capturing demand that was previously allocated to exposed groups.

The opposite pattern holds in the group life market. Group life issuance by exposed insurers remained stable over the beginning of the post-crisis period before rapidly increasing in 2019.[19] While the average non-exposed group increased their group life issuance as well, the increase was modest and less pronounced than in ordinary life markets. This points to the effects of competition: lower competition in ordinary life markets led to the increase for non-exposed groups, while risk management motives led to a modest increase in group life markets.

In Figure 5, we further decompose ordinary life insurance into whole life policies and term life policies and study the dynamics of insurers' product issuance portfolio over the sample period. For each year, we calculate the average issuance for the three product categories

[19]Metlife was a large factor in the strong growth in group life issuance. In Appendix Figure B.2, we remove Metlife from the sample and recalculate the trends for both product groups. Ordinary life dynamics are similar, but the rapid increase in group life is replaced by flat issuance over time. Nevertheless, this is still consistent with our theory if there were contemporaneous declines in demand.

Figure 4: Product Issuance Across Insurance Groups Over Time



(a) Ordinary Life

(b) Group Life

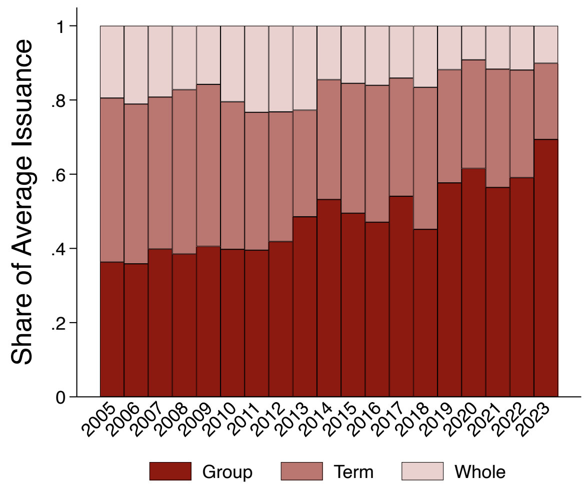
Note: This figure reports average life insurance issuance for exposed (red) and non-exposed (blue) insurance groups from 2005 to 2023. Panel (a) reports ordinary life insurance, and panel (b) reports group life insurance. Units are in billions of US dollars.

and plot their corresponding share of total issuance for exposed and non-exposed insurance groups. Exposed groups strongly increased their group life issuance share from 36% in 2005 to 69% in 2023. Term life shares fall from 44% to 21%, while whole life shares fall from 20% to 10%. Non-exposed groups have relatively stable shares over the time period, with a slight uptick in whole life issuance replacing group life issuance.

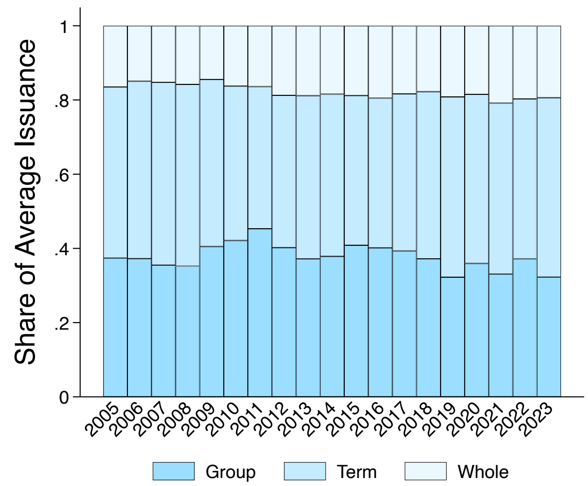
In Appendix Figure B.3, we also examine how policy issuance (as opposed to coverage issuance) changed for each set of insurers. The results continue to hold, which alleviates concerns that insurers are simply issuing smaller policies. We also explore the mechanics through which insurers reduce their issuance. In Appendix Figure B.4, we show that average ordinary life commissions paid as a fraction of premium revenues are decreasing at a faster rate for exposed insurers relative to non-exposed insurers, despite being similar in the pre-crisis period. This is also consistent with our theory: insurers pay lower commissions and attract fewer agents, which in turn leads to a contraction in their issuance. We also highlight that this is not driven by the size difference between newly issued policies and renewed policies, but rather a systematic decline across all sources of commissions.[20]

[20] Life insurance policies typically pay a very large commission in the first year of issuance to promote sales, but pay a low commission in subsequent years.

Figure 5: Liability Rebalancing Across Insurance Groups



(a) Exposed Groups



(b) Non-Exposed Groups

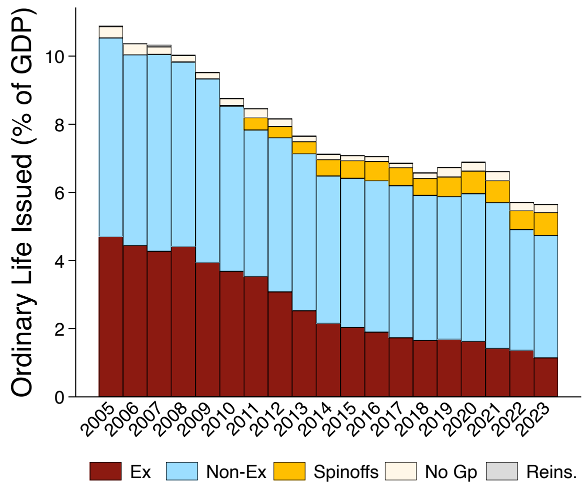
Note: This figure reports the share of average product issuance for exposed (red, panel (a)) and non-exposed (blue, panel (b)) insurance groups between 2005 and 2023. The darkest bar reflects average group life issuance, the medium bar reflects average term life issuance, and the light bar reflects average whole life issuance.

