The Evolution of Insurance Markets

Capital Regulation and Insurance Provision*

PRELIMINARY

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Abstract

The insurance sector has undergone significant changes in risk regulation in recent decades. This paper examines how risk-based capital regulation impacts the evolution of insurance product markets. Risk regulation affects insurance product markets through both supply, from insurers adjusting, and demand sides, from households limiting purchases from high risk insurers. We exploit a natural experiment, the adoption of risk-based regulation in the UK, to distinguish between supply and demand effects. We do so exploiting a first-of-a-kind granular database derived from regulatory stress tests detailing insurers' risk exposures across key factors. We show that the insurance sector is increasingly moving away from its traditional role of insuring against a range of different risks to merely serving as a pass-through for investments into mutual funds. We provide causal estimates of the shift in insurers' product composition and market concentration. Furthermore, we explore how differences in regulatory environments across countries contribute to variations in insurance portfolios, suggesting that stricter regulations correlate with reduced ownership of traditional insurance products, particularly among lower-income individuals. This research underscores the complex interplay between regulatory frameworks and the insurance market landscape.

Keywords: Insurance & Pensions; Mutual Funds; Capital Regulation; Product Markets, Risk Sharing

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The insurance sector has experienced a ramping up of risk regulation in many parts of the world in the past few decades. This is not without reason – there have been several instances of insurance companies failures in recent years. Many large U.S. insurers took significant losses during the 2008-2009 financial crisis and had to be bailed out under the Troubled Asset Relief Program; Equitable Life, the largest insurance company in the U.K., failed in the late 1990s; insurers also regularly feature among the most systemically risky financial institutions (Acharya et al. 2017); and many of them report having large exposures to aggregate risks (EIOPA, 2017).

However, while risk regulation improves the resiliency of the insurance sector, it also likely affects insurance product markets. At about one-third of the financial sector, the insurance industry plays a pivotal role in safeguarding the financial resilience of households worldwide. Insurance contracts provide a hedge against various negative life events (e.g., loss of life). Insurance contracts are also a key source of long-term guaranteed retirement savings, which is particularly important given the decline of other sources of guaranteed savings (e.g., state pensions and defined-benefit plans). In supplying these contracts, insurers take risks out of the hands of households and into their own balance sheets. Insurers therefore hold residual exposures to various types of risks, including potentially large exposures to aggregate market risks. On the one hand, these risks make them vulnerable to fluctuations in aggregate market conditions. On the other hand, it is often argued that insurers may be better suited to hold aggregate risks in equilibrium relative to households and other financial sectors whose liabilities, unlike insurers', are subject to runs.

In this paper, we study how risk-based capital regulation of the insurance sector affects the evolution of insurance product markets. We show that the insurance sector is increasingly moving away from its traditional role of insuring against a range of different risks to merely serving as a pass-through for investments into mutual funds. Using a natural experiment, we causally identify risk-based capital regulation as a key factor behind this shift.

There are two main empirical challenges that have previously hindered the study of how risk regulation affects insurance intermediation. First, risk regulation affects insurance product markets through both supply and demand. In response to higher risk-based capital requirements, insurers may alter the *supply* of insurance contracts. A supply-side response inherently implies that raising capital is costly: an increase in capital requirements alters insurers' risk-bearing capacity and the extent of financial intermediation they provide, in sharp contrast to standard models of capital structure (Modigliani and Miller 1958) where insurers frictionlessly raise capital and their optimization problem remains unchanged.

Changes in risk regulation (or rather the information contained therein) may also change households' perception of insurers' creditworthiness, thus altering *demand* for insurance. A key feature of insurance contracts is that households are effectively long-term lenders to insurers, making insurers' long-term solvency a critical factor in demand (Koijen and Yogo 2015). As a result, when we observe variation in product market outcomes across insurers, it is not immediately obvious whether supply or demand-side forces are driving this variation. For instance, when we observe "constrained" insurers reducing underwriting, this may be driven both by increases in the marginal cost due to stricter regulation (supply) and because households may be less likely to purchase insurance from these constrained insurers when worried about future solvency (demand).

The insurance literature has not been able to distinguish between these two different interpretations of the decline in intermediation. Yet, the distinction is important – (a) because regulatory changes often follow periods of financial distress when measures of regulatory constraints are more likely to be correlated with demand shifts in the cross-section, and (b) because the two interpretations have different implications for assessing households' welfare and designing future regulatory policy. Another key point is that the demand channel in insurance differs fundamentally from that in bank lending. When examining the effects of supply constraints on bank lending, the concern is there are coinciding economic shocks affecting both credit demand and lending supply. Because regulatory shocks in insurance can alter demand directly, the standard tests used in banking studies, such as comparing a borrower's loans from two differently constrained banks (Khwaja and Mian 2005) or supply shocks originating abroad (Peek and Rosengren 1997) are insufficient to distinguish supply from demand in the insurance context. To effectively separate supply and demand effects in insurance, we also require that the regulatory shock should not change households' underlying information set. These considerations highlight the unique challenges in analyzing the impact of regulatory constraints on insurance markets compared to the banking sector. We make progress by studying the effects of a natural experiment in the UK that allows us to separate the effects of supply from demand.

Second, risk regulation penalizes risk retention. Yet data on the risk exposures of insurance companies is unavailable, as is true for financial institutions more broadly (Begenau, Piazzesi, and Schneider 2015). The insurance sector is exposed to several types of aggregate (e.g., equity market, interest rate) and idiosyncratic (e.g., mortality) risks. These risks arise both on the liability side, from the products insurers sell, and on the asset side, from the assets they invest in. However, despite the availability of relatively comprehensive data on insurers' assets, liability information is sparse and opaque (Koijen and Yogo 2016). Absent data on risk exposures, it is unclear how much risk insurers assume from households, how easily those risks diversify, how common (and important) is that insurers retain these risks as opposed to pass them on to counterparties in financial markets through hedging and reinsurance (Sen 2023; Koijen and Yogo 2015).

The first contribution of our paper is to provide first-of-its-kind data on the actual risk exposures of insurance companies. Our comprehensive database, which we access through regulatory stress tests of insurers from Europe, encompasses granular information on insurers' risk exposures across all relevant sources of risk, providing a holistic view of each insurer's risk profile.

We use this data to establish three novel facts about European "long-term" insurance markets. First, there is large heterogeneity in insurance product portfolios across European countries. There are two broad classes of insurance contracts, traditional and linked. Traditional contracts, which include guaranteed savings, annuities, and life insurance contracts, offer households protection against aggregate and idiosyncratic risks helping them offload risks to insurers. Linked contracts are mainly pass-throughs, which channel households' premiums into mutual funds while offering no risk protections. We document wide differences in the share of traditional contracts across countries, with a precipitous decline in recent decades. At the same time, we find linked contracts increasing rapidly.

Second, insurers have large exposure to aggregate risks. In particular, equity market, interest rate, and credit risk constitute a more than 64% of their total risk exposures. Exposure to non-financial underwriting risks (e.g., longevity, mortality) also form a significant portion (18%). Importantly, much of these risks are concentrated among insurers that sell traditional and not linked products. This reinforces the view that linked products are essentially pass-throughs where insurers do not bear any residual risks. Moreover, in writing traditional products, insurers do not hedge risks in financial markets entirely and carry economically large exposures. A back of the envelope calculation implies that these exposures are comparable to the exposures carried by large banks.

Third, there is substantial variation in the way countries set capital requirements for insurance products. In particular, countries that have historically had a lax regulatory regime, where capital requirements have remained largely insensitive to underlying risks, are also the ones which have larger traditional product shares. In contrast, in countries with higher prevalence of risk-based capital requirements, insurers act largely as pass-throughs to mutual funds.

While these facts suggest a strong correlation between risk-based regulation and insurers' product portfolios, it is not clear whether regulation causally affects product markets nor whether it does so through a supply channel. The second contribution of our paper is to exploit a natural experiment from the United Kingdom that allows us to identify regulatory-induced shifts in the supply of insurance plausibly holding demand fixed.

In 2002, the UK adopted a risk-based capital regulation framework in which capital requirements became a function of insurers' underlying risk exposures, a significant shift from the old framework that was largely risk insensitive. In particular, as insurance contracts transfer substantial amounts of risk, the introduction of a risk-based capital regulation regime that is calibrated to modern macro-prudential solvency standards meant that capital requirements rose substantially in the new framework relative to the old. We estimate that capital requirements increased on average by about 7 percentage points (pp) for insurers that primarily had traditional liabilities. In contrast, capital requirements remained largely unchanged (and small) for insurers that primarily had linked liabilities. Thus, a shift to a risk-based regime amounts to a more stringent regulation of traditional insurance products. And as insurers have large and long-dated exposures to traditional products, half of the insurers that were unconstrained under the old regulation (had enough equity to meet required capital) became constrained.

Using a difference-in-differences identification strategy, we show that moving to a risk-based regulation affects the traditional insurance market in substantial ways. Two aspects of the regulation are important to note. First, a key feature of our setting is that both the risk exposures and the resulting capital positions arising from the new regulation were strictly confidential. This allows us to interpret the product market changes as supply adjusting rather than demand adjusting because in the absence of public disclosures, it is unlikely that households could identify exactly which insurers faced a capital shortfall to substitute away from them. Second, a challenge in measuring risk constraints from stress test submissions such as ours is that the stress tests are conducted after the regulation has been announced (the timing itself is endogenous), so it is often hard to know who was constrained *ex-ante* at the time of the announcement. A unique feature of our DID strategy is that we are able to exploit ex-ante variation in regulatory risk constraints, which we construct from proprietary risk models, allowing us to trace product market outcomes as soon as regulation is announced, inclusive of any endogenous responses between the announcement and reporting.

We have two main results. First, there is a statistically significant and economically large decline in traditional underwriting for constrained relative to unconstrained insurers after the regulation. And because linked underwriting remains largely unaffected, there is a marked shift in the product composition away from traditional products and into mutual funds. The economic magnitudes are substantial. We estimate that constrained insurers experience 7.3pp higher decline in traditional underwriting and 6pp higher decline in traditional share for every 1pp increase in capital requirements relative to unconstrained insurers after the regulation. Furthermore, prices of traditional contracts rise and linked remain unchanged, consistent with our interpretation that higher regulatory costs shift the *supply* of traditional products.

Second, we observe a substantial rise in market concentration. Constrained insurers are more likely to exit the market for traditional products and sell a fraction of their existing business to unconstrained insurers, while smaller constrained insurers get taken over altogether, as the insurance industry reallocates risk exposures to available capital. Moreover, there are potentially important distributional implications, as it is primarily the smaller contracts associated with poorer households that are more likely to drop out of the market.

Europe is slowly transitioning to the same risk-based capital regulation that the UK adopted in 2002. While the transition is gradual and does not give us the kind of sharp identification that the UK provides, the fact that different countries are at different points along this transition generates interesting cross-sectional variation in capital regulation. We exploit this variation to confirm our UK findings internationally.

On the supply side, countries that adopt the more stringent risk-based capital regulation early on end up with insurance sectors that are more concentrated but more resilient, with companies that are bigger, better capitalized, and more likely to share their risks with the financial markets via hedging, reinsurance or stock ownership structures.

On the demand side, we exploit a uniquely detailed survey of individual demographics, preferences and beliefs, income and wealth, taxation and social benefits, pensions and insurance choice – that is representative and harmonized across European countries – to document vast differences in traditional insurance market participation that strongly correlate with risk regulation. In particular, stricter regulations correlate with reduced ownership of traditional insurance products. Gaps in insurance are most evident among the poor, and those left without coverage seem unable to substitute it through social security, corporate health and pension plans or individual coverage in the private markets, resulting in sizable cross-country differences in household risk exposures.

1. Institutional Background

Insurance Products

There are two broad categories of life insurance products, depending on the extent of risk transfer between households and insurance companies. Traditional products, which include life or term annuities, whole or term life insurance and retirement savings products with minimum return guarantees, protect households against a range of idiosyncratic or aggregate risks. For instance, an annuity contract protects against the risk of outliving one's assets (longevity risk). A life insurance contract protects against the risk of premature death (mortality risk). A guaranteed savings contract protects one's estate or retirement savings against fluctuations in the financial markets (equity market and interest rate risk). Traditional products imply a risk transfer between households and insurance companies as insurers take risks out of the hands of households and onto their balance sheets. While a some of these risks are idiosyncratic which the insurer may diversify away, there is typically a large residual aggregate component. The insurer may try to pass on these aggregate risks to the financial markets through hedging or reinsurance, or retain them on their balance sheets, in which case they are required to post a minimum capital requirement.

In contrast, linked insurance products offer no protection against idiosyncratic or aggregate market risks. In linked products, insurance companies channel households premiums into a mutual fund of their choice. When the contract ends, e.g. due to death, contract termination, or maturity, households simply receive the prevailing market value of the mutual fund. There are typically no return or interest rate guarantees, no mortality and longevity protection (or at least not in a material sense – in many European countries, insurance companies add a small element of protection just to qualify as insurance contracts and benefit from the tax advantage). Thus, unlike traditional products, there is no risk transfer between households and insurance companies. All risks stay with the households as insurers put none on their balance sheets. And as a result, there are no (or negligible) capital requirements.

Capital Requirements

There are two regimes for setting capital requirements for insurance products in Europe. Under a rule-based regime, the insurance company sets capital requirements as a fixed percentage of insurance liabilities, largely irrespective of the risks that those liabilities pose to the overall balance sheet. For instance, since 1979, the European Commission Directive 79/267/EEC requires all insurance companies in the European Economic Area to hold minimum required capital equal to 4% of traditional insurance liabilities plus up to 0.3% of the face value of any life insurance contract (the amount one gets upon death in a term of whole life insurance contract), for a total of around 5-6% for the typical traditional insurance contract.

By the early 2000s, partly in response to insurance company failures (Equitable Life in 2000) and partly to developments in banking regulation (Basel II), a number of national insurance regulators adopt risk-based capital regulation – regimes where capital requirements are sensitive to the risks embedded in insurance contracts (Figure 3). The UK was the first country to adopt such regime (the Individual Capital Adequacy Standards or ICAS in 2002), followed by the Netherlands (the Financial Assessment Framework or FTK in 2003), and Switzerland (the Swiss Solvency Test in 2006). Ireland did not develop its own regime, but rather borrowed the 2005 C3-Phase II risk-based standard from United States (see Koijen and Yogo 2022).

Under a risk-based capital regulation, insurance companies stress-test their entire balance sheets against a range of adverse scenarios which are calibrated by the regulator. Insurers then compute the capital deficiency (or risk exposure) in each of these scenarios and set capital requirements by aggregating the individual risk exposures.

We illustrate how risk-based capital requirements are calibrated in the UK, with the understanding that this is representative of all subsequent risk-based capital regimes. Insurance companies stress-test their balance sheets against five risk factors: market risk (adverse movements in equity markets, property prices and exchange rates), interest rate risk (adverse movements in nominal interest rates and inflation), credit risk (adverse movements in corporate bond credit quality and ratings of reinsurance or hedging counterparties), underwriting risk (risks arising from insurance provision such as adverse movements in aggregate mortality, longevity, morbidity or policyholder behavior) and other operating risks. Each scenario is calibrated to a 1-in-200-year event, which means that the resulting capital deficiency is a 99.5% Value at Risk at a 1-year horizon,[1] and so insurers are required to hold enough capital against each of these risks to ensure they remain solvent with a 99.5% probability over the next 12 months (Financial Services Authority 2002; Financial Services Authority 2003).[2] For the typical traditional insurance contract, this amounts to 10-12% of liabilities (as opposed to 5-6% under the rule-based regulation). As a result, moving to a risk-based capital regulation leads to a sizeable tightening in the regulation of traditional insurance products.

Ultimately, all European countries are expected to transition to a risk-based capital regulation that is very similar to the one in the UK. Adopted in 2016, the European Solvency II Directive

[1]Ireland is again the exception. Rather than simulating the 0.5 percentile worst scenario, Irish insurers are required to simulate the entire distribution of adverse scenarios and set capital requirements as the average of the 5% worst realizations (a 95% Conditional Tail Expectation). This again reflects the design of the US system.

[2]For comparison, the Basel Committee on Banking Supervision specifies a target prudential standard of a 99.9 percent solvency rate over a one-year horizon (Kupiec 2006). The capital standard under the ICAS regime was therefore less stringent. The Committee of European Insurance and Occupational Pensions recommended 99.5 capital standard as it was believed to roughly correspond to a financial strength of a "BBB" rated company. The same standard is also used under Solvency II used to regulate insurers in the European Union, starting in 2016.

requires all insurance companies to disclose risk exposures, and gives them 16 years to comply with the resulting capital requirements. As a result, the experience of early risk-based capital adopting countries, including the UK, may be informative in predicting the future of European insurance markets.

2. Motivating Facts

2.1. Novel European Insurance Data

We collect data on European insurance companies product composition and risk exposures from the first round of regulatory disclosures that companies made under the pan-European Solvency II regulation in 2016, collected by AM Best. The disclosures are audited, standardized and, importantly, harmonized to ensure consistent reporting across countries.

For every company, we observe the sales (gross written premia), payouts (gross incurred claims), and reserves (present discounted value of expected future claims arising from contracts currently in force) overall and broken down by product line, as well as the extent to which these products are reinsured or contain minimum return guarantees. On the statutory capital side, we observe the amount of available capital and required capital for solvency purposes, both overall and broken down by broad sources of risk (market risk, credit risk, mortality or longevity risk, health risk, catastrophe risk), which allows us to compute risk exposures. While capital requirements are computed at the company level taking into account risks on both the asset and liability sides, we also observe a product-specific capital requirement which allows us to compare risk exposures across products.

2.2. Aggregate Facts

We start by establishing 5 stylized facts about European insurance markets. These facts serve as background for our main motivating facts presented in the next subsection. First, the European insurance sector is large (Table I). At €8.1 trillion in net present value of expected future benefits, insurance contracts make up 29% of households net financial assets in the European Economic Area. Second, insurance companies' risk exposures are large. Contrary to a traditional view that insurers are safe intermediaries that pool idiosyncratic risks and invest policyholder premiums in safe bonds, risk exposures coming from insurers capital requirements are €1 trillion for the sector as a whole or 12% of reserves and are similar to those of banks. As we will show throughout this paper, a majority of these risk exposures originate from the liability side in the kind of risks they assume from households and not the asset side in the type of risks they assume in financial markets. Third, if one thinks of the basic functions of insurers – protecting households against idiosyncratic mortality and longevity, protecting their retirement savings against aggregate market risk, protecting individuals and property against damages and disability – the primary function of insurance companies nowadays is protection against aggregate market risk. This was also assumed to be true in the US (Barbu 2023, Koijen and Yogo 2022) but could never be proven because insurance companies there do not disclose individual risk exposures. Traditional products with minimum return guarantees make up to half of all insurance companies sales, claims and reserves, and associated aggregate market risks make up 64% of overall risk exposures. These are followed by mortality and longevity risks (18%) and property and casualty or catastrophe risks (a category that incorporates climate risks – 11%). Fourth, no less than 25% to 30% of insurance companies operations come from linked products that involve little or no risk at all, products that simply channel households retirement savings into tax-advantaged mutual funds. So, an important function of insurance companies nowadays is tax-advantaged retirement savings.

2.3. Cross-Sectional Facts

We next turn to our main motivating facts of the paper. There is a large and persistent heterogeneity in the types of insurance products being sold and risks being insured across countries, and in particular in the extent to which households use insurance companies to offload idiosyncratic and longevity risks as opposed to a vehicle for investing in tax-advantaged mutual funds. In Germany, France and Italy, more than 80% of life insurance contracts are traditional insurance (often with minimum return guarantees). In Ireland, Netherlands and the UK, less than 25% are so. (Figure 1). This results in large differences in risk exposures across national insurance sectors as insurers do not (entirely) hedge, reinsure or diversify (Figure 2)[3]. And since these exposures are long lived (10Y-30Y on average, see EIOPA 2018), these differences in risk exposures are likely to persist for decades. Second, different countries are at different points in their transition to risk-based capital regulation. As explained in Section 1, a subset of countries (UK, Ireland Netherlands, Switzerland) switched to risk-based capital regulation early on, in the early 2000s. All other countries are still transitioning

[3] By design, insurers reported risk exposures could originate from both the liability side from the risks they assume in the product markets as well as from the asset aside from the risks they assume in the financial markets, and are subject to netting, hedging and reinsurance. We confirm that these different risk exposures indeed originate from the product market in two ways. First, the bottom panel of Figure 2 plots the share of traditional insurance contracts with minimum return guarantees against the amount of market risk exposures retained, both as a percentage of reserves, to show there is a strong correlation between product composition and risk *retention*. Then in Internet Appendix E4, we examine product-level capital requirements – which capture variation in risks originally assumed from households holding all other aspects of the balance sheet (such as netting and hedging) fixed – to show how the risks ultimately retained on insurers balance sheets can be traced back to risks assumed in the product markets.

today. Third, where a country is in its transition to risk-based capital regulation goes a long way in explaining if it specializes in insurance provision or tax advantaged mutual funds. Figure 4 plots the composition of life insurance liabilities for countries with laxer rule-based capital regimes and stricter risk-based capital regimes to find that traditional insurance provision concentrates in those countries where it has historically been more favorably regulated (in risk-insensitive rule-based capital regimes).

As we show in Section 5, this correlation between life insurance provision and capital regulation is strikingly robust. It is persistent through time, it holds within insurance groups, it shows up in household insurance ownership, persists even within highly similar individuals, concentrates exactly around the regulatory jurisdiction boundaries, and will share the same characteristics documented causally in Section 3 in the UK. On the one hand, companies operating under the strict regime grow bigger, more capitalized, are less likely to remain mutual and more likely to share their risks via hedging or reinsurance. On the other hand, traditional insurance ownership under the strict regime is less widely distributed and more concentrated among the rich. And the poor left without insurance coverage seem unable to substitute for lost insurance through other ways such as social security, corporate health and pension plans or individual coverage in the private markets.

And so the question is how much of these differences in insurance portfolios across Europe can be attributed to differences in risk regulation as opposed to unobserved differences in the demand and supply of insurance across countries. To make progress, we exploit a quasi-natural experiment in the UK where risk regulation shifts insurance supply plausibly holding demand fixed.

3. The UK Quasi-Natural Experiment

3.1. The Regulatory Shock

In 2002, the U.K. became the first country to adopt an insurance risk-based capital regulation. Before 2002, capital requirements were set as a fixed percentage of liabilities, irrespective of the actual risks on insurers' balance sheets. Under the new regulation, risk exposures were computed by stress testing insurers' entire balance sheets against a full spectrum of risks. Insurers were then required to hold capital against these risks at a level that would ensure solvency with a 99.5% probability over a one-year horizon, exactly as described in Section 1.

The stress tests followed a two step process. First, insurers submitted their own assessments of risk exposures, following the regulator's stress testing guidelines. These submissions started in 2003 immediately after the new framework was announced in 2002, and ended in 2006, when the new framework was fully implemented. In a second step, the regulator reviewed the submissions to ascertain whether the stress test guidelines were properly complied with and the outcomes adequately reflected actual risk exposures. The review process typically lasted from three to six months and involved multiple actuaries and insurance supervisors. Where an insurer's assessment was deemed inappropriate, the regulator would impose additional capital requirements (capital add-ons) to more accurately quantify the risk exposures.

Stress tests were binding. To pass the stress tests, insurers needed available capital exceed required capital. Failure to do so could result in costly regulatory interventions including providing plans to recapitalize, raising costly external financing, being subject to more frequent regulatory exams and actions, suspension of bonuses and dividends, and in extreme cases, suspension and revocation of licenses.

And finally, and unique to our setting, over the entire period from the announcement in 2002 to when the regulation went live in 2006, the stress test outcomes (both insurers' own assessments of risk exposures and the regulator's capital add-ons) and resulting capital positions, whether at the company or aggregate level, remained undisclosed to the public. This makes it unlikely that the market, credit rating agencies or households could identify exactly which insurers faced a capital shortfall and which not, and will be important for interpreting the response to the regulation as supply adjusting rather than demand adjusting.

3.2. UK Data

We collect confidential data on the outcomes of the stress tests (capital requirements and risk exposures) from the Bank of England's Insurance Supervisory Database. We observe insurers overall net risk exposures, accounting for the risks in both assets and liabilities, as well as reported separately for each risk factor, including equity, credit, interest rate, underwriting, and other risks. Second, we observe not only insurers' own assessments of risk exposures, but also the capital add-ons levied by the FSA in cases where the reported exposures were deemed too low. Thus, we can check if the reported exposures are systematically biased downwards due to under-reporting (Sen and Sharma 2020).

We also collect data on the regulatory filings that insurance companies reported to the UK Financial Services Authority, which were available to the public, from the Standard and Poor's Synthesys Database. They contain detailed information on insurers asset allocation (treasuries, corporate bonds, equities), insurance sales (premiums and number of contracts sold) and reserves, including their breakdown into main product lines (traditional and linked) and the extent to which they were reinsured, their claims, mortality and morbidity experience, capital resources, and importantly capital requirements that insurance companies continued to report under the risk insensitive regulation (so we can measure capital requirements under both regimes simultaneously). The data are annual spanning from 1985 to 2014. Importantly, the regulatory returns are audited, making the information highly reliable.

Companies also report any major change to their businesses, including transfers of liabilities and reorganizations. We define reorganizations as a change in legal owner of a firm, typically following change in the firm's parent. A transfer involves partial or complete sale of a firm's liabilities with no change in legal owners of the firm. Unlike reinsurance, where the firm ceding the exposure remains ultimately liable, in a transfer, there is a reallocation of the legal ownership of liabilities to the firm accepting the transfer. We hand collect these data from the financial notes section of insurers' regulatory filings. We also see the company's group structure and a record of whether a firm is a mutual from Financial Conduct Authority's register of mutual insurers. We further borrow historic data on mutual status from Alzmezweq (2015).

We supplement this with data on insurance companies credit ratings from S&P Global Market Intelligence. Where S&P ratings were not available, we use the credit rating from Moody's, A.M. Best or Fitch. Where ratings at the operating company were not available, we input the rating of the parent company. We convert the letter ratings into a rating score, which is a cardinal measure using both a linear scale (ratings from AAA to CCC- convert into a score from 10 to 1 in 0.5 increments) and a non-linear scale where rating scores equal Standard and Poor's historical default probabilities. Where firms were unrated, we construct rating scores from firm characteristics. We describe the methodology in Internet Appendix Figure D3. Results go through when restricting only to the sample of rated firms.

3.3. Risk Exposures

We use the data on stress tests to document four stylized facts about insurers' risk exposures.

First, as with the European evidence more than a decade later, the risk exposures coming out of insurers stress tests are economically large (Table II). Total risk exposures as a fraction of assets are about 8% for the average insurer. Underwriting risk (e.g., exposure to longevity, mortality etc.) accounts for the largest share of total risk exposures for the average insurer (33%). It is closely followed by market risk (e.g., exposure to the equity market) at 28%, interest rate risk

(13%) and credit risk (12%). Finally, other risks account for 14% of the total risk exposures. Comparing insurers initial risk assessments (column I) with those reported after the FSA reviews the submissions (column II) shows that insurers internal assessments of their risk exposures are fairly accurate.

Second, much of these risks are concentrated among insurers that sell traditional products, which include guaranteed savings, annuities, and life insurance (Figure 5, bottom panel). These products offer households protection against aggregate and idiosyncratic risks and help them offload these risks to insurance balance sheets. In contrast, insurers that sell linked products, products that simply channel households' premiums to a mutual fund of their choice, carry negligible risks.

Third, small insurers carry greater risk exposures than large insurers (Figure 5, top panel). This is mainly driven by small companies retaining lots of usually diversifiable underwriting (longevity, mortality, morbidity and policyholder behavior) risk. This will also be a feature in cross-country data, as we explain in Section 5. Lax regulatory regimes accommodate smaller companies which are potentially underdiversified.

Fourth, capital requirements increased substantially in the new framework relative to the old framework (Figure 6). However, the increase was uneven. We estimate that capital requirements increased on average by about 7 percentage points (pp) for insurers that primarily had traditional liabilities. In contrast, capital requirements remained largely unchanged (and small) for insurers that primarily had linked liabilities. Thus, a shift to a risk-based regime equates to a more stringent regulation of traditional insurance products.

Next, we show how the tightening in capital regulation for traditional products under the new framework caused a large share of UK insurance companies to become constrained.

3.4. Measuring Regulatory Constraints

A limitation of our setting is that while the stress tests were announced in 2002, insurance companies only submitted their confidential stress test outcomes between 2003-2006. Using the risk exposures submitted between 2003 and 2006 to assess the extent to which the new regulation was binding in 2002 may be problematic for several reasons. First, these submissions likely already incorporate the adjustments insurers make to comply with the new regulation. Second, the choice about when to submit the stress test results is itself endogenous. Third, restricting attention to only those who eventually submit could introduce survivorship bias. Indeed, many insurers undergo portfolio sales after 2002, as we show in Subsection 3.12. These factors may to underestimate insurers' responses to the regulatory shock.

In what follows, we develop a framework to identify constrained insurers ex-ante (i.e. back in 2002). We proceed in two steps. In the first step, we develop risk exposure replicating models. These models attempt to explain the observed stress test results as reported at different times between 2003 and 2006 by mapping the submitted risk exposures onto observable insurer characteristics. We develop separate replicating models for each risk factor: market, credit, interest rate, underwriting, and other risks, using precisely those characteristics prescribed by the regulatory guidelines that insurance companies used to conduct their stress tests (for a more detailed description of the models and their performance, see Internet Appendix Figures D1 and D2). In the second step, we map the estimated models onto observable insurer characteristics at the time the regulation was announced to predict the risk exposures in 2002. We then compute the total capital requirements by adding all the individual predicted risk exposures. We define an insurer to be constrained if the ratio of its available capital to predicted required capital in 2002 (the capital buffer) is below 1.[4]

We next show that the new regulation became binding for a large number of insurers. Figure 7 compares the distribution of capital buffers under the old regime (gray bars) vis-a-vis the new regulatory regime (black bars) for the sample of insurers with more than 50% of liabilities in traditional products in 2002. Out of 101 insurers in sample, a total of 49 insurers are constrained and 52 are unconstrained in the new regime. In contrast, almost all (98 out of 101) insurers met the old capital requirements. Thus, a large fraction of insurers, 46 out of the 98 previously unconstrained (or 47%), become constrained under the new regime.

3.5. *Properties of Constrained and Unconstrained Insurers*

We then investigate why did regulatory constraints bind for some insurers but not for others.

Table III presents key firm characteristics for the constrained and unconstrained firms at the time the stress tests were announced in 2002. By construction, the two groups are different in their solvency positions (panel A). The average unconstrained firm has an available to required capital ratio of 1.8, whereas the average constrained firm has an available to required capital ratio of 0.7. This difference is largely driven by differences in the available capital, which is 16.5% of assets for unconstrained and 8.6% for constrained firms on average, and less so from required capital.

[4]It is worth noting that this approach to recover ex-ante regulatory constraints makes two main assumptions. First, as we assume insurers are responding to the predicted 2002 capital shortfalls, we must assume that insurers were able to quantify this capital shortfall themselves. Second, we assume that the relationship between risk exposures and insurer characteristics recovered using 2003 to 2006 data well captures the relationship between exposures and characteristics back in 2002. Internet Appendix Figures D1 and D2 provide support for these two assumptions.

Constrained companies also have a higher required capital ratios (12.4% vs 9.6%) but this was mostly originating from higher exposures to underwriting (mortality and longevity) risk. As we show in Internet Appendix Table EIX, moving to risk-based capital requirements would if anything have reduced requirements for underwriting risk, so this cannot explain why these companies got constrained.

Second, we compare constrained and unconstrained companies along characteristics other than capital to asset ratio to show that these companies were also similar in terms of asset risk (proportion of assets held in equities, non-government bonds, and mortgages), liability risk (claims resulting from death, disability, annuity, and surrenders as a proportion of net liabilities), product composition (linked vs traditional liabilities), reinsurance (proportion of liabilities ceded to reinsurers), group structure (whether a firm is part of a group), organizational structure (whether a firm is organized as a mutual or a stock corporation), ratings and profitability (return on assets). If anything, it is larger companies, companies that are part of a group, generally companies that are better able to deal with financial constraints, that ended up being constrained by the regulation — though even there, the differences are not statistically significant. Nevertheless, we control for firm size defined as logarithm of total assets in all our subsequent regressions.[5]

We then ask why constrained insurance companies had lower available capital to begin with? A firm's choice of capital ratio is typically endogenous. One concern could be that firms that choose a low capital ratio are inherently different, which results in the different choices these firms subsequently make in the product market.

First, we show that constrained firms have consistently had lower capital ratio compared to unconstrained firms long before the regulation was adopted in 2002. Figure 8 plots the difference in capital ratios between the two groups from 1997 to 2007. The difference is consistently 7.5 percentage points and statistically significantly different from zero before 2002.

Second, we dig into the origins of the extra capital resources sitting on unconstrained insurers balance sheets. We find these differences originate in reserves set up decades or even centuries ago in inherited estates. Historically, most insurance companies in the UK were set up as mutual companies. There, an association of policyholders would endow the company with an initial capital and would then share in the gains and losses. Yet prudent accounting meant that capital was more likely to accumulate than deplete. As the founding policyholders died, the resulting estate

[5] Koijen and Yogo 2015 show how large insurers face relatively more inelastic demands, which means that for the same cost-shock, households are less likely to switch out of constrained relative to unconstrained insurers. This makes our results all the more surprising.

was to be shared among subsequent generations of policyholders (or in the case where companies demutualized, shareholders). However, the company by-laws often did not specify how exactly were these estates to be shared among different claimholders or even generations of claimholders. By the time the regulation was announced, inherited estates made up an estimated £20 billion, money that, due to its uncertain legal status, could not normally be appropriated as distributions to shareholders or lower prices of higher benefits to policyholders, but which the regulator counted as eligible capital under both the old and the new regulation.[6]

3.6. Identification Strategy

We exploit variation in regulatory tightness across constrained and unconstrained companies, in capital-intensive and capital-light insurance policies, before and after the regulation to try to tease out the causal effect of risk regulation on insurance product market outcomes.

What we find is that constrained insurers respond to a tightening in capital regulation by raising capital, lowering sales of capital-intensive products and raising prices. Some stop selling traditional life insurance altogether, shed capital intensive liabilities or get taken over. Smaller insurance companies are disproportionately affected. As a result, there is a rising concentration in the market for traditional life insurance, higher average prices and lower aggregate quantities (In Appendix B, we show how these predictions emerge from standard model of insurance markets with financial frictions and market power where insurers set prices over multiple products with heterogeneous capital requirements).

3.7. Capital

First, constrained insurance companies respond to the regulatory shock by raising capital. In the previous subsection, we have argued that constrained insurance companies have had persistently lower available capital ratios before the announcement of the regulation. Figure 8 shows how the gap gradually narrows and eventually disappears in the 5 years after announcement. Looking at the evolution of capital to asset ratios separately for constrained and unconstrained insurers shows that the effect is driven by constrained insurers raising new capital as opposed to unconstrained insurers shedding excess capital.

[6]It is also unclear to what extent a rational policyholder would have deemed the company safer (and its promises more valuable) if it had a large inherited estate. Historically, insurers were underreporting liabilities relative to their true economic value. This means that a policyholder could not challenge a shareholder in appropriating the estate on grounds of solvency even if the company did not have enough resources to cover the economic liability.

To test this response more formally, we estimate a difference-in-differences regression:

$$K_{it} = \alpha_i + \alpha_t + \beta(C_i \times P_t) + \gamma X_{it-1} + \epsilon +_{it} \tag{1}$$

where K_{it} is the capital to assets ratio for firm i at time t, C_i is an indicator variable that takes a value of 1 if a firm is constrained, P_t is the post regulation dummy variable and takes a value of 1 after 2002 and α_i and α_t are firm and time fixed effects absorbing firm and time invariant variation in firms capital to asset ratios and X_{it} are time-varying insurance characteristics (explained below).

On average, constrained companies increase their capital ratio by 4.8 percentage points relative to the unconstrained companies during the five years following the announcement of the regulation (Table IV Column I), supporting the hypothesis that the new capital requirements became a binding constraint for constrained firms, which had to raise capital to comply with it. We also control for other time-varying insurance characteristics that might differentially drive capital ratios even absent a firm's active response to regulation (Column II). We include asset composition (different asset classes may have different returns driving capital gains), claims experience (lower than expected claims are recorded as underwriting profits increasing capital), lapsation experience (lapsation tends to be profitable increasing capital). The coefficient at 4.8 percentage points remains unchanged.

We then dive into the drivers of insurers capital ratio dynamics. An insurer can improve its capital ratio by raising external capital, acquiring or being acquired by a better capitalized insurer, shedding capital-intensive liabilities, transferring risk exposures through reinsurance, or titling its underwriting away from capital-intensive products. Our results hold when controlling for transfers of existing liabilities, changes in legal ownership and reorganizations, reinsurance or demutualizations (Column III). We also confirm our results for the subset of mutual insurers, which generally cannot raise external equity. This collectively suggests that insurance underwriting must have been an important tool in insurers' response to the regulation.

3.8. Underwriting: Summaries

We next characterize the evolution of insurance sales around the regulatory shock. The shift in capital regulation implies an increase in regulatory costs for all insurers that have traditional liabilities. This would result in an increase in the marginal cost of supplying both traditional and linked products. However, this increase would be more pronounced for constrained insurers for whom the regulatory costs are higher and for traditional products for which capital requirements increased more. Thus, if regulatory constraints matter, we would expect a decrease in underwriting for constrained relative to unconstrained insurers, with stronger effects for traditional products.