4.4 Aggregate Product Market Dynamics

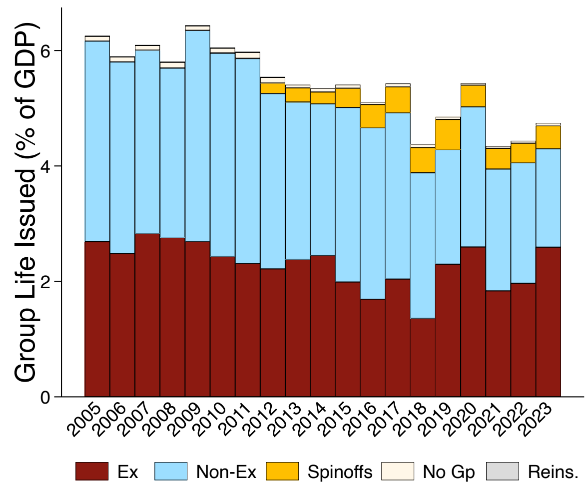
We now turn to the market-level effects of liability rebalancing. In addition to exposed and non-exposed groups, we also consider the issuance of three other categories of insurance companies. First, we include spin-offs, e.g., companies that were part of either an exposed or non-exposed insurance group in the pre-crisis period but later left to form their own group (e.g., Brighthouse Financial departing with Metlife in 2017). Second, we include insurers that are not a part of an insurance group. Third, we include reinsurers.

Although ordinary life issuance declined for exposed insurers, this does not necessarily imply that aggregate issuance declined. In particular, if non-exposed insurers more than picked up the slack, it could be that issuance was stable over time at the market level. Panel (a) of Figure 6 suggests this is not the case: as measured by total coverage as a percent of GDP, aggregate ordinary life issuance fell by 48.2% (10.9% to 5.6% of GDP) between 2005 and 2023. This was predominantly driven by exposed insurers (4.7% to 1.15% of GDP), but issuance also fell for non-exposed insurers (5.8% to 3.6% of GDP). Spinoffs and no-group insurers added only a small amount relative to the issuance of the primary groups in the sample.

Figure 6: Aggregate Issuance By Product



(a) Ordinary Life



(b) Group

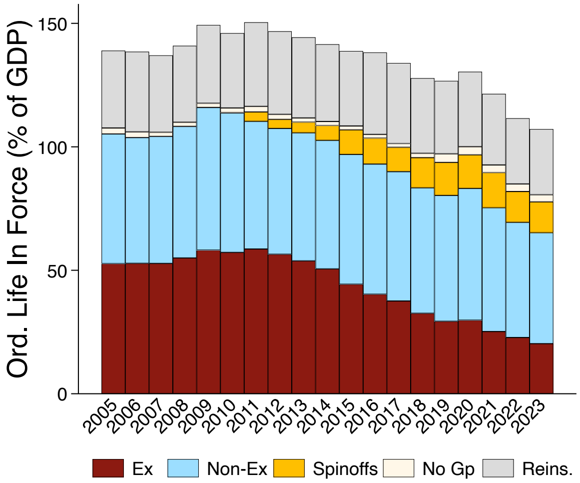
Note: This figure reports real aggregate life insurance issuance as a percentage of real GDP from 2005 to 2023. Panel (a) reflects ordinary life issuance, and panel (b) reflects group life issuance. Red bars represent exposed insurance groups ("Ex"), blue bars represent non-exposed insurance groups ("Non-Ex"), yellow bars reflect insurance companies that belonged to either the exposed or non-exposed insurance groups in the pre-crisis period but have since spun off, cream bars represent insurers not in a life insurance group, and gray bars reflect reinsurance companies.

Group life issuance, seen in Panel (b) of Figure 6, also fell as a percentage of GDP, but by a smaller amount (6.2% to 4.7%). Importantly, exposed insurers, aside from a few years, only slightly decreased their issuance relative to 2005 (2.7% to 2.6%). Non-exposed insurers decreased their issuance more (3.5% to 1.7%), likely due to increased competition in this market by exposed insurers.

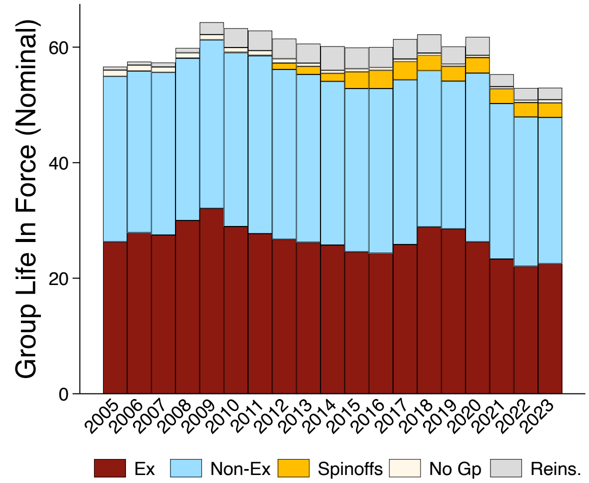
In Appendix Figure B.5, we report changes in nominal issuance for both ordinary and group life. Nominal ordinary life issuance increased by 31% for non-exposed insurers and declined by 48% for exposed insurers, while nominal group life issuance increased by 4% for non-exposed insurers and increased by a sizable 105% for exposed insurers. The discrepancy between the nominal trends and Figure 6 is the relative growth rate of GDP, which grew faster than issuance of both products.