We start by presenting aggregate evidence on the insurance product market. To avoid double counting, we only consider policies sold directly to households, excluding premium income arising from reinsurance written to other firms. We exclusively focus on new underwriting, which excludes regular premium received from policies underwritten in the past. First, there is a large aggregate decline in traditional underwriting following the regulatory change. Figure 9 shows that between 2002 and 2014, total traditional underwriting declined from £30 to £15 billion for the sector as a whole. The decline in relative terms is even starker: the ratio of linked to traditional underwriting rose from 1.5 to 1 in 2002 to 6.1 to 1 in 2014. Over time, this resulted in a marked shift in insurers' liability mix, with the share of traditional products falling by 33% during this period.

We then show that these patterns are driven by insurers that were insufficiently capitalized under the new regime (constrained insurers). The bottom panel of Figure 9 reports insurance underwriting separately for traditional and linked policies, but now broken down into constrained and unconstrained insurers. First, there is a strong comovement in insurance underwriting between constrained and unconstrained insurers prior to the announcement of the regulation in 2002. This is true for both traditional and linked product lines and confirms our parallel trends assumption. Second, there is a sharp contraction in insurance underwriting after the regulatory announcement, but only for capital-intensive traditional policies from constrained insurers. Specifically, sales of traditional products drop from £300 million in 2002 to £115 million by 2007 for the average constrained insurer, yet increase from £175 million in 2002 to £230 million by 2007 for the average unconstrained insurer. There is no differential trend in linked sales, at least in the first few years following the regulation. This is consistent with regulatory frictions binding for constrained insurers in capital intensive products.

3.9. Underwriting: Intensive Margin

We next examine the impact of the regulatory shifts on traditional insurance underwriting more formally using a difference in differences specification. We start with the intensive margin (the amount of insurance underwriting conditional on underwriting at all) by estimating:

$$lnU_{it} = \alpha_i + \alpha_t + \beta(C_i \times P_t) + \gamma X_{it-1} + \epsilon +_{it} \tag{2}$$

where U_{it} is the total amount of traditional underwriting for insurer i at time t, C_i is an indicator variable that takes a value of 1 if a firm is constrained, P_t is the post regulation dummy variable and takes a value of 1 after 2002, and α_t are time fixed effects absorbing any aggregate variation in insurance underwriting.

Even though stress test submissions were confidential, households may have inferred regulatory capital positions from observable insurer characteristics. Following the insurance literature (Koijen and Yogo 2015), we control for a wide range of insurer characteristics that may simultaneously affect insurers solvency positions and demand, including company size, ratings, leverage (capital to asset ratio), profitability (return on assets), liquidity (liquid assets to total assets), share of risky assets in total assets (as a measure of asset risk), death, disability, annuity and surrender claims as percentage of total liabilities and the share of reserves reinsured (as a measure of liability risk), ownership (stock vs mutual) and group structure.[7] We stack these time-varying characteristics in the vector X_{it} and absorb any residual time-invariant company characteristics through firm fixed effects α_i.

We find that traditional underwriting declines by 40% for constrained relative to unconstrained insurers after the regulation ($\beta = -0.51$ in Table V Column I). Given that capital requirements increased by about 7% for traditional products under the new regime (Figure 6), our estimates imply a 5.7% decline in traditional underwriting for every 1% rise in capital requirements. The decline in traditional underwriting is larger when measured in terms of number of policies (58.2%, coefficient -0.872 Column II), suggesting it is primarily smaller policies, which are typically associated with poorer households, that get driven out of the market. This suggests risk regulation may have distributional implications, a point we expand upon using European data, where we actually observe individual insurance ownership (see Section 5.4).

We repeat equation (2) for linked underwriting. The effect is far more muted (-9%, Column VI), suggesting that a shock increasing internal capital scarcity affects primarily those policies that use that capital most intensively. And as the sales of linked policies do not fall as much, the share of traditional products in total underwriting also falls by 9.5% more for constrained insurers relative to unconstrained insurers after the regulation (Column V).

We then zoom into the subset of companies that sell both traditional and linked policies. The relative drop in traditional underwriting is even higher (from -40% to -64%), but that is now partly compensated by a relative increase in linked underwriting (from -9% to +5%).[8] This suggests that

[7]We control for leverage and profitability also to make sure the estimated coefficients capture regulation requiring additional capital, as opposed to any potentially confounding story where losses on investment portfolios or insurance underwriting push down on available capital bringing firms closer to the constraint.

[8]In fact, we can subtract the difference in differences coefficient in the linked regression from that in the traditional regression for the common sample where companies sell both types of policies to recover a more tightly identified triple difference estimator. We find that $\beta_{DDD} = \beta^T_{DID} - \beta^L_{DID} = -1.024 - 0.053 = -1.077$. In other words, traditional

part of the equilibrium response to tightening regulation is sales reallocating from capital-intensive products towards capital-light products within constrained companies (we revisit this result in Section 4.3).

3.10. Underwriting: Extensive Margin

We then turn to the extensive margin and ask whether constrained insurance companies are more likely to exit traditional life insurance underwriting following the regulatory shock. Table VI reports the share of constrained and unconstrained companies active in the traditional insurance market before and after the regulation to see that from the outset, it is primarily constrained companies that exit traditional underwriting following the regulation. To test the effect more formally, we restrict to our previous set of matched constrained and unconstrained companies specializing in traditional underwriting (101 companies) and estimate a logit difference in differences regression:

$$\mathbb{1}(Sales > 0)_{it} = \Phi(\alpha_i + \alpha_t + \beta(C_i \times P_t) + \delta X_{it-1} + \epsilon_{it}) \tag{3}$$

where $\mathbb{1}(Sales > 0)$ is a dummy variable that takes the value of 1 if insurer i sold traditional products at time t and Φ is the logistic function which transforms the linear prediction into a probability between 0 and 1. All other variables are as defined before. Firm fixed effects absorb variation from insurers whose dependent variable is always 0 or 1 and hence allow us to focus on cases where insurers switch from selling to not selling and vice versa. Table VI reports the results. Constrained firms are also significantly more likely to exit the traditional life insurance market (coefficient -3.113) relative to unconstrained firms after the announcement of the regulation. By comparison, they do not seem to be systematically more likely to enter or exit the linked insurance markets (coefficient -1.260 and not statistically significant).

3.11. Underwriting: Cross-Sectional Variation

Next, we examine how the adjustment in underwriting varies in cross-section of insurers. Specifically, we split the sample into two groups: large and small insurers. We then run a triple difference specification:

$$Y_{it} = \alpha_i + \alpha_t + \beta_1(Small_i \times P_t) + \beta(C_i \times P_t) + \beta(Small_i \times C_i \times P_t) + \delta X_{it-1} + \epsilon_{it} \tag{4}$$

underwriting declines by 67% relative to linked underwriting, for constrained relative to unconstrained insurers after the regulation.

where Small is a dummy set to 1 whenever the insurer had less than £500 million in assets in 2002 (roughly the median firm size), and the dependent variable Y_{it} is either ln(Sales) (in which case we look at the intensive margin) or $\Phi^{-1}\mathbb{1}(Sales > 0)$ (in which case we look at the extensive margin and the specification becomes a logit). All other variables are defined as before. Here, the first interaction absorbs aggregate differences in underwriting trends between large and small insurers, the second interaction captures the effect of regulatory frictions for large insurers, and the triple interaction the additional effect of regulatory frictions for small insurers. We find that large insurers reduce, but do not completely stop traditional underwriting. In contrast, small insurers completely pull out of the traditional market (Table DI).

3.12. Transfers and Reorganizations

We then turn to other margins that insurers may use to adjust to shifts in capital regulation. We consider liability transfers and reorganizations. Transfers involve a partial sale of liabilities to a third party while the ownership of the selling company remains intact. Reorganizations involve a change in the legal ownership of the company as a result of a merger or acquisition by a third party.

Transfers and reorganizations are another way to meet the new regulatory requirements. By selling capital intensive liabilities or slowing down the purchase of existing capital-intensive liabilities, firms can release capital that would otherwise have been locked in risk-based capital requirements and improve their solvency position. Selling the company as a whole to a potentially better-capitalized acquirer is also an opportunity to receive capital from the acquiring firm. Transfers and reorganizations, therefore, help alleviate regulatory constraints by either reducing capital requirements or by increasing available capital (and are one way in which the industry can better allocate risk exposures to available capital).

Table VII reports the percentage of UK insurance companies engaged in significant sales of insurance portfolios (transfer-out), purchase of insurance portfolios (transfer-in) and changes in ownership in the 5 years before and after the announcement of the regulation, separately for constrained and unconstrained insurance companies (top panel). Constrained firms are substantially less likely acquire new insurance portfolios (2% vs 20%), substantially more likely to sell a major portion of their insurance business (29% vs 4%), and considerably more likely to experience a change in ownership (39% vs 16%) in the 5 years after the announcement of the regulation, compared to the 5 years prior. By comparison, unconstrained insurance companies do not experience a significant change, or are increasingly buying insurance portfolios (8% vs 12%), suggesting again companies allocate risk exposures to available capital.

We analyze these trends more formally using a difference-in-differences logit regression:

$$T_{it} = \Phi(\alpha_i + \alpha_t + \beta(C_i \times P_t) + \delta X_{it-1} + \epsilon_{it}) \tag{5}$$

where the outcome variable is either a portfolio sale (transfer-out), a portfolio purchase (transfer-in) or mergers and acquisitions (reorganizations), C_i is an indicator variable that takes a value of 1 if a firm is constrained, P_t is the post regulation dummy variable and takes a value of 1 after 2002, α_t denotes time fixed effects absorbing any aggregate variation in the prevalence of transfers and reorganizations over time, X_{it} are time-varying insurer characteristics (size, leverage, ratings, liquidity, asset and liability composition, operations, ownership and profitability), that may influence a company's decision to engage in corporate sales and reorganizations or become a takeover target even absent regulatory constraints, and Φ is the logistic function which transforms the linear prediction into a probability between 0 and 1.

We find that constrained insurers are 5 times more likely to engage in portfolio sales, 97% less likely to buy new exposures, and 3.5 times more likely to be acquired after 2002 vis-a-vis before 2002, compared to unconstrained insurers during the same period (bottom panel). The results are robust to controlling for ex-ante differences in characteristics between the treatment and control group. Columns 4-5 then repeat the mergers and acquisitions regressions, but now splitting the sample into insurers below and above the median sample size at the time the regulation was announced in 2002, to find it is the small and constrained insurers that are most likely to be acquired after the regulation.

3.13. Concentration

Collectively, the industry response to tighter capital regulation manifests itself in higher market concentration for traditional insurance. Figure 10 shows the evolution of the total share of the 10 largest insurers by traditional underwriting. The 10 largest sellers of traditional insurance maintained a stable market share of about 60% between 1985 to 2002 (in the 17 years before the regulation). After 2002 however, their market share starts to rise. By 2007, the 10 largest traditional underwriters were cumulating 70% of the market, and by 2015, their share was 81%.[9]

[9] While this could at least partially reflect a more secular trend in rising market concentration in the financial services industry, in Table EVII, we note that by 2016, market concentration was still substantially lower in countries that had not gone through tightening capital regulation, providing external validity to our findings.

4. Robustness

4.1. Demand or Supply

Even if stress test outcomes remained confidential, consumers, rating agencies or the market might have already inferred, based on the publicly available information, that companies which ended up being constrained were already not in great financial shape/the companies that would end up being constrained. Therefore, the lower sales recorded by constrained insurers may have been the consequence of lower consumer demand coming from default concerns (a demand shock) rather than the cost of regulatory constraints (a supply shock). We alleviate these demand concerns in several ways.

First, we split our control group into companies with solvency ratios below 1.5 and companies with solvency ratios above 1.5 at the time of the regulatory announcement, to show that there is as large a drop in traditional underwriting even within companies located in the neighborhood of the regulatory constraint boundary (Table DII, Column I). For that to result from consumers predicting which companies got constrained and which not, they must have been quite precise at it.

Next, we split our sample along two dimensions: an observed measure of creditworthiness (company ratings) and a potentially correlated but unobserved measure of creditworthiness (company solvency under the new regime) but which dictates whether the company might have to raise capital (constrained) or not (unconstrained). Specifically, we compare companies which are constrained from the perspective of the regulation but have a better than median ratings (BBB+ or above) from the perspective of consumers against companies which are unconstrained but have lower than median ratings (below BBB+) to find that it is the highly rated, but constrained insurers that have a larger decline in sales after the regulation (Table DII Column 3).

We obtain similar results if we use another measure of perceived creditworthiness – company size. In column II of the same table, we compare large but constrained companies against small but unconstrained companies to find that sales falls more for large but constrained companies even relative to small but unconstrained companies after the regulation (Table DII Column 4).

4.2. Prices

Finally, we supplement our sales data with data on product-level insurance prices from a subset of large insurance companies. The data are hand-collected from past issues of Moneyfacts Investment Life and Pensions available in the British Library Archives. The timeframe is from 1997 to 2007 and all quotes are collected as of December to match the sales data.

UK life insurance products are split between annuities and pensions. Pension contracts can be traditional, where premiums are invested and payouts are guaranteed by the insurance company and so the insurer assumes the investment risk, or linked, where premiums are invested in mutual funds and the policyholder assumes the investment risk. Only traditional contracts annuitize. We consider single premium pension contracts with expected accumulation periods of 20, 25 and 30 years and immediate fixed, escalating and period-certain annuities for females aged 65Y.

We then examine the evolution of insurance prices during this period. However, each product follows a different pricing convention which makes price comparisons across products difficult. For instance, pensions savings contracts typically feature explicit upfront and annual fees. By contrast, annuities only quote an amount of annual income payable per dollar of initial investment. The price is then a measure of how far is that stream of income from a stream of income that is actuarially fair. In Internet Appendix C, we develop a methodology to construct a price equivalent measure that is comparable across products.

Table VIII shows prices for both annuities (decumulation contracts) and pensions (accumulation contracts in the context of the British insurance market) in the 5 years before and after the announcement of the regulation, for the market as a whole and separately for constrained and unconstrained insurance companies. Under a demand-side explanation, we would expect prices of traditional products to decline relative linked products and fall more for constrained (hence risky) relative to unconstrained companies. However, we observe the exact opposite. Pension and annuity prices increase after the regulation, and the increase tends to be concentrated in companies that are most constrained and contracts that are most capital intensive, consistent with our regulatory story (we compute the resulting semi-price elasticity of demand in Internet Appendix C4).[10]

We then dive into pension contracts, where prices are being broken down into upfront and ongoing fees, to better understand the nature of the price increase. First, there is a secular decline in upfront fees. This is true for both constrained and unconstrained companies, traditional and linked policies, and possibly reflects a broader trend in internet adoption reducing search frictions

[10] Note annuities (decumulation contracts) have substantially higher effective annual fees than pensions (decumulation contracts). This is likely due to adverse selection on mortality that is stronger in the former than the latter (Finkelstein and Poterba, 2004). Second, annuity prices are also more sensitive to cost shocks. With adverse selection, a cost shock also changes the composition of the risk pool. Higher premiums drive out healthier low-risk consumers. High risk consumers stay, and average cost per policy rises endogenously, which amplifies the initial cost increase. We note, however, that our price estimates are rather noisy, perhaps due to subtle differences in contract features or distribution that we cannot control for as they are not reported in Moneyfacts. To absorb firm-specific variation in contract features, we reestimate the price trends with firm fixed-effects and find similar results.

for consumer financial products. Upfront fees are more salient than recurring annual fees and so companies may compete more fiercely over them under an environment characterized by reduced search (Brown and Goolsbee 2002; Ellison and Fisher Ellison 2009). Instead, there is a more than compensating increase in recurring annual fees which now primarily concentrates among constrained insurers and capital-intensive traditional products. Annual fees for traditional pension products rise by 70 bps for constrained insurers compared to only 28 bps for unconstrained insurers and compared to only about 9 bps for linked products, consistent again with our supply-side explanation.

4.3. Spillovers

All our causal estimates on the effect of regulation are general equilibrium estimates inclusive of reallocation. A more precise definition of a causal effect is one that requires a stable unit treatment assumption, that is the initial direct effect on the treated absent reallocation (Berg, Reisinger, and Streitz 2021). Under a standard model of price competition, a cost shock to constrained insurers would cause those insurers to raise prices, which would not only lower sales at constrained firms but also plausibly raise sales at unconstrained firms as consumers adjust to new prices. And so by comparing sales at treated and control firms, what we are capturing is the joint effect of the direct effect of regulation on the treated and spillovers to the control. While such reallocation and resulting consequences on e.g. market concentration are themselves of interest, we try to provide some guidance on the relative importance of the direct effects and spillovers in our setting.

We first look at the nature of reallocation. Following a cost shock to a constrained company, customers of traditional policies who would have otherwise bought from that company can now reallocate to linked policies at the same company (within company reallocation) or policies (traditional or linked) at other (potentially unconstrained) companies (across company reallocation). The distinction is important as within-company reallocation does not contaminate our control group (unconstrained companies). As explained in Section 3.9, the decline in traditional underwriting grows from -40% to -63% and the growth in linked underwriting rises from -9% to +5% when consumers have the option to reallocate within company, suggesting an important component in reallocation is within and not across companies.

Second, we investigate the nature of reallocation across companies. The insurance literature (Koijen and Yogo 2015) has shown that credit ratings are important determinants of demand. This means that households who would otherwise match with insurers with a high credit rating are unlikely to switch to insurers that are less well rated, even when the former raise their prices. As such, the extent to which companies can benefit from reallocation likely increases in credit ratings. This is even more plausible when questions of insurers creditworthiness loom large, as seems the case here.

As a result, in Section 4.1 we compare highly-rated constrained companies with low-rated unconstrained companies to show that even when we compare treated companies that are most likely to benefit from spillovers with control companies that are least likely to benefit from spillovers, we still identify a sizable effect.

4.4. Dot-Com Crash

As the new regulatory regime followed on the heels of the dot-com crash, one concern could be that our measure of regulatory constraints coincides with firms that were most affected by the dot-com crash. Specifically, the dot-com crash generated losses (both in terms of dividends and capital gains) on the equity portfolios of insurance companies exposed to technology stocks, which reduced available capital tightening financial constraints. As a result, financial constraints due to economic losses from the dot-com crisis (lower available capital), and not the regulatory announcement per se (higher required capital), could be driving the subsequent product market behavior that we document. We construct two alternate ways to measuring the extent of losses suffered on the asset side of insurers balance sheet as a result of the Dot-Com crisis: (i) change in the market value of equity portfolio between 1999 and 2002 (equity portfolio growth); (ii) investment income between 1999 and 2002 as a proportion of total assets in 1999 (investment income ratio). The investment income is intended to capture variation in dividend income. We then sort firms into two groups affected and unaffected - depending on whether they have below median (affected) or above median (unaffected) dividend income or equity portfolio growth. We then rerun our difference in differences regressions on the intensive margin (traditional and linked underwriting), extensive margin (traditional and linked market exit) and reorganizations (sales and purchases of existing policy portfolios and mergers and acquisitions) with both our measure of regulatory induced financial constraints and dot-com induced financial constraints (Table DIII).

While our two measures of financial constraints have similar predictions (companies more exposed to the dot-com crisis experience lower traditional underwriting, are more likely to exit the traditional market, sell portfolio of existing policies or are more likely to be part of a merger or acquisition), the effect of dot-com related constraints are lower in magnitudes, not statistically significant and more importantly does not drive out variation in financial constraints coming from the regulation. In fact, the results remain almost unchanged. This suggests there is variation in financial constraints coming from the 2002 regulation that is independent of companies exposures to the dot-com bust that is driving the results.

4.5. Equitable Life

The adoption of stricter capital requirements in the UK in 2002 has been associated with the failure of Equitable Life two years prior (UK Parliament Treasury Committee 2017). There, a court has rejected Equitable's attempt to renegotiate lower payouts on traditional annuity products with minimum return guarantees — potentially setting a precedent for the industry. This raises the possibility that the product market effects documented in this paper may not be a result of capital regulation but may have occurred from companies tightening risk management in response to Equitable Life, even absent the regulation. To address this concern, we use the Bank of England risk model to identify undercapitalized insurers as of 1999, the year prior to Equitable's failure, and run a series of placebo tests. Specifically, we redefine C_t is an indicator variable that takes a value of 1 if a firm is constrained (undercapitalized) as of 1999 and rerun equations (2)-(5) on the effect of undercapitzalition on insurance underwriting, exit and portfolio sales and takeovers, separately for traditional and linked policies, but now with the regression centered around 1999 (post defined as after 1999). The results (Table DIV) are muted and more importantly there is no differential impact for traditional vs linked policies, suggesting our results cannot be explained by fallout from Equitable Life.

5. External Validity: Cross-Country Evidence

We next turn to the European evidence. As mentioned earlier, Europe is slowly transitioning to the same risk-based capital regulation that the UK adopted in 2002. While the transition is gradual and does not give us sharp time-series discontinuities, the fact that different countries are at different points along this transition generates interesting cross-sectional variation. We use this variation in two ways. To validate our UK findings and to make the somewhat broader point that differences in risk regulation seem to be a first-order factor in explaining the extent to which insurers specialize in insurance provision or asset management across countries.

5.1. Data on Insurance Ownership and Demographics

We obtain data on individual life insurance ownership and demographics across Europe from the SHARE Dataset. The Survey of Health, Ageing and Retirement in Europe (SHARE) is a pan-European, nationally representative survey of individuals aged 50 or older which, importantly, is harmonized across European countries. It contains detailed information on individuals age, gender and domicile, language, migration histories and origins, education and family situation, employment status and industry, income, assets, liabilities and wealth, objective and subjective measures of health and longevity, self-reported preferences (risk aversion, political leaning) and beliefs, ownership of retirement savings products (individual retirement accounts, occupational pensions and estimates of social security wealth) and, importantly, insurance choice. Specifically, we see whether the respondent owns a life insurance contract, the risks being insured (term life insurance or annuities mostly insure against idiosyncratic mortality and longevity, whole life insurance protects against market risk) and the associated face value.

We combine this with data on individual marginal tax rates and social benefits from EUROMOD. EUROMOD is the official tax-benefit microsimulation model of the European Union. It takes an individual personal and family circumstances, employment and disability histories, sources of income, wealth and tax deductible expenditures (voluntary pension and insurance contributions, mortgage payments), and applies national tax and benefit rules to compute individual and households average and marginal income, capital and wealth tax rates, social contributions, eligibility for social assistance programs and ultimately disposable income in the same way as the local tax authority would do.

5.2. Predictors of Insurance Ownership

We start by characterizing household ownership for the most common type of traditional insurance contracts: life insurance with minimum return guarantees. The first two columns of Table EI show the characteristics of guaranteed life insurance owners and non-owners across Europe. Guaranteed insurance owners tend to be younger, richer (both objectively and think of themselves as being richer – this is similar to Gropper and Kuhnen 2025) in the US), and more educated than their non-owner counterparts. They are more likely to be homeowners, have a mortgage (in many countries, life insurance is either a requirement or an advantage when taking up a mortgage) and participate in the stock markets. They tend to be less risk averse, trust other people more, generally be more optimistic, have had fewer health problems during childhood, be and consider themselves healthier, and be more satisfied with their current health insurance coverage. They are less concerned that the government will reduce social security benefits (by either lowering pensions or raising retirement age), but also less reliant on Social Security as a source of replacement income in retirement. They tend to be more prepared for retirement (Table EII). They are more likely to invest in mutual funds and have an individual retirement account, and more likely to receive (if retirees) or contribute to (if employees) occupational pensions. Thanks to their higher income, they face higher marginal income tax rates and higher marginal capital gains tax rates, so they are more likely to benefit from retirement products whose contributions or accumulation are tax-exempt, and since they are expected to be richer, any additional income from private retirement sources is less likely to displace means-tested social benefits. These differences are true on average and also within countries (when controlling for country fixed effects).

The next two columns of Table EI compare the characteristics of residents in lax regulation countries (where guaranteed life insurance ownership is high) and strict regulation countries (where guaranteed life insurance ownership is low), to show that the correlation between consumer characteristics, personal taxation, retirement wealth and guaranteed life insurance ownership systematically switches sign when moving from a within country to a cross country setting. This suggests that standard demand-side drivers of insurance ownership cannot simultaneously explain the within- and across-country variation in insurance ownership. In other words, there must be a large omitted component that varies at the country level, component we have shown to correlate with risk regulation.

5.3. Cross-Country Differences in Insurance Ownership

We then absorb these demand-side characteristics through a rich set of fixed effects to show that very similar individuals end up with very different guaranteed life insurance participation rates, depending on whether they reside in a lax (rule-based) or strict (risk-based) jurisdiction. This leads to large differences in household risk exposures and market incompleteness across countries as we show households do not seem to get comparable protection in other ways. Specifically, we run the following cross-sectional regression on individual-level data:

$$\text{Ownership}_{ic} = \alpha + \beta Lax_c + \delta X_{ic} + \epsilon_{ic} \tag{6}$$

where the dependent variable is set to 1 whether an individual i in country c owns guaranteed life insurance, Lax is a dummy equal to 1 if the individual resides in rule-based regulation country and X

summarize other demand-side drivers of insurance choice. We consider four broad types of demand-side factors, including respondents' demographic profiles, their self-reported preferences and beliefs, their financial assets and finally retirement and health situations. Demographic characteristics include the respondent's age, gender, place of domicile (urban vs. rural), years in education, marital status, work status (whether in employment or retiree) and employment industry (as a measure of background risk), legal status (citizen or immigrant), and income. Preferences and beliefs include the respondents' self-stated tolerance for risk, general levels of pessimism, reported ability to make ends meet, self-reported health status, and political leanings. Financial portfolios include whether the respondent participates in the stock market, bond market, and mutual funds. We also observe whether the respondent is a homeowner, and whether they have a mortgage. Retirement and health portfolios include whether the respondent has an individual retirement account, participates in an occupational pension plan, and supplementary health insurance. Combining pension and insurance products (and social security discussed below) can substitute for guaranteed life insurance (Koijen, Van Nieuwerburgh, and Yogo 2016).

Finally, for a subset of individuals, we have data on taxation, social security and other government benefits. Specifically, we consider the tax treatment of contributions (whether life insurance contributions are deductible for income tax purposes, which is dependent on the country, income and family situation of the individual), the tax rate on relatively large long term capital gains (most life insurance contracts allow for tax-free accumulation) and the individual marginal income tax rate, (even where insurance premiums are not tax deductible, it affects the relative advantage of other retirement savings products and the salience of other product characteristics such as guarantees (Brown and Poterba 2006)). Among social insurance, we consider an individual's social security wealth (which we normalize by income) and the extent to which extra income in retirement displaces means-tested social benefits (the more progressive those benefits, the lower the incentive to accumulate additional income in retirement through guaranteed insurance).

We consider two specifications. In the first one, each characteristic enters additively (Columns I-III). However, since most of these characteristics enter as dummies (e.g. the individual has an IRA or not) or categorical variables where we estimate a separate coefficient on each category (e.g. marital status, work status, employment industry), one can think of our specification as a cross-sectional regression with a very rich set of fixed effects. This also alleviates concerns of model mispecification coming from the fact that characteristics may not affect insurance choice linearly. In the second, we combine all characteristics in a single composite fixed effect (Column IV). This absorbs any interactions between characteristics and so identification comes from variation within very similar individuals across countries.[11]

We find that even within highly similar individuals matched along a range of different characteristics, residing in a lax regulation country is associated with up to 18pp higher guaranteed insurance ownership (depending on the specification – Table EIII). The magnitude increases the tighter the specification (as demand-side variation tends to go the other way), and is sizable, given the average guaranteed insurance ownership in sample is 16pp. Second, results survive controlling for alternative pension and insurance arrangements (Column VI), making it unlikely that households in strict regulation countries procure their insurance coverage some other way, which means they end up bearing the extra risk.

5.4. Inequality in Insurance Market Participation

We then examine how the observed differences in guaranteed life insurance ownership vary across the income distribution. Internet Appendix Figure E1 plots ownership rates by income decile separately for countries under lax (rule-based) and strict (risk-based) regulatory regimes to find that while more affluent households enjoy the same level of insurance ownership in both regimes, it is primarily poorer households in risk-based regulation countries that explain the lower insurance market participation. This survives controlling for differences in demographics, self-reported preferences and beliefs, taxation, assets and wealth, alternative insurance arrangements such as private health, pensions, and social security (Internet Appendix Table EVI) and is consistent with the UK evidence: under a risk-based regulation, it tends to be the poorer households that end up dropping out of the insurance market.

[11] In Internet Appendix E1, we exploit data on individual residential location histories to show that the gap in insurance ownership concentrates precisely around the regulatory jurisdiction boundaries. Another possibility is that is not regulation but rather slow moving differences in unobservable characteristics that correlate with regulation (such as local culture) that drive the differences in insurance ownership across countries. In Internet Appendix E2 we exploit data on individual migration histories to show that insurance ownership reflects the country of destination and not the country of origin, and moreover, even for the same culture of origin, different immigrants get different insurance ownership depending on capital regulation in destination countries. A remaining concern may be that immigrants self-select into different destinations based on factors correlating with local regulation, so in Internet Appendix E3, we exploit data on war refugees that were randomly resettled to different European countries by the United Nations to show that traditional insurance ownership concentrates among those refugees allocated to lax regulation countries. However, as our paper ultimately does not seek to find a causal effect for regulation driving differences in insurance portfolios across countries, we have decided to not pursue these lines of inquiry further and relegate this evidence to the Appendix.

5.5. Supply-Side Variation

Yet maybe companies in lax regulation countries are in a better financial position to hold aggregate market and longevity risk. This does not seem to be the case (Table EVII). Companies in lax regulation countries are smaller, they are less likely to be a part of a group, less likely to use an internal model (all measures of lower financial sophistication), they are more likely to be mutuals and less likely to use reinsurance (all signs of a lower ability to share risks), and even though they are slightly less levered in absolute terms, they end up being slightly less capitalized in relative terms when accounting for the amount of risk sitting on their balance sheets (as measured by their solvency capital requirement ratios which capture the extent to which their available capital is able to withstand an adverse scenario), suggesting a lower overall risk-bearing capacity. This is true regardless of whether they use an internal model or the standard formula, when equal and size weighted, when controlling for other company characteristics or removing outliers, and is consistent with the UK evidence: under a lax (rule-based) regulatory system, more, smaller, less capitalized companies survive.

5.6. Within-Group Variation

Second, we identify 27 insurance groups which operate subsidiaries across different regulatory regimes, to find that even within the same insurance group, different subsidiaries sell vastly different products depending on how they were historically regulated (Table EVIII). Specifically, same-group subsidiaries located in lax regulation countries have a substantially larger share of guaranteed return products as percentage of liabilities (53pp more - Column I) and continue to sell a disproportionately larger share of guaranteed return products today (43pp more - Column II). As a result, they assume more aggregate risk from households (Column 3) and end up retaining more of it, and in particular more market risk, on their balance sheets (44pp more - Column 5).

6. Conclusion

In this paper, we exploit a quasi-natural experiment to identify the causal effect of risk regulation on insurance provision. We argue that risk regulation is a first-order factor in explaining variation in the type of insurance products being written and risks being insured across countries, and discuss implications for competition in the insurance markets, market incompleteness and inequality.

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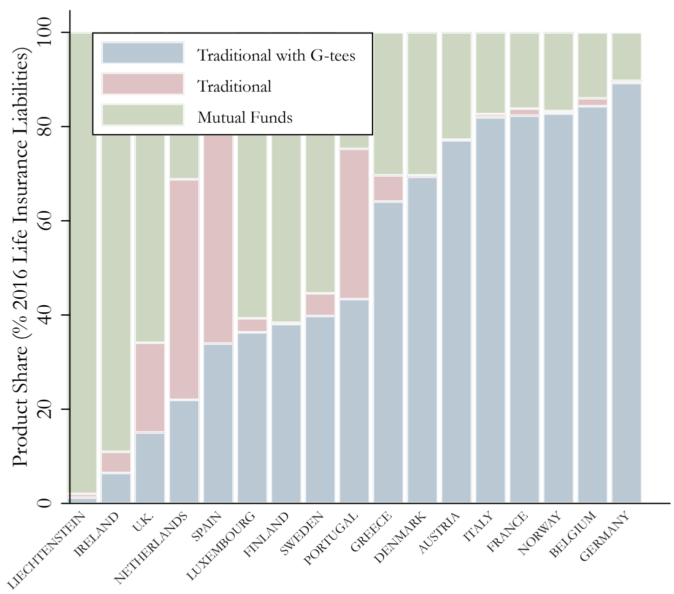
Table I: **European Insurance Markets**

This table show the distribution of sales (gross written premia), payouts (gross incurred claims), and reserves (present discounted value of expected future claims arising from contracts currently in force) broken down by main type of risk being insured in European insurance markets. The first life insurance subcategory captures traditional life insurance contracts with minimum return guarantees (whole life insurance, guaranteed annuities) which insure against aggregate market and biometric (longevity and mortality) risks. The second subcategory captures traditional life insurance contracts without minimum return guarantees (term life insurance, term and life annuities) which insure mostly against biometric (longevity and mortality) risk. The last subcategory captures linked life insurance – pure savings contracts that provide households with limited or no insurance. Property and casualty refers to products such as homeonwers insurance, auto, marine and aviation insurance or workers compensation. The last panel reports the risk exposures that end up being retained by insurance companies after hedging, reinsurance and diversification, as measured by their solvency capital requirements. Sample restricted to countries that were members of the European Single Market by 1995. Data from insurance companies 2016 Solvency and Financial Condition Reports collected by AM Best and SNL.

Item	Amt €Bn	% Total
Reserves		
Life Insurance	7,384	90.1
Market and Biometric Risk	3,949	48.2
Biometric Risk	666	8.1
Mutual Funds	2,324	28.4
Health Insurance	405	4.9
Property and Casualty	404	4.9
Total	8,193	100.0
Sales		
Life Insurance	663	76.2
Market and Biometric Risk	271	31.2
Biometric Risk	70	8.0
Mutual Funds	224	25.7
Health Insurance	60	6.9
Property and Casualty	147	16.9
Total	870	100.0
Claims		
Life Insurance	535	81.1
Market and Biometric Risk	264	40.0
Biometric Risk	51	7.7
Mutual Funds	179	27.1
Health Insurance	38	5.8
Property and Casualty	86	13.1
Total	660	100.0
Risk Exposures		
Market Risk	556	59.3
Default Risk	48	5.1
Biometric Risk	171	18.3
Health Risk	59	6.3
Catastrophe Risk	104	11.0
Total	938	100.0

Figure 1: **Life Insurance Products and their Risks across Countries**

This figure shows the composition of life insurance liabilities (top chart) and premiums (bottom chart) across Europe, by main type of products and risks. The blue bar captures traditional life insurance contracts with minimum return guarantees (whole life insurance, guaranteed annuities) which insure against aggregate market and life-related (longevity and mortality) risks. The red bar captures traditional life insurance contracts without minimum return guarantees (term life insurance, term and life annuities) which insure mostly against life-related (longevity and mortality) risk. While some of these contracts may contain financial guarantees (e.g. return of premium), these are kept to a minimum. The green bar captures linked life insurance (mutual funds). These are pure savings contracts that provide households with limited or no insurance. Data from insurance companies 2016 Solvency and Financial Condition Reports collected by AM Best.



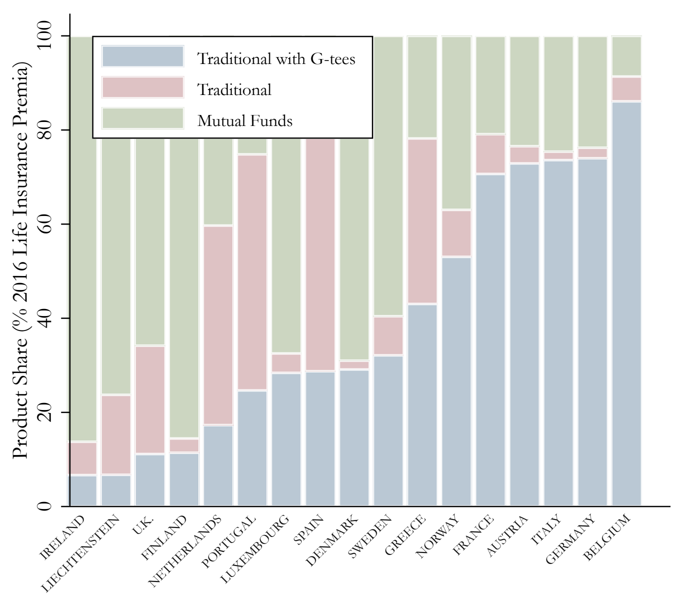
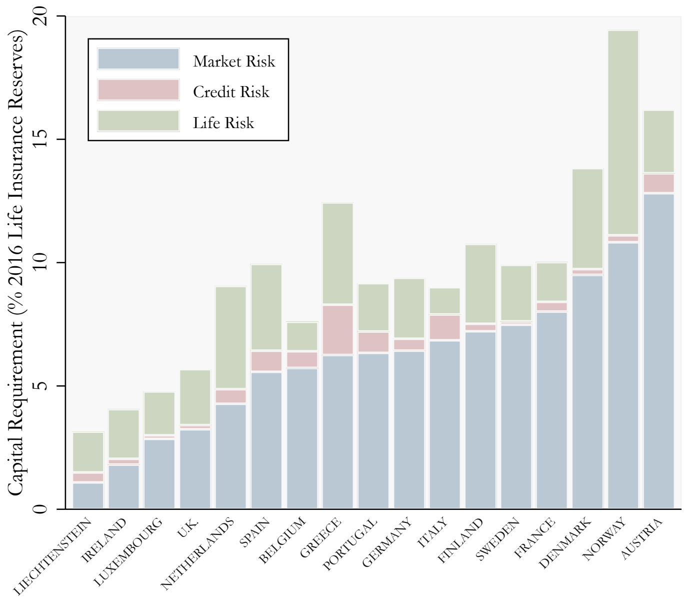


Figure 2: **Risk Exposures Retained across Countries**

This figure shows the amount and composition of risks that are ultimately retained by life insurance companies after hedging, reinsurance and diversification, across countries. Specifically, for every insurance company, we observe reserves and solvency capital requirements broken down by sources of risk. Each requirement is calibrated to a 99.5% value at risk over a 1 year horizon. For instance, the capital requirement for market risk is the amount of capital that is necessary to withstand a one in 200 years adverse shock to interest rates, equity, currency and property markets hitting the overall balance sheet, after accounting for hedging, reinsurance and securitization. The capital requirement for life risk is the amount of capital that is necessary to withstand a one in 200 years adverse shock to mortality, longevity or policyholder lapsation. The capital requirements for credit risk is the amount of capital that is necessary to withstand a one in 200 years adverse shock to the default of bonds, derivatives and reinsurance counterparties. The resulting value at risk is plotted as percentage of life insurance reserves. There is large variation in the amount of risk retained by life insurance companies across countries. This is largely driven by exposure to aggregate market risk (top chart). And the most important factor explaining cross-country variation in exposure to market risk is the extent to which different countries write insurance products with minimum return guarantees (bottom chart).