While issuance declined as a percentage of GDP for both ordinary and group life insurance, this does not necessarily translate into a decline in market-level insurance coverage. Issuance may have declined due to insurers already reaching a large fraction of households; if households are not lapsing on their policies, there will be fewer households to reach in a given

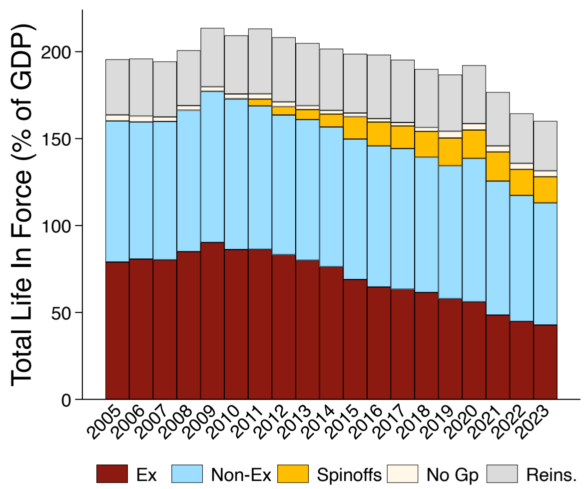
Figure 7: Aggregate Market Dynamics



(a) Ordinary Life



(b) Group



(c) Total

Note: This figure reports real aggregate gross life insurance in force as a percentage of real GDP from 2005 to 2023. Panel (a) reflects ordinary life issuance, panel (b) reflects group life issuance, and panel (c) reflects the sum of ordinary and group life insurance. Red bars represent exposed insurance groups ("Ex"), blue bars represent non-exposed insurance groups ("Non-Ex"), yellow bars reflect insurance companies that belonged to either the exposed or non-exposed insurance groups in the pre-crisis period but have since spun off, cream bars represent insurers not in a life insurance group, and gray bars reflect reinsurance companies.

year, and therefore less issuance would be expected. We therefore examine the dynamics of insurance coverage in force over time.

As shown in Figure 7, this was not the case. Although ordinary life insurance in force increased in the early part of the post-crisis period, peaking around 150.4% of GDP, it ultimately fell to 107% of GDP by 2023. While both exposed and non-exposed groups were responsible, the vast majority of the decline can be explained by exposed insurers: their life insurance in force fell from 52.7% of GDP in 2005 to 20.3% of GDP in 2023, accounting for three quarters of the decline.

Unlike issuance, group life insurance in force remained stable throughout most of the post-crisis period, only moderately declining relative to initial levels after the COVID-19 crisis. Consistent with our hypothesis, exposed insurers were the key difference between ordinary and group life market dynamics. Putting the two together, life insurance in force at the industry level fell from 213.2% to 160% of GDP.

5 Conclusion

Interest rate risk is of first order to many financial institutions. During the low interest rate period that accompanied the recovery from the financial crisis, exposure to interest rate risk grew for many of these institutions. In particular, due to the long-term nature of their liabilities and issues of market incompleteness and regulatory frictions, many life insurance companies had their equity squeezed by low rates.

We provide theory and evidence that insurers with especially convex liabilities, such as variable annuities, may retreat from long-duration product markets to reduce their exposure to interest rate risk. While they substitute toward short-duration products to an extent, the industry as a whole may not remain stable if there are substantive differences in product market characteristics. This appears to be the case for life insurers today: group life insurance markets did not grow enough to offset the decline in ordinary life insurance markets, resulting in a shrunken system.

Our analysis, while telling, abstracts from simultaneous fluctuations and trends in insurance demand. This is a relevant omission since the low interest rate environment coincided with a sharp economic recession and a sluggish recovery, both of which would put downward pressure on already declining tastes for standard insurance products. That being said, our model is amenable to estimation that would allow us to separate demand-based changes from supply-side contractions due to duration mismatch and interest rate risk. We intend to carry out such an analysis in the future.

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A Model Proofs

A.1 Proof of Lemma 1

The proposition follows from the first order condition for product i. In particular, note that we can combine terms and rewrite i's contribution to the objective function as

$$\left[(1+\mathbb{E}_t[\lambda_{jt+1}R^A_{jt+1}])P_{ijt} - (1+\mathbb{E}_t[\lambda_{jt+1}R_{it+1}])V_{it}\right]Q_{ijt} - (1+\mathbb{E}_t[\lambda_{jt+1}R^A_{jt+1}])F_{ijt}.$$

The first order condition with respect to P_{ijt} is then

$$(1+\mathbb{E}_t[\lambda_{jt+1}R^A_{jt+1}])Q_{ijt} + \left[(1+\mathbb{E}_t[\lambda_{jt+1}R^A_{jt+1}])P_{ijt} - (1+\mathbb{E}_t[\lambda_{jt+1}R_{it+1}])V_{it}\right](1-\varepsilon_{it})\frac{Q_{ijt}}{P_{ijt}} = 0.$$

Rearranging, we have

$$P_{ijt} = \left(\frac{\varepsilon_{it}}{\varepsilon_{it}-1}\right)\mathcal{M}_{ijt}V_{it}, \qquad \mathcal{M}_{ijt} \equiv \frac{1+\mathbb{E}_t[\lambda_{jt+1}R_{it+1}]}{1+\mathbb{E}_t[\lambda_{jt+1}R^A_{jt+1}]}.$$

Next, we'll solve for the optimal number of agents hired, T_{ijt}. Substituting our expression for P_{ijt} into the objective function, note that the component corresponding to product i becomes

$$\frac{1+\mathbb{E}_t[\lambda_{jt+1}R_{it+1}]}{\varepsilon_{it}-1}\overline{Q}_{ijt}\left(\frac{\varepsilon_{it}}{\varepsilon_{it}-1}\right)^{-\varepsilon_{it}}\mathcal{M}_{ijt}^{-\varepsilon_{it}}\kappa(T_{ijt}) - (1+\mathbb{E}_t[\lambda_{jt+1}R^A_{jt+1}])\eta_{it}T_{ijt}.$$

Define $\mathcal{E}_{it} \equiv \varepsilon_{it}^{-\varepsilon_{it}}(\varepsilon_{it}-1)^{\varepsilon_{it}-1}$. The first order condition with respect to T_{ijt} can therefore be written, conditional on $T_{ijt} > 0$,

$$(1+\mathbb{E}_t[\lambda_{jt+1}R_{it+1}])\mathcal{E}_{it}\overline{Q}_{ijt}\mathcal{M}_{ijt}^{-\varepsilon_{it}}\kappa'(T_{ijt}) = (1+\mathbb{E}_t[\lambda_{jt+1}R^A_{jt+1}])\eta_{it}.$$