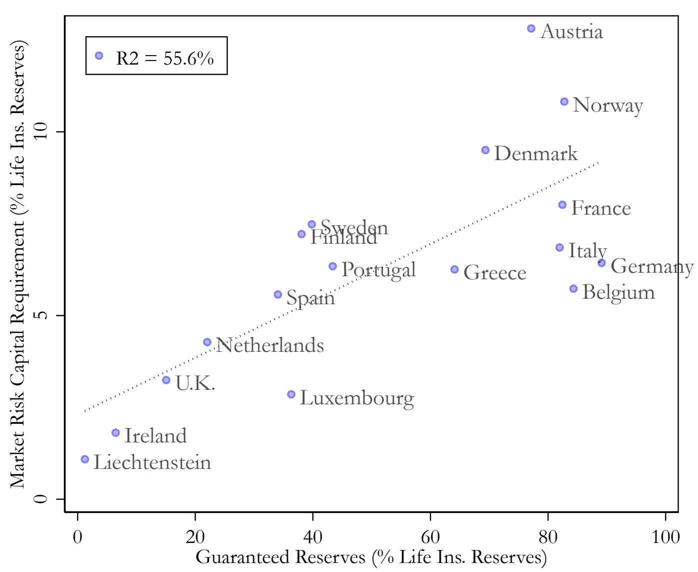


Figure 3: **Insurance Capital Regulation Regimes Across Europe**

This figure maps historical capital regulation regimes across Europe. Countries in red used historical cost accounting to value their insurance liabilities and capital requirements that were risk insensitive. Countries in blue accounted their insurance liabilities at market values and/or used capital requirements that were risk sensitive at least since the early 2000s. As explained in text, with the secular decline in interest rates and as the minimum return guarantees embedded in many insurance contracts got less out of the money, historical cost risk insensitive regulation became increasingly lax compared to its market consistent risk sensitive counterpart. Denmark is a middle case: it switched to market-consistent risk-sensitive regulation, but only partially and only starting with 2007. The sample is countries that were members of the European Single Market by 1995.

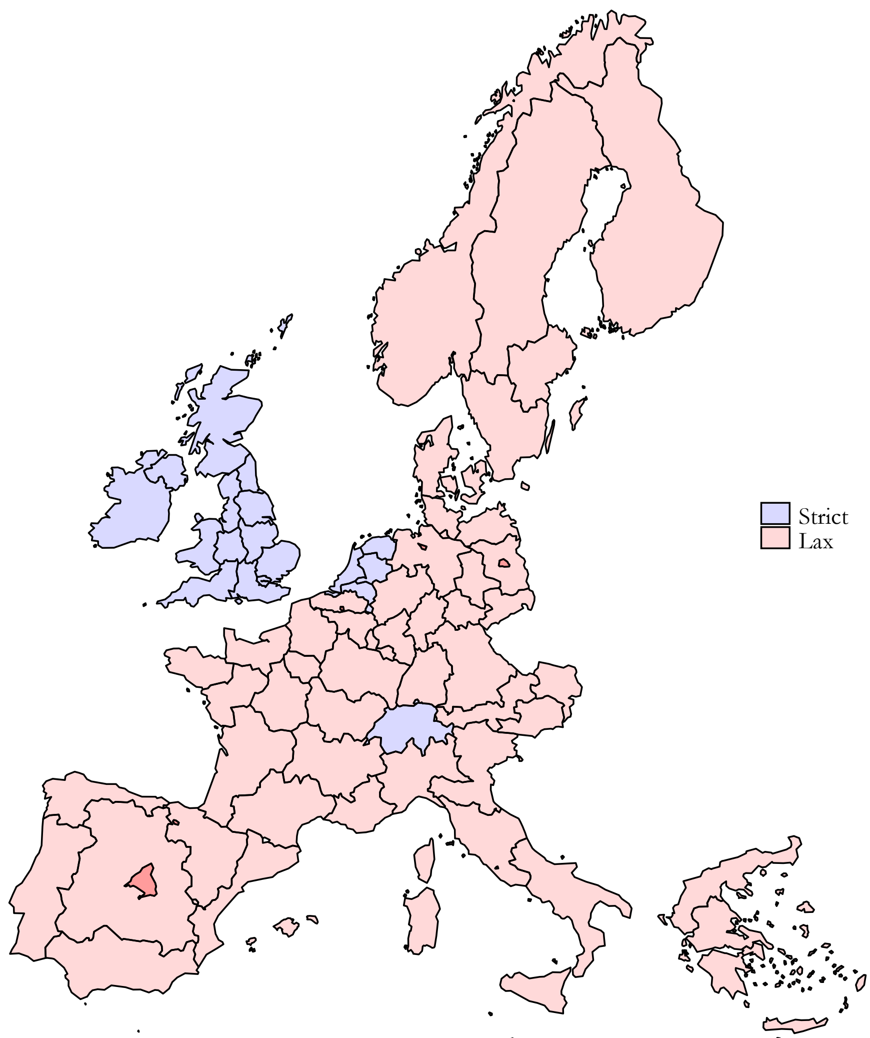


Figure 4: **Capital Regulation and Market Risk Insurance**

This chart ranks countries by the share of traditional life insurance products with minimum return guarantees (top) and market risk-related capital requirements (bottom) as percentage of their life insurance reserves, but this time broken down by historical regulatory regimes. Countries in blue were operating under a market-consistent risk-sensitive regultion at least since 2005. Countries in red are countries operating under historical-cost risk-insensitive regulation up to Solvency II. Sample excludes micro-states (Liechtenstein and Luxembourg) which are less likely to assume aggregate market risk as sales are almost exclusively abroad. Data on life insurance companies reserves and capital requirements from individual 2016 Solvency and Financial Condition Reports collected by AM Best.

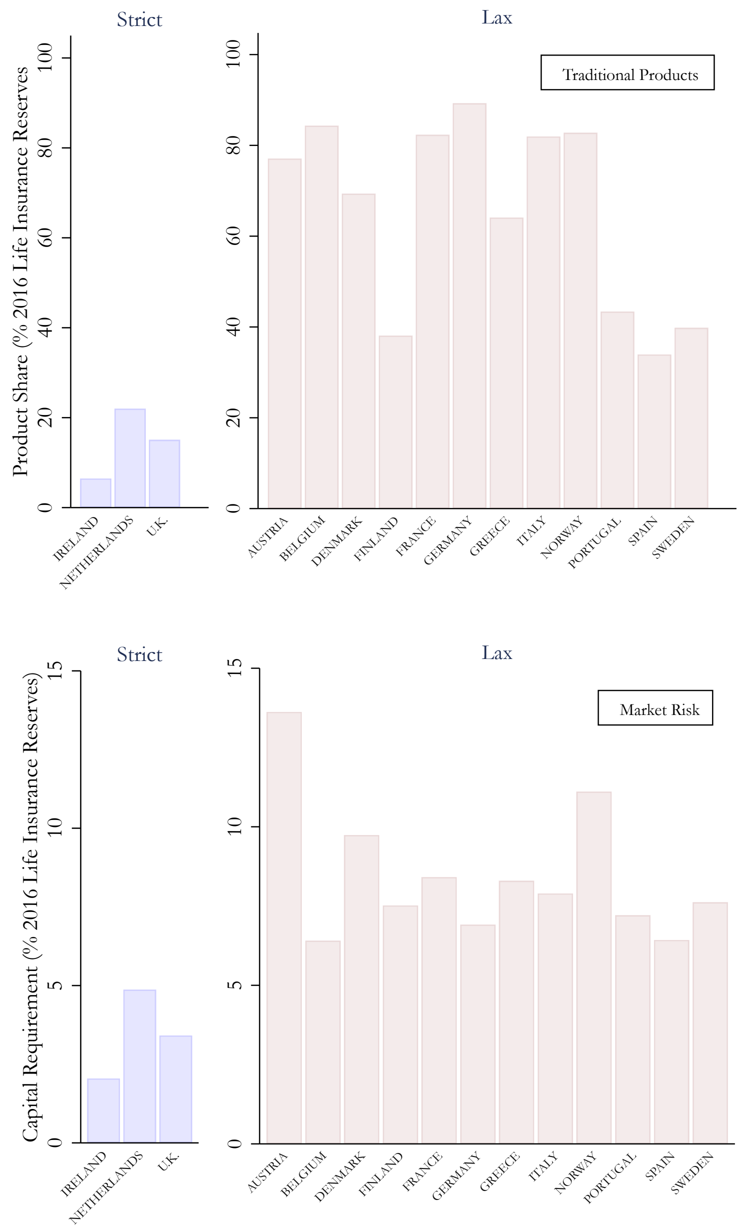


Table II: **Assessing UK Insurance Companies Risk Exposures**

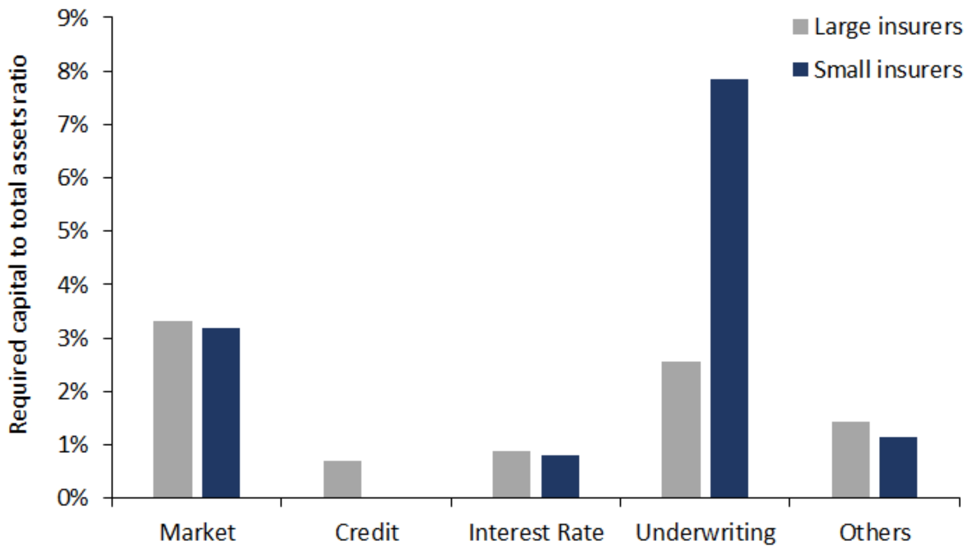
The table shows risk exposures (defined as capital requirement per class of risk in percentage of total assets), as extracted from UK life insurance companies confidential stress test submissions between 2003 and 2006. Column I shows firms own initial assessments of their risk exposures. Column shows the final risk exposures after the Financial Services Authority reviews their submissions. Table reports sample means and standard error of the means. The third column shows a test of difference in mean risk exposure between firms initial assessments and their post-review equivalents.

Risk Factor	Own Assessment	Post Review	Difference |T-stat|
Market Risk	1.95	1.93	0.04
	[0.26]	[0.26]	
Credit Risk	0.81	0.84	0.18
	[0.13]	[0.13]	
Interest Rate Risk	0.93	0.94	0.06
	[0.19]	[0.19]	
Underwriting Risk	2.33	2.77	0.91
	[0.30]	[0.38]	
Other Risks	1.00	1.35	1.34
	[0.18]	[0.18]	
Total Risk	7.02	7.84	0.84
	[0.63]	[0.74]	

Risk exposures were computed by conducting stress tests on insurance balance sheets against a range of risk factors. Insurers were then required to hold capital against these risks at a level that would ensure solvency with a 99.5% probability over a one-year horizon. Market risk measures exposure to fluctuations in equity, exchange rate, and real estate markets. Credit risk measures exposure to decline in the credit quality of corporate bonds and reinsurance counterparties. Interest rate risk measures exposure to fluctuations in interest rates and inflation due to mismatch in the duration of assets and liabilities. Underwriting risk measures exposure to longevity, mortality, morbidity, and policyholder behavior risks (e.g., lapses). Other risks include operational risks and risks stemming from complex group and subsidiary structures.

Figure 5: **Variation in UK Insurance Companies Risk Exposures**

The top chart shows a breakdown of risk exposures (defined as capital requirement per class of risk in percentage of total assets) by insurance company size. Large (small) insurers are insurers with total assets greater (lesser) than £500 million, which was roughly the median company size at the time the regulation was announced in 2002.



The bottom chart shows a breakdown of risk exposures for traditional and linked products. Since firms submit stress test results for their combined balance sheets (and not separately by products), we focus on firms that have more than 95% liabilities in a particular product to compute risk exposures for each product. The data from firms confidential stress test submissions between 2003 and 2006. Required capital includes any add-ons that Financial Services Authority levied after reviewing firms' initial submissions.

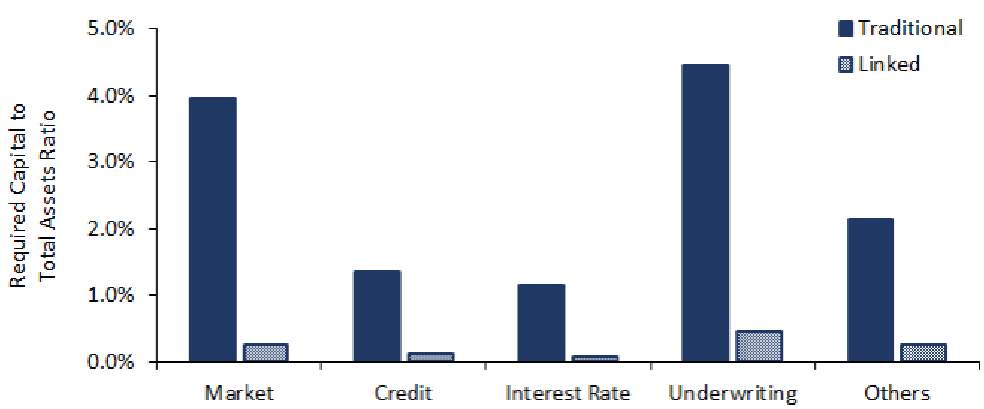


Figure 6: **Assessing the Shift in UK Capital Requirements**

This chart shows average capital requirements per dollar of total assets in the old regime as compared to the new regime for reporting insurance companies between 2003 and 2006. Since firms submit stress test results for their combined balance sheets (and not separately by products), we focus on firms that have more than 95% of their liabilities in a particular product to assess the shift in capital requirements for each product. The vertical error bars denote the associated 95% confidence intervals. Required capital includes any add-ons that the UK Financial Services Authority may have levied after reviewing firms initial stress test submissions.

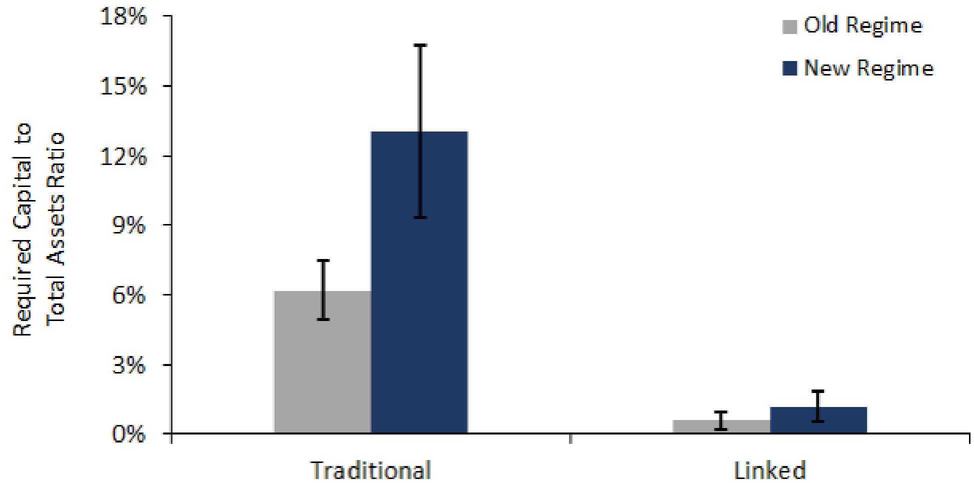


Figure 7: **Distribution of UK Solvency Capital Ratios across Regimes**

This chart plots distribution of solvency capital ratios (or capital buffers) for the sample of insurers having more than 50% of their liabilities in traditional products at the time the regulation was announced in 2002. The blue bars show the distribution of capital buffers under the new regime, where capital requirements are predicted using the risk exposure models. The grey bars show the distribution of capital buffers as observed under the old regime. The highlighted area to the left of one denotes the mass of constrained firms defined as firms whose available capital is less than the required capital and who may have to raise capital to comply with the regulation.