Rearranging to isolate T_{ijt} on the left-hand side, we have

$$\kappa'(T_{ijt}) = \frac{\eta_{it}}{\mathcal{E}_{it}\overline{Q}_{ijt}\mathcal{M}_{ijt}^{1-\varepsilon_{it}}}.$$

The solution follows from inverting $\kappa'(\cdot)$ to solve for T_{ijt}. Of course, $T_{ijt} \geq 0$, so the solution must be bounded below by 0. $\square$

A.2 Proof of Lemma 2

From the approximation in (7), note that we can write the numerator of $\mathcal{M}_{ijt}$ as

$$
\begin{aligned}
& 1 + \mathbb{E}_t[\bar{\lambda}'_{jt+1} R_{it+1}] - \mathbb{E}_t[\bar{\lambda}'_{jt+1} D^K_{jt} \Delta R_{t+1} R_{it+1}] \\
= \; & 1 + \mathbb{E}_t[\bar{\lambda}_{jt+1}(\overline{R}_{it+1} - D_{it}\Delta R_{t+1})] - \mathbb{E}_t[\bar{\lambda}'_{jt+1} D^K_{jt} \Delta R_{t+1}(\overline{R}_{it} - D_{it}\Delta R_{t+1})] \\
= \; & 1 + \bar{\lambda}_{jt+1}\overline{R}_{it+1} - (D_{it}\bar{\lambda}_{jt+1} + \bar{\lambda}'_{jt+1} D^K_{jt}\overline{R}_{it})\mathbb{E}_t[\Delta R_{t+1}] + \bar{\lambda}'_{jt+1} D^K_{jt} \mathbb{E}_t[(\Delta R_{t+1})^2] D_{it}
\end{aligned}
$$

Since R_{t+1} follows a martingale process, $\mathbb{E}_t[\Delta R_{t+1}] = 0$. Substituting this into the above equation gives

$$1 + \bar{\lambda}_{jt+1}\overline{R}_{it+1} + (\bar{\lambda}'_{jt+1} D^K_{jt} \sigma^2_{t+1}) D_{it}$$

as claimed. A similar series of calculations for the denominator term delivers the results. $\square$

A.3 Proof of Proposition 1

Note that under the approximation in (7), we can write the derivative of the risk management markup with respect to σ^2_{t+1} as

$$
\begin{aligned}
\mathcal{M}_{ijt} & \propto \bar{\lambda}'_{jt+1} D^K_{jt} D_{it}(1 + \bar{\lambda}_{jt+1}\overline{R}^A_{jt} + \bar{\lambda}'_{jt+1} D^K_{jt} D^A_{jt}\sigma^2_{t+1}) - (1 + \bar{\lambda}_{jt+1}\overline{R}_{it+1} + \bar{\lambda}'_{jt+1} D^K_{jt} D_{it}\sigma^2_{t+1})\bar{\lambda}'_{jt+1} D^K_{jt} D^A_{jt} \\
& = \bar{\lambda}'_{jt+1} D^K_{jt}\Big[D_{it}(1 + \bar{\lambda}_{jt+1}\overline{R}^A_{jt+1}) - D^A_{jt}(1 + \bar{\lambda}_{jt+1}\overline{R}_{it+1})\Big] \\
& = \bar{\lambda}'_{jt+1} D^K_{jt}(1 + \bar{\lambda}_{jt+1}\overline{R}^A_{jt+1})\Big[D_{it} - D^A_{jt}\mathcal{R}_{jt+1}\Big]
\end{aligned}
$$

If $D_{it} > D^A_{jt}\mathcal{R}_{jt+1}$, then the above is expression is positive. Hence, $\mathcal{M}_{ijt}$ is increasing in σ^2_{t+1} when $D_{it} > D^A_{jt}$, so P_{ijt} is increasing in σ^2_{t+1}. From the expression for T_{ijt}, it also follows that T_{ijt} is declining in $\mathcal{M}_{ijt}$, so κ_{ijt} is declining in σ^2_{t+1}. It therefore follows that Q_{ijt} is declining in σ^2_{t+1}.

On the other hand, if $D_{it} < D^A_{jt}\mathcal{R}_{jt+1}$, then the expression above is declining. Therefore, prices decline and market penetration increases, resulting in a higher Q_{ijt}. This completes the proof. $\square$

A.4 Proof of Proposition 2

This proof is identical to the proof of Proposition 1 except for replacing the derivative with respect to D_{jt}^K. By assumption, the two insurers are identical except for their convexity, so prior to the shift in rates, $D_{jt}^{K,0} = D_{j't}^{K,0}$. After the shift, their durations are $D_{jt}^K \approx D_{jt}^{K,0} - |\gamma_{jt}^K|(R_t^2 - R_t^1) < D_{j't}^{K,0} - |\gamma_{j't}^K|(R_t^2 - R_t^1) \approx D_{j't}^K$ and therefore, $|D_{jt}^K| > |D_{j't}^K|$. Since $\bar{\lambda}'_{jt+1} < 0$ for both j, it further follows that we can write $\bar{\lambda}'_{jt+1} D_{jt}^K = |\bar{\lambda}'_{jt+1}| \times |D_{jt}^K| > 0$. Hence, it suffices to show the relationships for a change in $|D_{jt}^K|$, which will have the same form as in the proof of Proposition 1. $\square$

A.5 Proof of Proposition 3

We will separate this proof into a few parts. First, we derive a closed form expression for the price level, $\mathcal{P}_{it}$. We then show that it's unique conditional on the change in markups. Finally, given the implied change in the price level, we show the existence and uniqueness of the cutoffs.

A.5.1 *Part 1: Deriving a Closed Form Expression for the Price Level*

Let $\kappa(T) = 1 - e^{-T}$. First, note that

$$\begin{aligned}
\alpha_j \frac{Y_{it}}{P_{ijt}} \left(\frac{P_{ijt}/V_{it}}{\mathcal{P}_{it}} \right)^{1-\varepsilon_{it}} (P_{ijt} - V_{it}) &= \alpha_j Y_{it} \mathcal{P}^{\varepsilon_{it}-1} \left(\frac{P_{ijt}}{V_{it}} \right)^{-\varepsilon_{it}} \left(\frac{P_{ijt}}{V_{it}} - 1 \right) \\
&= \alpha_j Y_{it} \mathcal{P}^{\varepsilon_{it}-1} \mathcal{E}_{it} \mathcal{M}_{ijt}^{1-\varepsilon_{it}}
\end{aligned}$$

where $\mathcal{E}_{it} \equiv \varepsilon_{it}^{-\varepsilon_{it}} (\varepsilon_{it} - 1)^{\varepsilon_{it}-1}$. It follows then from the FOC for T_{ijt} that

$$\alpha_j Y_{it} \mathcal{P}_{it}^{\varepsilon_{it}-1} \mathcal{E}_{it} \mathcal{M}_{ijt}^{1-\varepsilon_{it}} (1 - \kappa_{ijt}) \leq \eta_{it}.$$

Therefore,

$$\kappa_{ijt} = \max \left\{ 1 - \frac{\eta_{it} \mathcal{P}_{it}^{1-\varepsilon_{it}}}{\mathcal{E}_{it} Y_{it} \alpha_j \mathcal{M}_{ijt}^{1-\varepsilon_{it}}},\ 0 \right\}.$$

We can use this expression to explicitly solve for $\mathcal{P}_{it}^{1-\varepsilon_{it}}$. Let $\mathcal{J}_{it} \subset \mathcal{J}$ denote the set of insurers that are active in product market i at time t (e.g., $j \in \mathcal{J}_{it}$ if $\kappa_{ijt} > 0$). Then we have

$$\begin{aligned}
\mathcal{P}_{it}^{1-\varepsilon_{it}} &= \alpha_{it}^0 + \sum_{j\in\mathcal{J}} \alpha_j \kappa_{ijt} \left(\frac{P_{ijt}}{V_{it}}\right)^{1-\varepsilon_{it}} \\
&= \alpha_{it}^0 + \sum_{j\in\mathcal{J}_{it}} \alpha_j \left[1 - \frac{\eta_{it}\mathcal{P}_{it}^{1-\varepsilon_{it}}}{\mathcal{E}_{it} Y_{it} \alpha_j \mathcal{M}_{ijt}^{1-\varepsilon_{it}}}\right] \varepsilon_{it}\mathcal{E}_{it}\mathcal{M}_{ijt}^{1-\varepsilon_{it}} \\
&= \alpha_{it}^0 + \varepsilon_{it}\mathcal{E}_{it} \sum_{j\in\mathcal{J}_{it}} \alpha_j \mathcal{M}_{ijt}^{1-\varepsilon_{it}} - \frac{\varepsilon_{it}\eta_{it}}{Y_{it}} |\mathcal{J}_{it}| \mathcal{P}_{it}^{1-\varepsilon_{it}}.
\end{aligned}$$

Solving for $\mathcal{P}_{it}^{1-\varepsilon_{it}}$, it follows that

$$\mathcal{P}_{it}^{1-\varepsilon_{it}} = \frac{\alpha_{it}^0 + \varepsilon_{it} \sum_{j\in\mathcal{J}_{it}} \alpha_j \mathcal{E}_{it}\mathcal{M}_{ijt}^{1-\varepsilon_{it}}}{1 + \frac{\varepsilon_{it}\eta_{it}}{Y_{it}} |\mathcal{J}_{it}|}.$$

A.5.2 Part 2: Uniqueness of the set $\mathcal{J}_{it}$

Order the set of insurers as follows: $j > j'$ if and only if $\alpha_j \mathcal{M}_{ijt}^{1-\varepsilon_{it}} > \alpha_{j'} \mathcal{M}_{ij't}^{1-\varepsilon_{it}}$. We claim that there exists a cutoff j_{it} such that $j \in \mathcal{J}_{it}$ if and only if $j \geq j_{it}$.

To show this, suppose first that there are no firms currently active in the market, $\mathcal{J}_{it} = \varnothing$. Then $\mathcal{P}_{it}^{1-\varepsilon_{it}} = \alpha_{it}^0$. This is an equilibrium if and only if no insurer j would find it optimal to enter, i.e.

$$\alpha_j \mathcal{E}_{it} \mathcal{M}_{ijt}^{1-\varepsilon_{it}} < \frac{\eta_{it}\alpha_{it}^0}{Y_{it}} \equiv \Gamma_{it}.$$

Note that Γ_{it} therefore defines a lower bound on j. Suppose that this condition does not hold for a positive subset of $\mathcal{J}$. For all such insurers, let $1 + \mu_{ijt} = \alpha_j \mathcal{E}_{it} \mathcal{M}_{ijt}^{1-\varepsilon_{it}} / \Gamma_{it} > 1$. Then for a given set $\mathcal{J}_{it} \subseteq \mathcal{J}$, we can express $\mathcal{P}_{it}^{1-\varepsilon_{it}}$ as

$$\mathcal{P}_{it}^{1-\varepsilon_{it}} = \alpha_{it}^0 \left[\omega_{it} + (1-\omega_{it}) \frac{1}{|\mathcal{J}_{it}|} \sum_{j\in\mathcal{J}_{it}} (1+\mu_{ijt})\right], \quad \omega_{it} \equiv \left(1 + \frac{\varepsilon_{it}\eta_{it}}{Y_{it}} |\mathcal{J}_{it}|\right)^{-1}.$$

If $j \notin \mathcal{J}_{it}$, then this price index is an equilibrium price index if and only if

$$(1+\mu_{ijt}) \frac{\alpha_{it}^0 \eta_{it}}{Y_{it}} < \frac{\alpha_{it}^0 \eta_{it}}{Y_{it}} \left[\omega_{it} + (1-\omega_{it}) \frac{1}{|\mathcal{J}_i|} \sum_{j\in\mathcal{J}_{it}} (1+\mu_{ijt})\right]. \tag{10}$$