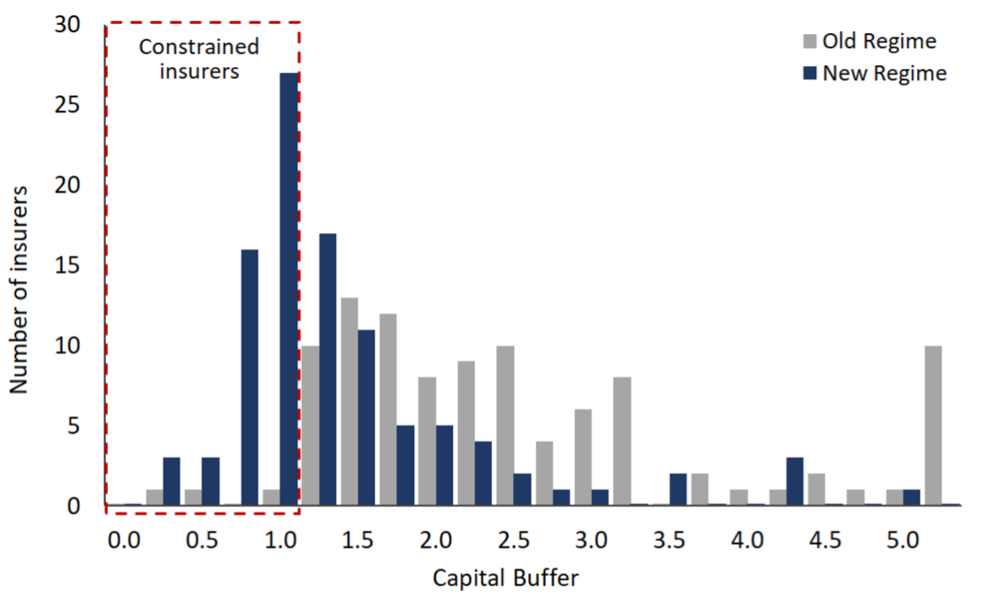
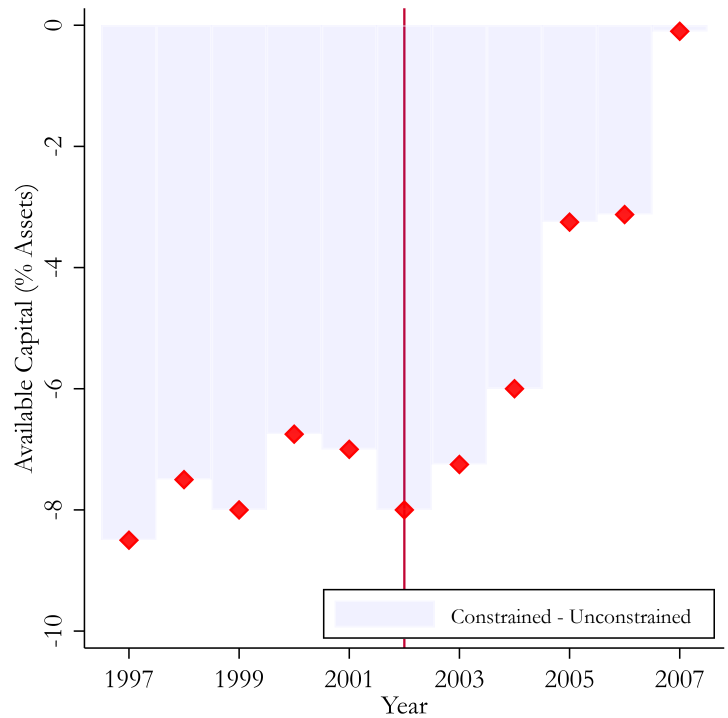


Table III: **Characteristics of Constrained and Unconstrained UK Insurers**

Variable	Constrained	Unconstrained	|T-stat|
	Solvency		
Solvency Capital Ratio	0.70	1.81	7.87
	[0.03]	[0.13]	
Available Capital (% Assets)	8.60	16.50	3.72
	[1.40]	[1.57]	
Required Capital (% Assets)	12.42	9.66	1.39
	[1.77]	[0.98]	
	Risk Exposures		
Market Risk (% Assets)	2.94	3.56	1.28
	[0.35]	[0.33]	
Credit Risk (% Assets)	0.57	0.13	2.51
	[0.15]	[0.09]	
Interest Rate Risk (% Assets)	0.85	0.83	0.83
	[0.02]	[0.01]	
Underwriting Risk (% Assets)	6.69	3.94	1.31
	1.87	1.04	
Other Risks (% Assets)	1.37	1.20	1.60
	[0.10]	[0.03]	
	Asset vs. Liability Risk		
Risky Assets (% Assets)	55.1	47.1	1.53
	[3.58]	[3.83]	
Traditional Products (% Reserves)	89.0	92.9	1.62
	[1.85]	[1.59]	
Reserves Reinsured (%)	11.7	12.7	0.26
	[2.97]	[2.70]	
	Claims Experience		
Death and Disability (% Liabilities)	6.58	3.59	1.31
	[2.03]	[1.12]	
Annuities (% Liabilities)	1.27	1.09	0.38
	[0.30]	[0.35]	
Surrenders (% Liabilities)	2.56	2.52	0.07
	[0.47]	[0.47]	
	Others		
Size (Bn)	7.53	3.80	1.57
	[2.15]	[1.09]	
Rating (1-10)	6.46	6.59	0.32
	[0.28]	[0.30]	
ROA (%)	-1.38	-1.85	0.16
	[1.78]	[2.26]	
Mutual (%)	51.0	53.9	0.28
	[7.22]	[6.98]	
Group (%)	20.4	13.5	0.93
	[5.82]	[4.78]	
N	49	52	

Figure 8: **Insurers Capital to Asset Ratios: Constrained vs Unconstrained**

The top chart plots the difference in available capital to asset ratios between constrained and unconstrained UK insurers over time. The red vertical line marks the announcement of the risk-sensitive insurance capital regulation in 2002. Constrained insurers had persistently lower available capital ratios before the announcement of the regulation. The gap narrows and eventually disappears after the announcement. The bottom chart plots available capital to asset ratios but now separately constrained and unconstrained UK insurers to show it is constrained insurers raising new capital and not unconstrained insurers shedding excess capital that is driving the effect.



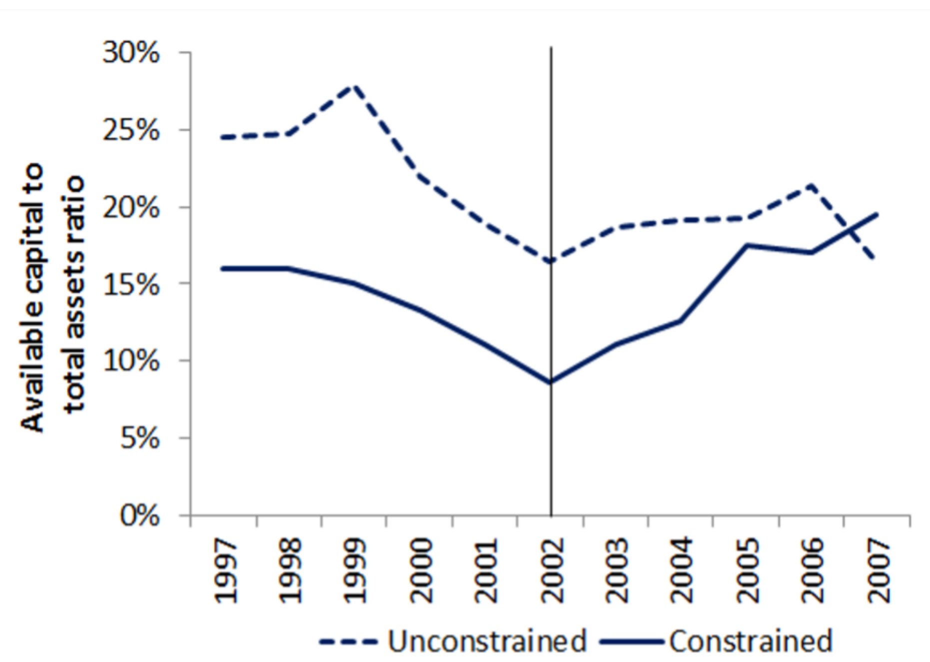


Table IV: **Insurers Capital to Asset Ratios**

This table reports results from difference-in-differences regressions on the effect of regulatory frictions on insurers available capital to asset ratios for the UK life insurance market. $C \times P$ is the independent variable of interest where C is an indicator variable taking a value of 1 if a firm is constrained at the announcement of the new regulation in 2002 and P is a post regulation dummy that takes a value of 1 after 2002. Controls include the share of risky assets in total assets (as a measure of asset return), death, disability, annuity and surrender claims as percentage of total liabilities (as measures of underwriting profit), reinsurance (as a measure of the ability to transfer risks externally) and group and mutual status (as a measure of the ability to raise internal or external financing). Column (3) controls additionally for any transfers of existing liabilities or reorganizations the companies might have engaged in during the sample period. Standard errors are clustered at the firm level. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.

Capital / Assets	(1)	(2)	(3)
$C_i \times P_t$	0.048**	0.048**	0.043**
	[0.020]	[0.019]	[0.019]
Controls	No	Yes	Yes
Reorganization	No	No	Yes
Firm FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
N	1020	1020	1020

Figure 9: **Trends in UK Life Insurance Products**

The top chart plots the composition of life insurance liabilities (stock, left chart) and life insurance underwriting (flow, right chart) by main product type (traditional vs linked) for the UK life insurance sector as a whole, over the period 1985 to 2015. The bottom chart reports insurance underwriting separately for traditional and linked policies, but now broken down into constrained and unconstrained insurers, over the period 1997 to 2007. For comparability, it restricts the sample to the 101 insurers with more than 50% of their liabilities in traditional policies in 2002. Underwriting defined as sales of new contracts excluding regular premium from existing contracts, net of reinsurance. The vertical lines mark the announcement of the risk-sensitive insurance capital regulation in 2002.

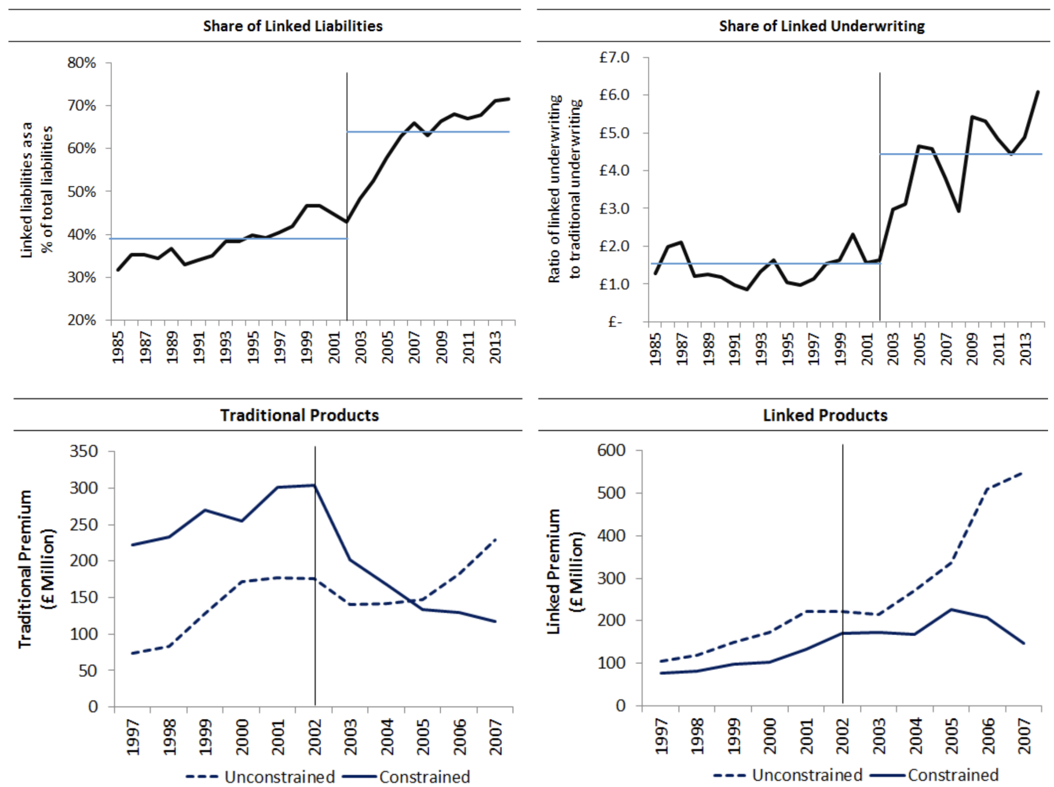


Table V: **Insurance Underwriting: Intensive Margin**

This table reports results from difference-in-differences regressions on the effect of risk regulation on the intensive margin of insurance underwriting for the UK life insurance market. Columns (1)-(5) refer to traditional underwriting. Columns (6)-(7) focus on linked underwriting. The dependent variable is log insurance underwriting, except for column 2 which looks at the number of traditional policies sold, and columns 3 and 5 which look at the share of traditional underwriting in total life insurance underwriting (number of policies is only available for traditional products). C is a time-invariant indicator variable that takes a value of 1 if a firm is constrained at the announcement of the new regulation in 2002 (if required capital exceeds available capital under the new regulation). P is a post regulation dummy that takes a value of 1 after 2002. The sample is either the full set of matched constrained and unconstrained companies specializing in traditional underwriting ("All") or the subset of companies selling both traditional and linked policies ("Both"). The controls are the insurer log total assets, credit rating, return on assets, liquidity ratio, available capital to asset ratio, share of risky assets in total assets (as a measure of asset risk), death, disability, annuity and surrender claims as percentage of total liabilities (as measures of liability risk), the share of reserves reinsured, organizational structure (stock vs mutual) and group structure. All specifications are linear except column 3 which is logit. Standard errors are clustered at the firm level. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.

	Traditional					Linked	
DepVar	ln(Sales)	ln(# Ctr)	Share	ln(Sales)	Share	ln(Sales)	ln(Sales)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$C_i \times P_t$	-0.512**	-0.872**	-0.057*	-1.024***	-0.095**	-0.093	0.053
	[0.245]	[0.393]	[0.030]	[0.338]	[0.047]	[0.430]	[0.423]
Sample	All	All	All	Both	Both	All	Both
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	956	1008	963	565	567	558	541

Table VI: **Insurance Underwriting: Extensive Margin**

This table looks at the effect of risk regulation on the extensive margin of life insurance underwriting: whether insurer sell or exit the UK life insurance market. The top panel shows the share of companies that were active in the traditional insurance market in the 5 years before and after the regulation. Constrained insurers defined as insurers whose available capital exceeded predicted required capital in 2002.

	1997-2002	2003-2007	Diff |T-stat|
Constrained (%)	95.6	88.3	3.09
	(1.23)	[2.16]	
Unconstrained (%)	95.4	94.1	0.66
	[1.21]	[1.53]	

The bottom panel shows results from a difference in differences logit regression on the effect of risk regulation on traditional and linked insurance market participation. The sample is now the set of 101 insurers with more than 50% of insurance liabilities in traditional policies in 2002. The dependent variable is an indicator variable set to 1 if the insurer sells any traditional life insurance. C is a time-invariant indicator variable that takes a value of 1 if a firm is constrained at the announcement of the new regulation in 2002 (if required capital exceeds available capital under the new regulation). P is a post regulation dummy that takes a value of 1 after 2002. The controls are the insurer log total assets, credit rating, return on assets, liquidity ratio, available capital to asset ratio, share of risky assets in total assets (as a measure of asset risk), death, disability, annuity and surrender claims as percentage of total liabilities (as measures of liability risk), the share of reserves reinsured, organizational structure (stock vs mutual) and group structure. Standard errors are clustered at the firm level. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.

	Traditional	Linked
$\mathbb{1}$(Sales>0)	(1)	(2)
$C_i \times P_t$	-3.113***	-1.260
	[0.965]	[1.313]
Controls	Yes	Yes
Firm FE	Yes	Yes
Time FE	Yes	Yes
N	197	238

Table VII: **Portfolio Sales and Reorganizations**

This table reports statistics on the percentage of UK insurance companies engaged in significant sales of insurance portfolios (transfer-out), purchase of insurance portfolios (transfer-in) or reorganization (such as being merged or acquired) in the 5 years before and after the announcement of the regulation, separately for constrained and unconstrained insurance companies. Firms defined as constrained if at the time of announcement of the new insurance regulation, their required capital as computed under the new regulation exceeds their available capital. For each insurer group (constrained and unconstrained), the T-test performs a difference in means across the two periods.

	Constrained			Unconstrained		
	1997-2002	2003-2007	Diff |T-stat|	1997-2002	2003-2007	Diff |T-stat|
Transfer-out (%)	4.08	28.57	3.44	9.62	17.31	1.15
	[2.86]	[6.52]		[4.13]	[5.30]	
Transfer-in (%)	20.41	2.04	2.98	7.69	11.54	0.66
	[5.82]	[2.04]		[3.73]	[4.47]	
Reorganizations (%)	16.33	38.78	2.54	23.08	25.00	0.23
	[5.33]	[7.03]		[5.90]	[6.06]	

This table reports results from difference-in-differences logit regressions on the effect of regulatory frictions on a set of alternative product market outcomes for the UK life insurance market. The dependent variables are dummies set to 1 whenever the insurer engages in a significant portfolio sale (transfer-out), portfolio purchase (transfer-in) or a full reorganization (columns 3-5). C is a time-invariant indicator variable that takes a value of 1 if a firm is constrained at the announcement of the new regulation in 2002 (if required capital exceeds available capital under the new regulation). P is a post regulation dummy that takes a value of 1 after 2002. Columns 1-3 look at the full sample. Columns 4-5 focus on the sample of insurers whose total assets are below (small) or exceed (large) the median size (£500m) in 2002. The controls are the insurer log total assets, credit rating, return on assets, liquidity ratio, available capital to asset ratio, share of risky assets in total assets (as a measure of asset risk), death, disability, annuity and surrender claims as percentage of total liabilities and share of traditional liabilities in total liabilities (as measures of liability risk), the share of reserves reinsured, organizational structure (stock vs mutual) and group structure. Standard errors are clustered at the firm level. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.

				Small Ins	Large Ins
	Transfer-Outs	Transfer-Ins	Reorganizations		
	(1)	(2)	(3)	(4)	(5)
$C_i \times P_t$	1.755*	-3.498**	1.262*	15.414***	1.592
	[1.021]	[1.553]	0.750	[1.590]	[1.082]
Odds Ratio	5.79	0.03	3.53	-	4.91
Controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
N	1027	1027	1027	481	456

Table VIII: **Insurance Prices**

This table shows price equivalent measures for annuities (decumulation contracts) and pensions (accumulation contracts in the context of UK insurance markets), for the market as a whole and separately for constrained and unconstrained insurance companies, in the 5 years before and after the announcement of the regulation. Pension contracts further broken down into traditional pensions (where the insurance company bears the investment risk) and linked pensions (where the policyholder bears the investment risk). The annuity ratio is defined as the ratio between the annuity price (the amount of money a policyholder spends to buy an annuity) and the mortality adjusted expected present value of the income arising from that annuity over the life of the contract. Ratios greater than 1 mean annuities sell at a premium from actuarially fair values. The reduction in yield ratio is defined as the ratio between the investment yield on the pension account before fees and after fees. The higher the ratio, the higher the price. Table shows single premium pension contracts with expected accumulation periods of 20, 25 and 30 years and immediate fixed, escalating and period-certain annuities for females aged 65Y. Data hand collected from past issues of Moneyfacts Investment Life and Pensions, available at the British Library Archives.