However, if $j' \in \mathcal{J}_{it}$ and $j > j'$, then (10) cannot hold. Hence, there exists a cutoff j_{it} that determines the equilibrium set of market participants: $\mathcal{J}_{it} = \left\{ j \in \mathcal{J} \;\middle|\; j \geq j_{it} \right\}$. $\square$

A.5.3 Part 3: Proof of the Proposition

Let $\psi_{ijt} \equiv \mathcal{M}^2_{ijt}/\mathcal{M}^1_{ijt}$. Note that we can write

$$
\begin{aligned}
P^2_{ijt}Q^2_{ijt} &= \alpha_j Y_{it} \kappa^2_{ijt} \left(\frac{P^2_{ijt}/V_{it}}{\mathcal{P}_{it}} \right)^{1-\varepsilon_{it}} \\
&= \frac{\eta_{it}\varepsilon_{it}}{Y_{it}} \left[\frac{\mathcal{E}_{it}(Y_{it} + \eta_{it}\varepsilon_{it}|\mathcal{J}_i|)\alpha_j {\psi_{ijt}^{1-\varepsilon_{it}}} \mathcal{M}_{ijt}^{1-\varepsilon_{it}}}{\eta\alpha^0_{it} + \eta_{it}\varepsilon_{it}\mathcal{E}_{it}|\mathcal{J}_i|\mathbb{E}_{it}[\alpha_{j'}\psi_{ij't}^{1-\varepsilon_{it}}\mathcal{M}_{ij't}^{1-\varepsilon_{it}}]} - 1 \right] \\
&= \frac{\eta_{it}\varepsilon_{it}}{Y_{it}} \left[\frac{\mathcal{E}_{it}(Y_{it} + \eta_{it}\varepsilon_{it}|\mathcal{J}_i|)\alpha_j \mathcal{M}_{ijt}^{1-\varepsilon_{it}}}{\eta\alpha^0_{it}\psi_{ijt}^{\varepsilon_{it}-1} + \eta_{it}\varepsilon_{it}\mathcal{E}_{it}|\mathcal{J}_i|\mathbb{E}_{it}\left[\alpha_{j'}\left(\frac{\psi_{ijt}}{\psi_{ij't}}\right)^{\varepsilon_{it}-1}\mathcal{M}_{ij't}^{1-\varepsilon_{it}}\right]} - 1 \right]
\end{aligned}
$$

under the assumption that $\mathcal{J}_{it}$ does not change. Further, note that if $\psi_{ijt} = \max_{j'}\{\psi_{ij't}\}$, then the denominator in the above expression is strictly larger than the denominator when $\psi_{ijt} = 1$ for all j (environment 1). Therefore, $P^2_{ijt}Q^2_{ijt} < P^1_{ijt}Q^1_{ijt}$, and since $P^2_{ijt} > P^1_{ijt}$, it follows that $Q^2_{ijt} < Q^1_{ijt}$. Therefore, the insurer whose prices most respond to interest rate risk reduces their issuance with certainty.

On the other hand, note that if $\psi_{ijt} = 0$ in environment 2, then the denominator is strictly less than in environment 1, implying that $P^2_{ijt}Q^2_{ijt} > P^1_{ijt}Q^1_{ijt}$. Since $P^2_{ijt} = P^1_{ijt}$, it follows that $Q^2_{ijt} > Q^1_{ijt}$. Therefore, since the denominator is strictly increasing in ψ_{ijt}, there must exist a cutoff $\overline{\psi}_{it}$ such that if $\psi_{ijt} < \overline{\psi}_{it}$, issuance increases; otherwise, issuance declines. This completes the proof. $\square$

A.6 Proof of Proposition 4

From the expression for the outside option share of expenditures, we have

$$\sigma_{it}^0 = \frac{Q_{it}^0}{Y_{it}} = \alpha_{it}^0 \mathcal{P}_{it}^{\varepsilon_{it}-1} = \frac{\alpha_{it}^0}{\alpha_{it}^0 + \sum_{j\in\mathcal{J}} \alpha_j \kappa_{ijt} (P_{ijt}/V_{it})^{1-\varepsilon_{it}}}$$

$$= \left(\frac{\alpha_{it}^0}{\alpha_{it}^0 + \varepsilon_{it} \sum_{j\in\mathcal{J}_{it}} \alpha_j \mathcal{E}_{it} \mathcal{M}_{ijt}^{1-\varepsilon_{it}}} \right) \left(1 + \frac{\varepsilon_{it}\eta_{it}}{Y_{it}} |\mathcal{J}_{it}| \right).$$

Clearly, if $\mathcal{M}_{ijt}$ increases for all insurers (which is the case when $D_{it} > D_{jt}^A \mathcal{R}_{jt}$), then Q_{it}^0/Y_{it} increases as well. Since total market expenditures constant, note that $Y_{it} = \sigma_{it}^{0,1} Y_{it} + (1 - \sigma_{it}^{0,1}) Y_{it} = \sigma_{it}^{0,2} Y_{it} + (1 - \sigma_{it}^{0,2}) Y_{it}$. Since $\sigma_{it}^{0,2} > \sigma_{it}^{0,1}$, it follows that

$$\sum_{j\in\mathcal{J}_i} P_{ijt}^1 Q_{ijt}^1 = (1 - \sigma_{it}^{0,1}) Y_{it} > (1 - \sigma_{it}^{0,2}) Y_{it} = \sum_{j\in\mathcal{J}_i} P_{ijt}^2 Q_{ijt}^2.$$

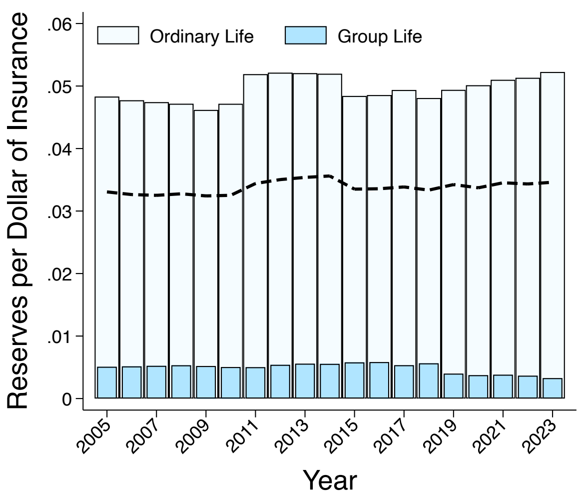
Therefore, expenditures on product i decline. Note further that since $\mathcal{M}_{ijt}^1 = \mathcal{M}_{it}^1$ for all j, we necessarily have $P_{ijt}^1 = P_{it}^1$ for all j. It follows from the above inequality that

$$Q_{it}^2 = \sum_{j\in\mathcal{J}_{it}} Q_{ijt}^2 < \frac{1}{P_{it}^1} \sum_{j\in\mathcal{J}_{it}} P_{ijt}^2 Q_{ijt}^2 < \frac{1}{P_{it}^1} \sum_{j\in\mathcal{J}_{it}} P_{ijt}^1 Q_{ijt}^1 = \sum_{j\in\mathcal{J}_{it}} Q_{ijt}^1 = Q_{it}^1.$$

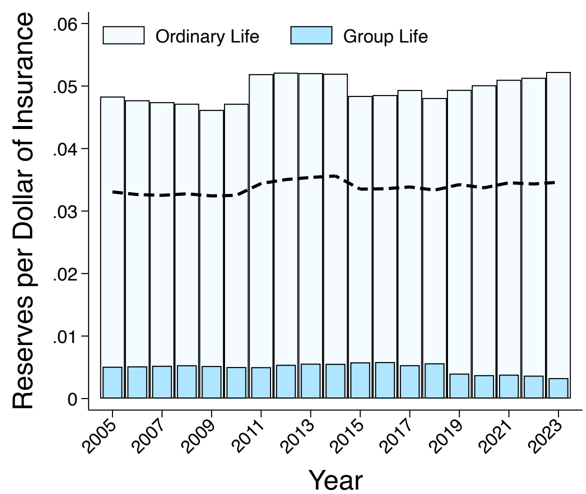
The result for $D_{it} < \mathcal{D}_{jt}^A \mathcal{R}_{jt}$ follows an analogous argument. $\square$

B Additional Figures

Figure B.1: Reserve Valuation for Non-Exposed Insurers



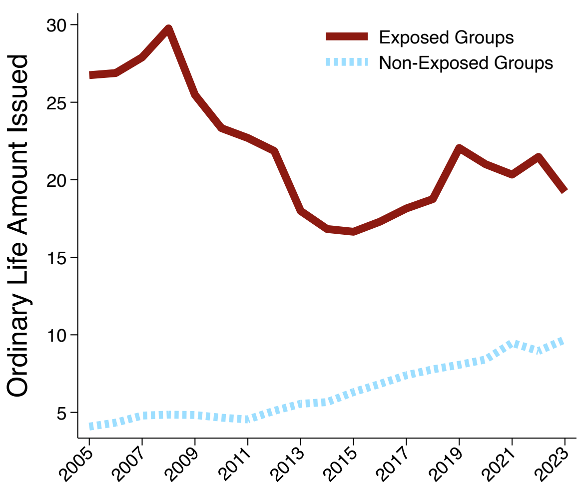
(a) Ordinary Life



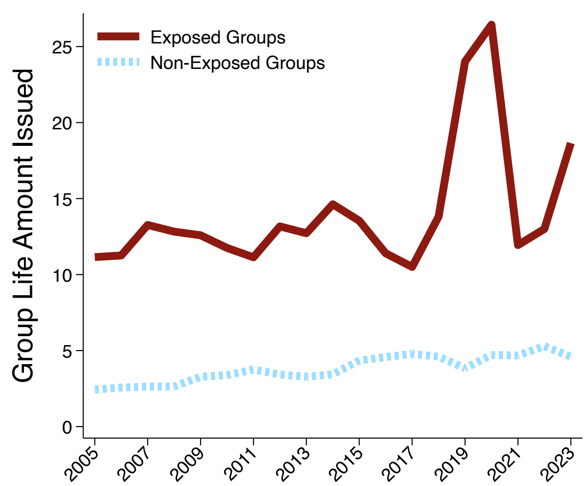
(b) Group Life

Note: This is a note. Please see notes for details about notes, which may be noteworthy.

Figure B.2: Product Issuance Across Groups (Excluding Metlife)



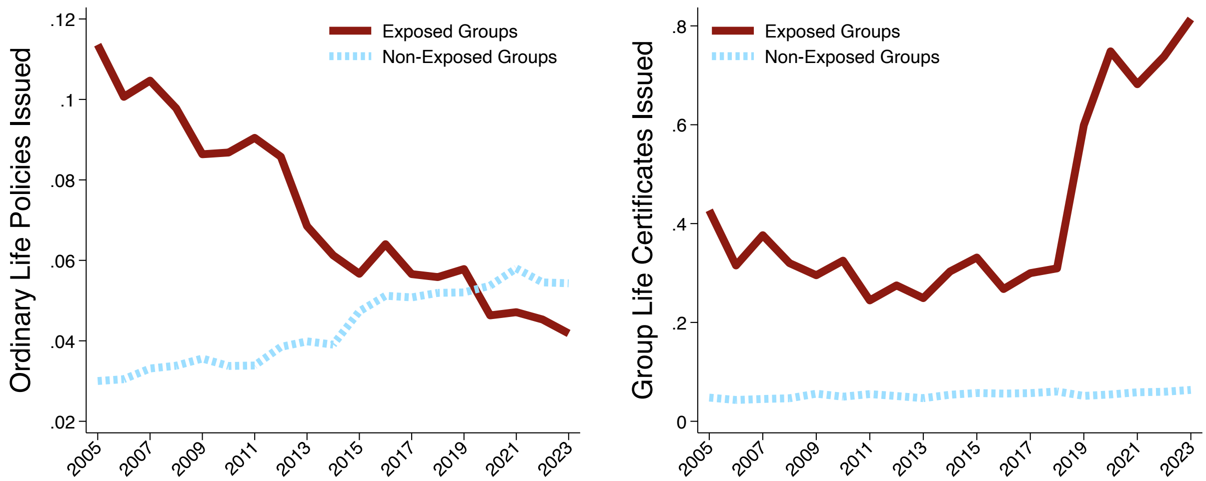
(a) Ordinary Life



(b) Group Life

Note: This figure reports average life insurance issuance for exposed (red) and non-exposed (blue) insurance groups from 2005 to 2023 excluding Metlife from the calculations. Panel (a) reports ordinary life insurance, and panel (b) reports group life insurance. Units are in billions of US dollars.