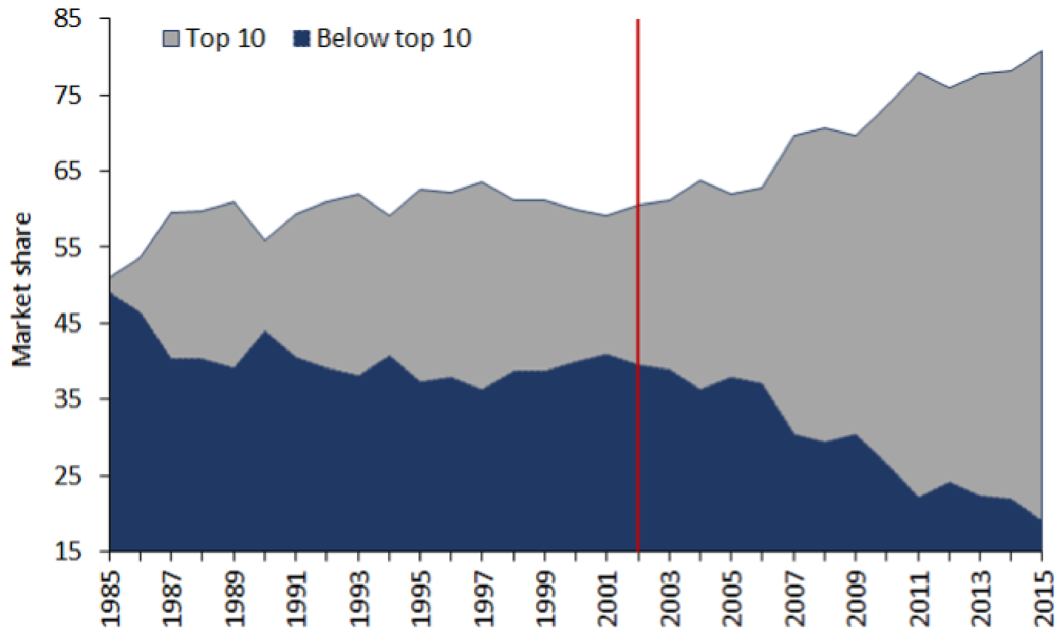
	1997-2002	2003-2007	1997-2002	2003-2007	1997-2002	2003-2007
	Full Sample		Constrained		Unconstrained	
			Annuities: Annuity Ratio			
Fixed Annuities	1.080	1.230	1.010	1.190	1.120	1.260
Escalating Annuities	1.090	1.300	1.030	1.200	1.120	1.360
5 Year Guarantee	1.080	1.230	1.020	1.190	1.120	1.250
			Traditional Pensions: Reduction in Yield Ratio			
20 Years	1.008	1.011	1.008	1.014	1.009	1.010
25 Years	1.008	1.011	1.007	1.013	1.008	1.010
30 Years	1.008	1.011	1.007	1.013	1.008	1.010
			Linked Pensions: Reduction in Yield Ratio			
20 Years	1.010	1.010	1.009	1.012	1.010	1.010
25 Years	1.009	1.010	1.009	1.012	1.010	1.010
30 Years	1.009	1.010	1.009	1.011	1.009	1.010

This table shows advertised upfront and annual charges underlying the computation of investment yields for single premium traditional and linked pension products above. Data from past issues of Moneyfacts Investment Life and Pensions, available at the British Library Archives.

			Traditional Pensions: Fees			
Upfront Charge (%)	3.50	0.75	4.18	1.67	3.27	0.44
Annual Charge (%)	0.65	1.04	0.56	1.26	0.68	0.96
			Linked Pensions: Fees			
Upfront Charge (%)	2.86	0.89	2.93	1.56	2.84	0.71
Annual Charge (%)	0.82	0.96	0.77	1.08	0.83	0.92

Figure 10: **Rising Product Market Concentration: UK Evidence**

This chart plots the share of the 10 largest insurance companies by sales in the UK market for traditional life insurance, between 1985 and 2015. The red vertical line marks the announcement of the risk-sensitive insurance capital regulation in 2002. Data from insurance companies annual regulatory returns with the UK Financial Services Authority collected from Standard & Poor's Global Market Intelligence Synthesys database.



Internet Appendix
The Evolution of Insurance Markets
Capital Regulation and Insurance Provision

Appendix A: European Life Insurance Products

A1. Classification

We classify European life insurance products into traditional insurance products, which involve a risk transfer between households and the insurance company, and linked insurance products, tax-advantaged mutual funds where there is no risk transfer between households and the insurance company as all risks stay with the household. We further break down traditional insurance products into traditional with guarantees (where the dominant risk being transferred is aggregate market risk) and traditional without guarantees (where the dominant risk being transferred is longevity, mortality or morbidiy risk). The following appendix describes the cashflows embedded in each of these products and the risks being transferred (TBC).

A2. Linked Insurance

A linked policy is a pure savings contract where the household purchases a mutual fund today and receives the future value of that mutual fund upon death, contract termination or maturity. Let $M_{t,t+m}$ a strictly positive stochastic discount factor discounting payoffs from $t+m$ to t and S the value of a mutual fund unit. By no arbitrage, the actuarially fair value of a linked insurance policy of maturity m at time t is just the value of the mutual fund today:

$$V_t(m) = \mathbb{E}_t\left[M_{t,t+m}S_{t+m}\right] = S_t \tag{7}$$

Linked policies can be unit-linked or index-linked. This just reflects the different assets the policyholder benefits are being tied to. In a unit linked policy, the benefits are tied to mutual funds owned by the insurance company. In an index-linked policy, the benefits are tied to the value of an external index. By law, the insurer is required to own the mutual fund or replicate the external index such that it bears no investment risk.

A3. Term Annuities

A term annuity is a policy that makes fixed annual payments for a fixed term. Let $R_t(m)$ be the zero coupon risk-free yield of maturity m at time t. Then the time t actuarial value of an M-year term annuity per dollar of income (to get it per dollar of initial premium, simply multiply by the annuity factor) is:

$$V_t(M) = \sum_{m=1}^{M} \frac{1}{R_t(m)^m} \tag{8}$$

A4. Life Annuities

A life annuity is a policy that makes fixed annual payments until the death of the insured. Let p_n be the 1-year survival probability at age n. Then the time t actuarial value of an immediate life annuity per dollar of income at age n is:

$$V_t(n) = \sum_{m=1}^{M} \frac{\prod_{l=0}^{m-1} p_{n+l}}{R_t(m)^m} \tag{9}$$

A5. Term Life Insurance

A term life insurance is a policy that pays out a fixed death benefit (called the policy face value) if death occurs within the term of the policy. Let p_n be the 1-year survival probability at age n and $1 - p_n$ the corresponding death probability. Then the time t actuarial value of an M-year term life insurance per dollar of death benefit at age n is:

$$V_t(n, M) = \sum_{m=1}^{M} \frac{\prod_{l=0}^{m-2} p_{n+l}(1 - p_{n+m-1})}{R_t(m)^m} \tag{10}$$

A6. Permanent Life Insurance

A permanent life insurance is a policy that pays out a fixed death benefit (called the policy face value) upon the death of the insured, regardless of the timing of death. Let p_n be the 1-year survival probability at age n and $1 - p_n$ the corresponding death probability. Then the time t actuarial value of an permanent life insurance per dollar of death benefit at age n is:

$$V_t(n) = \sum_{m=1}^{\infty} \frac{\prod_{l=0}^{m-2} p_{n+l}(1 - p_{n+m-1})}{R_t(m)^m} \tag{11}$$

A7. Whole Life Insurance

A whole life insurance policy combines a term or a permanent life insurance policy with a guaranteed savings contract. When you make the initial premium, part of the premium goes to fund death benefit in the life insurance policy and the excess is invested by the insurance company and accumulates at a minimum rate of return (endowment policy) or is paid out as a stream of annual payments that increase at a minimum rate of return (guaranteed annuity policy). We describe each component below.

A8. Term Endowment

Let $M_{t,t+m}$ a strictly positive stochastic discount factor discounting payoffs from $t + m$ to t and $R_t(m)$ the gross zero-coupon risk-free yield of maturity m at time t such that $R_t(m)^m = \mathbb{E}_t[M_{t,t+m}]$. Let $\hat{R}_t$ the contractual gross minimum return guarantee fixed at the time of issuance and $R_t^a...R_t + m^a$ the stream of realized asset returns. Then the time t actuarial value of an M-year term endowment policy, per dollar of account value, is:

$$V_t(n) = \mathbb{E}_t\left[M_{t,t+M} \prod_{m=1}^{M} \max\{R_{t+m}^a, \hat{R}_t\}\right] \tag{12}$$

which can be decomposed into:

$$V_t(n) = \mathbb{E}_t\Big[M_{t,t+M}\prod_{m=1}^{M}\hat{R}_t\Big] + \mathbb{E}_t\Big[M_{t,t+M}\Big(\prod_{m=1}^{M}\max\{R^a_{t+m},\hat{R}_t\} - \prod_{m=1}^{M}\hat{R}_t\Big)\Big]$$

$$= \frac{\prod_{m=1}^{M}\hat{R}_t}{R_t(M)^M} + \mathbb{E}_t\Big[M_{t,t+M}\Big(\prod_{m=1}^{M}\max\{R^a_{t+m},\hat{R}_t\} - \prod_{m=1}^{M}\hat{R}_t\Big)\Big] \tag{13}$$

where the first term captures the acturarially fair value of the guaranteed benefits, the second term is the actuarially fair value of any surplus to be distributed to policyholders if contract returns are high enough (which is always at least as great as zero), and the second equation accounts for the fact that the minimum return guarantee is constant and known in advance and so the stochastic discount factor collapses to the risk-free discount factor.

A9. Life Endowment

A life endowment policy is like a term endowment policy except now the cash value keeps accumulating until the death of the insured. Letting p_n be the 1-year survival probability at age n and $1-p_n$ the corresponding death probability, the time t actuarial value of an life endowment policy, per unit of account value, at age n is:

$$V_t(n) = \sum_{m=1}^{\infty}\prod_{l=0}^{m-2}p_{n+l}\big(1-p_{n+m-1}\big)\times\mathbb{E}_t\Big[M_{t,t+m}\prod_{s=1}^{\infty}\max\{R^a_{t+s},\hat{R}_t\}\Big] \tag{14}$$

which can be decomposed into:

$$V_t(n) = \sum_{m=1}^{\infty}\prod_{l=0}^{m-2}p_{n+l}\big(1-p_{n+m-1}\big)\frac{\hat{R}_t^m}{R_t(m)^m} +$$

$$+\sum_{m=1}^{\infty}\prod_{l=0}^{m-2}p_{n+l}\big(1-p_{n+m-1}\big)\mathbb{E}_t\Big[M_{t,t+m}\Big(\prod_{s=1}^{\infty}\max\{R^a_{t+s},\hat{R}_t - \prod_{s=1}^{\infty}\hat{R}_t\Big)\Big] \tag{15}$$

where the first term is the mortality adjusted present discounted value of the guaranteed benefits and the second term is the mortality adjusted present discounted value surplus. Low interest rates coupled with the fact that European insurers primarily invest insurance premiums into highly rated bonds means this expected surplus component has become increasingly small after the Great Financial Crisis.

A10. Guaranteed Term Annuity

A guaranteed term annuity is a policy that makes annual payments for a fixed term, where the annual payments grow at the maximum between the realized return on the invested portfolio (the contract return R^a_{t+s} for any $s \geq 0$) and the minimum return guarantee set at issuance $\hat{R}_t$. The actuarially fair value of an immediate term annuity of term M with minimum return guarantee $\hat{R}_t$ at time t, per dollar of prior year's annual payment, is:

$$V_t(M) = \mathbb{E}_t\Big[M_{t,t+M}\prod_{s=1}^{M}\max\{R^a_{t+s},\hat{R}_t\}\Big] \tag{16}$$

which can be decomposed into:

$$V_t(M) = \mathbb{E}_t\Big[M_{t,t+M}\prod_{s=1}^{M}\hat{R}_t\Big] + \mathbb{E}_t\Big[M_{t,t+M}\prod_{s=1}^{M}\Big(\max\{R^a_{t+s},\hat{R}_t\} - \prod_{s=1}^{\infty}\hat{R}_t\Big)\Big]$$

$$= \frac{\hat{R}_t^M}{R_t(M)^M} + \mathbb{E}_t\Big[M_{t,t+M}\prod_{s=1}^{M}\Big(\max\{R^a_{t+s},\hat{R}_t\} - \prod_{s=1}^{M}\hat{R}_t\Big)\Big] \tag{17}$$

where the first term is the mortality adjusted present discounted value of guaranteed benefits and the second term is the mortality adjusted present discounted value surplus, and the second equation accounts for the fact that there is no uncertainty in the mininum return guarantee. The assumption throughout is that any surplus paid out to policyholders is immediately annuitized at the same initial annuity factor.

A11. Guaranteed Life Annuity

A guaranteed life annuity is a policy that makes annual payments until the death of the insured, where the annual payments grow at the maximum between the realized return on the invested portfolio (the contract return R^a_{t+s} for any $s \geq 0$) and the minimum return guarantee set at issuance $\hat{R}_t$. Let p_n the 1-year survival probability at age n. Then the actuarially fair value of an immediate guaranteed life annuity with minimum return guarantee $\hat{R}_t$ at age n and time t, per dollar of prior year's annual payment, is:

$$V_t(n) = \sum_{m=1}^{\infty}\prod_{l=0}^{m-1} p_{n+l} \times \mathbb{E}_t\Big[M_{t,t+m}\prod_{s=1}^{\infty}\max\{R^a_{t+s},\hat{R}_t\}\Big] \tag{18}$$

which can be decomposed into:

$$V_t(n) = \sum_{m=1}^{\infty}\prod_{l=0}^{m-1} p_{n+l} \times \mathbb{E}_t\Big[M_{t,t+m}\prod_{s=1}^{\infty}\hat{R}_t\Big] +$$

$$+ \sum_{m=1}^{\infty}\prod_{l=0}^{m-1} p_{n+l} \times \mathbb{E}_t\Big[M_{t,t+m}\prod_{s=1}^{\infty}\Big(\max\{R^a_{t+s},\hat{R}_t\} - \prod_{s=1}^{\infty}\hat{R}_t\Big)\Big]$$

$$= \sum_{m=1}^{\infty}\prod_{l=0}^{m-1} p_{n+l} \times \frac{\hat{R}_t}{R_t(m)^m} + \sum_{m=1}^{\infty}\prod_{l=0}^{m-1} p_{n+l} \times \mathbb{E}_t\Big[M_{t,t+m}\prod_{s=1}^{\infty}\Big(\max\{R^a_{t+s},\hat{R}_t\} - \prod_{s=1}^{\infty}\hat{R}_t\Big)\Big] \tag{19}$$

where the first term is the mortality adjusted present discounted value of guaranteed benefits and the second term is the mortality adjusted present discounted value surplus. The assumption throughout is that any surplus paid out to policyholders is immediately annuitized at the same initial annuity factor.

Appendix B: Theoretical Framework

In this section, we use a standard model of insurance markets with market power and financial frictions to illustrate the impact of capital regulation of insurance provision. The core model ingredients come from Koijen and Yogo 2015, Koijen and Yogo 2016 and Koijen and Yogo 2022. The innovation of the model is that insurers optimize over multiple products with heterogeneous capital requirements that vary at the product level.

Model Setup

There is a finite set of insurers indexed by $i = 1, 2, ..., I$. Each firm sells two products indexed by $j = 1, 2$, where $j = 1$ denotes traditional and $j = 2$ denotes linked products. Firms face a frictionless marginal cost V_j in manufacturing each product, which denotes its fair actuarial value and is assumed to be the same across all firms. They optimally price each product in an oligopolistic market, where we assume the existence of a Nash equilibrium in prices. They face a demand function that is continuous, continuously differentiable, and strictly decreasing in its own price. Let P_{ij} and Q_{ij} be the current period equilibrium prices and associated quantities sold by firm i in product j. Current period underwriting profits are:

$$\Pi_i = \sum_j Q_{ij}(P_{ij} - V_j) \tag{20}$$

Each firm comes with inherited liabilities L_{ij}^- (previously sold still in force products) and associated available capital K_i^-. Every period, underwriting profits add to that capital and the fair value of products sold are reserved and add to those liabilities. The regulator requires that insurers set aside required capital for each unit of liability. Required capital is:

$$R_i = \sum_j \phi_j(Q_{ij}V_j + L_{ij}^-) \tag{21}$$

where the amount in brackets is current liabilities (newly generated reserves plus inherited liabilities) and ϕ_j is a product specific risk charge coming from risk based capital regulation. Available capital is:

$$K_i = \sum_j Q_{ij}(P_{ij} - V_j) + K_i^- \tag{22}$$

Financial Frictions

To operate, insurers need that available capital exceeds required capital. Low levels of available capital in excess of required capital could lead to a rating downgrade or regulatory action, which has adverse consequences in both retail and capital markets. We model these costs through a cost function and assume it is continuous, twice continuously differentiable, strictly decreasing, and strictly convex in firm-level excess capital:

$$C_i = C(K_i - R_i) \quad s.t \quad \frac{\partial C_i}{\partial(K_i - R_i)} < 0 \quad and \quad \frac{\partial^2 C_i}{\partial(K_i - R_i)^2} > 0 \tag{23}$$

The cost is decreasing as higher statutory capital reduces the probability of a rating downgrade or regulatory action, and convex, as building up statutory capital has diminishing returns. The shape of the cost function has been validated empirically (see Koijen and Yogo 2015). Implicit in this formulation are financial frictions that make funding statutory capital costly.

Product Market Frictions

Demand comes from a discrete choice problem (McFadden 1974). There are N consumers indexed by n = 1, 2, ...,N with indirect utilities over insurers and products given by:

$$u_{ij}(n) = -\alpha P_{ij} + \beta' X_i + \eta_{ij}(n) \tag{24}$$

where (α, β) are preference parameters, P_{ij} are prices, X_i are firm specific covariates and $\eta_{i,j}(n)$ are consumer specific taste shocks. Insurance firms produce differentiated products, where differentiation is due to company characteristics. Thus, expected indirect utility from product ij depends on the price of the product and characteristics of firm i. The coefficient on price $\alpha > 0$ ensures the demand is downward sloping. The market share s_{ij}, for product j at firm i becomes:

$$s_{ij} = \frac{exp\big(-\alpha P_{ij} + \beta' X_i\big)}{1 + \sum_{j'} \sum_{i'} exp\big(-\alpha P_{i'j'} + \beta' X_i'\big)} \tag{25}$$

where demand for outside options is normalized to 1 and resulting quantities demanded Q_{ij} are simply market shares multiplied by overall market size.