Figure B.3: New Policy Issuance Across Groups

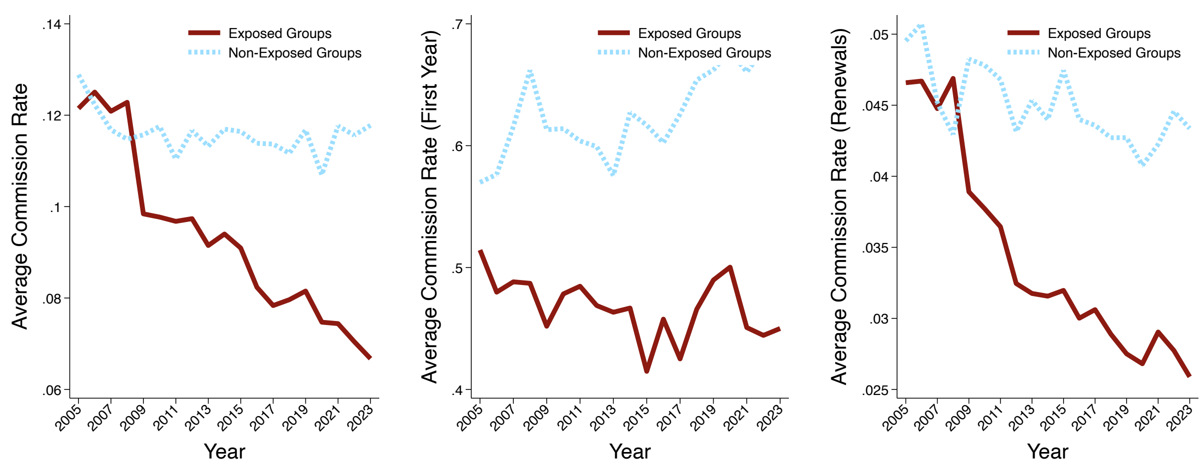


(a) Ordinary Life

(b) Group Life

Note: This figure reports average number of life insurance policies issued for exposed (red) and non-exposed (blue) insurance groups from 2005 to 2023. Panel (a) reports ordinary life insurance, and panel (b) reports group life insurance. Units are in millions of policies.

Figure B.4: Average Commission Rates



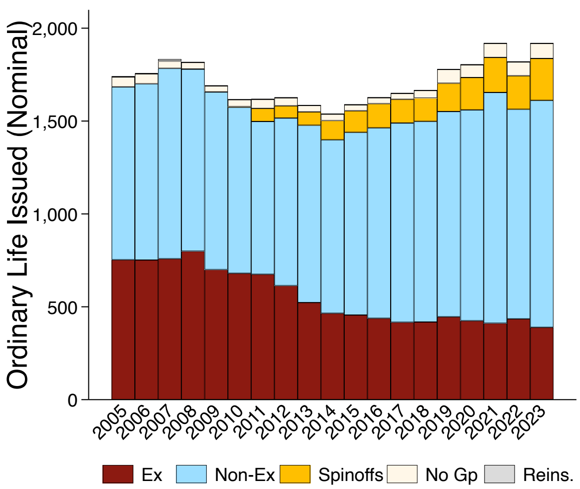
(a) Total

(b) New Policies

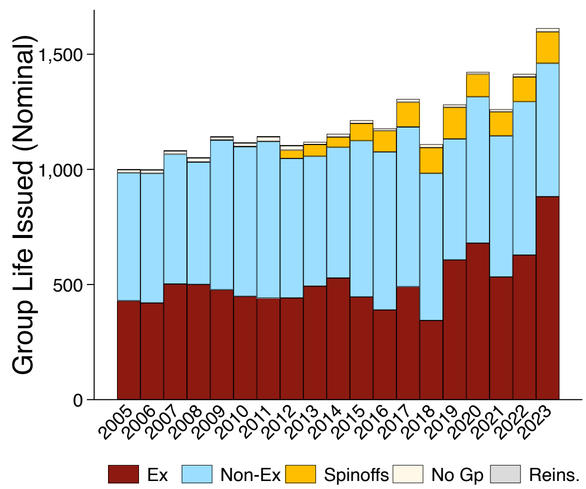
(c) Renewals

Note: This figure reports average commission rates for exposed (red) and non-exposed (blue) insurance groups from 2005 to 2023. Panel (a) reports total commission rates, panel (b) reports commissions on policies issued in the current year, and panel (c) reports commissions on policy renewals. Commission rates are calculated as direct commissions paid to agents divided by direct premium revenues. The data are winsorized at the 1% and 99% level to avoid outliers.

FIGURE B.5: AGGREGATE NOMINAL ISSUANCE BY POLICY



(a) Ordinary Life



(b) Group Life

Note: This figure reports nominal aggregate life insurance issuance from 2005 to 2023. Panel (a) reflects ordinary life issuance, and panel (b) reflects group life issuance. Red bars represent exposed insurance groups ("Ex"), blue bars represent non-exposed insurance groups ("Non-Ex"), yellow bars reflect insurance companies that belonged to either the exposed or non-exposed insurance groups in the pre-crisis period but have since spun off, cream bars represent insurers not in a life insurance group, and gray bars reflect reinsurance companies.