Objective Function

Firms set prices across products to maximize profits subject to a downward sloping demand function $_Qij(P_{ij})$ and the cost of financial constraints:

$$\max_{P_{ij}} \sum_j Q_{ij} \left(P_{ij} - V_j\right) - C_i \tag{26}$$

The first-order condition yields the following optimal pricing rule:

$$P_{ij} = \left(1 - \frac{1}{\epsilon_{ij}}\right)^{-1} V_j \Phi_{ij} \tag{27}$$

where:

$$\Phi_{ij} = \frac{1 + c_i\left(1 + \phi_j\right)}{1 + c_i} \quad ; \quad c_i = \frac{\partial C_i}{\partial (K_i - R_i)} \quad ; \quad \epsilon_{ij} = -\frac{\partial Q_{ij}/Q_{ij}}{\partial P_{ij}/P_{ij}} \tag{28}$$

are the cost of financial constraints, the shadow cost of regulatory capital, and the own price elasticity of demand, respectively. The optimal price is the frictionless marginal cost times a Bertrand markup times the cost of financial constraints. Products with higher regulatory risk weights ϕ (traditional products) sell at higher prices and all else equal receive lower demand. Companies with higher shadow cost of capital c (constrained companies) sell at higher prices and all else equal receive lower demand.

Comparative Statics

We next evaluate the effect of a tightening in capital regulation for traditional products ($\uparrow \phi_1$) on insurance underwriting. *Proposition 1: In response to a tightening in the capital regulation for traditional products,* *constrained insurers reduce underwriting relative to unconstrained insurers for all products:*

$$\frac{\partial s_{ij}}{\partial \phi_1} < \frac{\partial s_{i'j}}{\partial \phi_1} \quad if \quad c_i > c_i' \quad \forall j \tag{29}$$

An increase in ϕ_1 raises marginal costs and insurance prices for all firms. However, the effect is more pronounced for constrained firms for whom the shadow cost of capital c is higher, implying that prices increase more for constrained than unconstrained firms. The shift in equilibrium quantities and market shares depend on own and cross demand elasticities, the shift in firms' own prices, and the shift in the prices of all other firms. However, if firm i is relatively more constrained, all else equal, the market share of firm i reduces as (i) firm's own price increases; and (ii) relative to other firms, this increase is higher, implying a substitution away from firm i. Conversely, if firm i is relatively unconstrained, then despite an increase in its own price, it could even gain market share thanks to the substitution from relatively more constrained firms.

Proposition 2a: In response to a tightening in the capital regulation for traditional products, underwriting falls more for traditional than for linked products for all firms:

$$\frac{\partial s_{i1}/s_{i2}}{\partial \phi_1} < 0 \quad \forall i \tag{30}$$

Proposition 2b: In response to a tightening in the capital regulation for traditional products, underwriting falls more for traditional than for linked products and the fall is more pronounced for constrained firms:

$$\frac{\partial s_{i1}/s_{i2}}{\partial \phi_1} < \frac{\partial s_{i'1}/s_{i'2}}{\partial \phi_1} \quad if \quad c_i > c_i' \tag{31}$$

Propositions 2a and 2b say that all else equal, a tightening in the capital regulation of traditional products results in a change in the product mix towards linked products. Moreover, the effect is more pronounced for constrained firms.

Proofs (TBC)

Appendix C: Pricing

This section describes the computation of the annuity ratio and the reduction in yield ratio, the two measures used to price annuities and pensions contracts, and discusses conditions under which they are equivalent.

C1. Reduction in Yield Ratio

Let S_0 denote a policyholder's investment towards a single-premium pension contract at some time t_0. The contract matures in T periods and the policyholder cannot withdraw before T. Assets are invested by the pension fund earning a annually-compounded gross rate of return $R = 1 + r$. Assume without loss of generality R is constant over the life of the contract. To access this return, the policyholder pays upfront and ongoing annual fees. Upfront fees are denoted with f_0 and annual management fees are denoted with f. Both f and f_0 are quoted as percentage of the assets under management in the pension contract (the account value).

The account value at the inception of the contract net of upfront fees is:

$$S_0^+ = S_0(1 - f_0) \tag{32}$$

The account value at the maturity of the contract at time T is:

$$S_T = S_0(1 - f_0)(1 + r)^T(1 - f)^T \tag{33}$$

The gross annual investment yield before fees is simply:

$$Y = (1 + r) \tag{34}$$

The gross annual investment yield after fees becomes:

$$Y_f = \left[\frac{S_T}{S_0^+}\right]^{1/T} = (1 - f_0)^{1/T}(1 + r)(1 - f) \tag{35}$$

where the upfront fee has been amortized over the holding period of the contract.
Thus, the reduction in yield ratio (RIYR) becomes:

$$\text{RIYR} = \frac{Y}{Y_f} = \frac{1}{(1 - f_0)^{1/T}(1 - f)} \tag{36}$$

A higher ratio means more of the yield is lost to upfront and ongoing fees over the life of the contract.

C2. Annuity Ratio

Consider without loss of generality a single premium immediate life annuity for an individual aged n (for the purpose of our argument, a fixed term or period certain annuity will operate in the same way). Let π_n the one-year survival probability at age n, and Inc the annual annuity payment under the contract. Also let $M_{t,t+s}$ denote a strictly positive stochastic discount factor discounting payoffs from $t + s$ to t and $Y_{t,t+s}$ the term structure of gross (risk-free) interest rates of maturity s at time t such that $Y_{t,t+s}^s = \mathbb{E}_t\left[M_{t,t+s}\right]^{-1}$. Let S_0 denote the annuity premium (the initial investment in the contract). The annuity charges no explicit fees. Instead, in exchange of placing the initial premium with the insurance company, the policyholder receives the present discounted value of future annuity payments:

$$V_0 = \sum_{s=1}^{\infty} \frac{\prod_{l=0}^{s-1} \pi_{n+l} Inc}{Y^s_{t,t+s}} \tag{37}$$

Then the annuity ratio is:

$$AR = \frac{S_0}{V_0} \tag{38}$$

If $AR = 1$, then the annuity is actuarially fair and the policyholder gets back in present value of future annuity income exactly its initial investment. If however $AR > 1$, the annuity is sold at a markup. The higher the ratio, the more value is lost relative to the actuarially fair benchmark.

C3. Equivalence

Recall that annuity contracts charge no explicit fee. Nevertheless, receiving a present value of future annuity payments below the actuarially fair value is equivalent to charging an implicit fee on the annuity payment. To see this, let $\overline{Inc}$ be the annual annuity payment that would prevail if the annuity were actuarially fair:

$$\overline{Inc} \quad s.t. \quad \sum_{s=1}^{\infty} \frac{\prod_{l=0}^{s-1} \pi_{n+l} \overline{Inc}}{Y^s_{t,t+s}} = S_0 \tag{39}$$

Let $\bar{f}$ be the implicit percentage annual fee that, when applied to the actuarially fair annuity payment, results in a present value of future annuity payments that equals the initial investment:

$$\bar{f} \quad s.t. \quad \sum_{s=1}^{\infty} \frac{\prod_{l=0}^{s-1} \pi_{n+l} \overline{Inc}(1-\bar{f})}{Y^s_{t,t+s}} = V_0 \tag{40}$$

Then the annuity ratio becomes:

$$AR = \frac{S_0}{V_0} = \frac{1}{1-\bar{f}} \tag{41}$$

Comparing equations (36) and (41) reveals that the annuity ratio and the reduction in yield ratios are two equivalent pricing measures, where the implicit fee on the annuity contract:

$$\bar{f} = 1 - (1-f_0)^{1/T}(1-f) \tag{42}$$

is equivalent to the explicit annual fee charged on the pension contract inclusive of any upfront fees amortized over the life of the contract.

C4. Price Elasticity of Demand

Our shock to capital requirements equates to a shift in insurance supply holding the demand curve fixed. If we could measure the change in prices and quantities demanded, we could estimate the price elasticity of demand. In Section 3.9, we estimate the shift in insurance quantities in a difference in differences setting. We obtain two measures of changes in quantities: one value weighted (a 40% fall in dollar sales) which disproportionately samples from rich households with large contract values, and one equal-weighted (a 58.2% fall in contracts sold). We use both to learn about the distribution of price elasticity of demand for insurance in the cross-section of household wealth. In Section 4.2, we estimate the change in prices for the most common insurance products sold by constrained and unconstrained insurers around the regulatory shock. Even though our price data is noisy, we use it to provide a rough estimate of what would be the price semi-elasticity of demand implied by our findings.

As shown in Internet Appendix C3, we have price measures for both annuities and pensions. We are cautious in using annuity prices for interpreting price elasticities of demand as annuities are more liable to adverse selection (Finkelstein and Poterba 2004). There, the observed price change does not reflect only a change in demand for a given risk pool, but also a change in the composition of that pool.[12] For pensions, we note that our price measure can be converted into implied annual percentage fee by virtue of equations (36) and (42):

$$\overline{f} = 1 - \frac{1}{\text{RIYR}} \times 100 \tag{43}$$

We obtain a quasi-difference in differences change in pension fees by subtracting the pre-post change in fees for unconstrained companies from that of constrained companies. We find that fees have increased by 39bps for 30Y to 49bps for 20Y traditional pension contracts. Traditional pension demand is very elastic. A 1bps higher effective annual fee is associated with 0.81-1.02pp lower demand on aggregate, and 1.19-1.48pp lower demand for the average consumer shopping for insurance. This is likely because consumers see different pension contracts as close substitutes, and poorer households are more price sensitive than richer ones.

[12] Specifically, adverse selection makes demand seem more inelastic. For instance, the semi price elasticity of demand coming out of annuities is -7.9 compared to -15 for US variable annuities in Egan, Ge, and Tang 2022.

Table DI: **Traditional Underwriting Cross Sectional Heterogeneity**

This table looks at heterogeneity in the effect of regulatory frictions on traditional insurance underwriting by firm size. C is a time-invariant indicator variable that takes a value of 1 if a firm is constrained at the announcement of the new regulation in 2002 (if required capital exceeds available capital under the new regulation). P is a post regulation dummy that takes a value of 1 after 2002. Small is a dummy variable set to 1 if the company had less than £500 million in assets in 2002, which was roughly the median firm size. Column I looks at the intensive margin (the amount of traditional underwriting conditional on underwriting at all) and the specification is linear. Column II looks at the extensive margin of underwriting (sell or exit) and the specification is logit. Standard errors are clustered at the firm level. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.

	Linear	Logit
DepVar	ln(Sales)	$\mathbb{1}$(Sales>0)
	(1)	(2)
$\text{Small}_i \times C_i \times P_t$	0.637	-8.234*
	[0.494]	[4.574]
$C_i \times P_t$	-0.732*	3.503
	[0.382]	[3.769]
$\text{Small}_i \times P_t$	0.267	4.695
	[0.318]	[3.346]
Controls	Yes	Yes
Firm FE	Yes	Yes
Time FE	Yes	Yes
N	956	197

Table DII: **Insurance Underwriting: Demand vs Supply**

This table reports results from difference-in-differences regressions on the effect of regulatory frictions on traditional life insurance underwriting for the UK life insurance market, broken down into several subsamples. In all specifications, the dependent variable is log traditional insurance underwriting. C is a time-invariant indicator variable that takes a value of 1 if a firm is constrained at the announcement of the new regulation in 2002 (if required capital exceeds available capital under the new regulation). P is a post regulation dummy that takes a value of 1 after 2002. Column 1 compares constrained insurers against unconstrained insurers with a solvency ratio (available to required capital) at announcement lower than 1.5. Column 2 compares constrained insurers against unconstrained insurers with a solvency ratio (available to required capital) at announcement higher than 1.5. Column 3 compares constrained insurers with a high credit rating (BBB+ or above) against unconstrained insurers with a low credit rating (BBB or below). Column 4 compares constrained insurers with size above the 2002 median (large) against unconstrained insurers whose size is below the 2002 median (small). The controls are the insurer log total assets, credit rating, return on assets, liquidity ratio, available capital to asset ratio, share of risky assets in total assets (as a measure of asset risk), death, disability, annuity and surrender claims as percentage of total liabilities (as measures of liability risk), the share of reserves reinsured, organizational structure (stock vs mutual) and group structure. All specifications are linear. Standard errors are clustered at the firm level. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.

	All vs. Low Buffer	All vs. High Buffer	High vs. Low Rating	Large vs Small Size
ln(Sales)	(1)	(2)	(3)	(4)
$C_i \times P_t$	-0.513*	-0.547**	-0.685**	-0.842***
	[0.285]	0.273	[0.327]	[0.312]
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
N	735	674	494	549

Table DIII: **Dot-Com Crash**

This table repeats the difference-in-differences regressions on the effect of regulatory frictions on the intensive margin of underwriting (sales), the extensive margin of underwriting (exit), transfers of existing portfolios of policies and corporate reorganizations, but now controlling for insurance companies exposure to losses from the Dot-Com crash. Specifically, for every insurer having more than 50% of their liabilities in traditional products at the announcement of the regulation in 2002, we collect data on dividend income and capital gains on their equity portfolio from 1999 to 2002. We sort firms into two groups - affected and unaffected - depending on whether they have below or above median investment income ratio or equity portfolio growth, and set $DotCom_i = 1$ if insurer i has been affected (had losses above the median). P is a post regulation dummy that takes a value of 1 after 2002. The controls are the insurer log total assets, credit rating, return on assets, liquidity ratio, available capital to asset ratio, share of risky assets in total assets (as a measure of asset risk), death, disability, annuity and surrender claims as percentage of total liabilities and share of traditional liabilities in total liabilities (as measures of liability risk), the share of reserves reinsured, organizational structure (stock vs mutual) and group structure. Standard errors are clustered at the firm level. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.

	ln(Sales)		$\mathbb{1}$(Sales>0)		Reorganizations		
	Traditional	Linked	Traditional	Linked	Transfer Out	Transfer In	M&A
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$C_i \times P_t$	-0.549**	-0.114	-3.674***	-0.815	1.775*	-3.348**	1.347*
	[0.242]	[0.416]	[1.205]	[1.356]	[1.071]	[1.526]	[0.788]
$DotCom_i \times P_t$	-0.366	-0.193	-1.882	2.504	0.234	1.006	0.917
	[0.292]	[0.552]	[1.632]	[1.769]	[0.94]	[1.155]	[0.735]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	956	558	197	238	836	1,027	1,027

Table DIV: **Placebo Test – Equitable Life**

This table repeats the difference-in-differences regressions on the effect of financial frictions on the intensive margin of underwriting (sales), the extensive margin of underwriting (exit), transfers of existing portfolios of policies and corporate reorganizations, but now counterfactually assuming firms were responding to their undercapitalization at the time of Equitable Life failure in 1999 as opposed to the announcement of regulation in 2002. Specifically, for every insurer having more than 50% of their liabilities in traditional products at the announcement of the regulation in 2002, we use the Bank of England risk model to back out the ICAS regulatory solvency ratio that would have been in place at the time of Equitable Life failure (so that of end-year 1999). We redefine $C_i = 1$ if the insurer was constrained (undercapitalized) at end of 1999 and $P_t = 1$ if the year is after 1999. The controls are the insurer log total assets, credit rating, return on assets, liquidity ratio, available capital to asset ratio, share of risky assets in total assets (as a measure of asset risk), death, disability, annuity and surrender claims as percentage of total liabilities and share of traditional liabilities in total liabilities (as measures of liability risk), the share of reserves reinsured, organizational structure (stock vs mutual) and group structure. Standard errors are clustered at the firm level. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.

	ln(Sales)		$\mathbb{1}$(Sales>0)		Reorganizations		
	Traditional	Linked	Traditional	Linked	Transfer Out	Transfer In	M&A
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$C_i' \times P_t$	-0.165	-0.500	-0.758	-0.657	0.096	-0.337	-1.108*
	[0.326]	[0.625]	[1.639]	[1.266]	[1.031]	[0.973]	[0.627]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Figure D1: **Required Capital Prediction Models**

As discussed in text, a limitation of our setting is that while the stress tests were announced in 2002, stress test results were only submitted over 2003-2006. As a result, we develop a framework to identify risk exposures ex-ante (i.e. back in 2002). We proceed in two steps. In the first step, for every insurer i stress test submission between 2003 and 2006 and every risk category r, we project the observed risk exposures onto insurance and market characteristics X, interactions between those characteristics, and time fixed effects τ:

$$R_{rit} = \alpha_r + \beta_r X_{rit} + \tau_{rt} + \epsilon_{rit} \quad \forall r$$

and store the reported coefficients. Characteristics include the proportion of assets invested in equities and the past 10 years volatility of the FTSE100 index as predictors of equity market risk, the proportion of assets invested in fixed income securities and the fixed income portfolio yield as predictors of interest rate risk, the proportion of assets invested in non-government bonds, mortgages, and loans and the non-government bond yield spreads as predictors of credit risk, death and disability claim experience (claims as percentage of liabilities) as predictors of underwriting risk, the proportion of subsidiary assets in total assets as predictor of operational risk, and are taken directly from the UK Financial Services Authority guidelines on conducting ICAS stress tests. Time fixed effects account for the fact that submissions may occur at different times. Where applicable, we restrict attention to firms' first submissions only. This is to make sure we capture firms' own assessments of risk exposures – which is what firms would have likely responded to in 2002 as well – as opposed to subsequent submissions which may have been contaminated by learning from feedback and interactions with supervisors. In the second step, we map the stored regression coefficients onto the insurer and market characteristics as of the time announcement to predict risk exposures as of 2002:

$$\hat{R}_{ri0} = \hat{\alpha}_r + \hat{\beta}_r X_{ri0} \quad \forall r$$

We run the prediction separately for each risk category and then add all risk exposures together to obtain an insurer predicted required capital ex-ante at the time of the announcement (predicting total risk exposure at once as opposed to category by category returned similar results):

$$\hat{R}_{i0} = \sum_r \hat{R}_{ri0} \quad \forall i$$

Figure D2: **Required Capital Prediction Performance**

The chart shows a scatterplot of actual total required risk-based capital to asset ratio as reported by insurance companies in their first stress test submission after the regulatory announcement against the predicted total required risk-based capital to asset ratio as coming from our risk prediction model. The model works by projecting, for each insurance company and each individual risk category (equity market risk, interest rate risk, credit risk, underwriting risk, other risks),the observed risk exposures – as reported in insurance companies stress tests to the regulator – on a set of market and accounting variables that the Financial Services Authority recommends insurers to use in estimating their capital requirements, then storing the category-specific predicted risk exposure and adding them up to obtain the total predicted required capital. Actual and predicted required capital line up well, with an R2 of 68%.

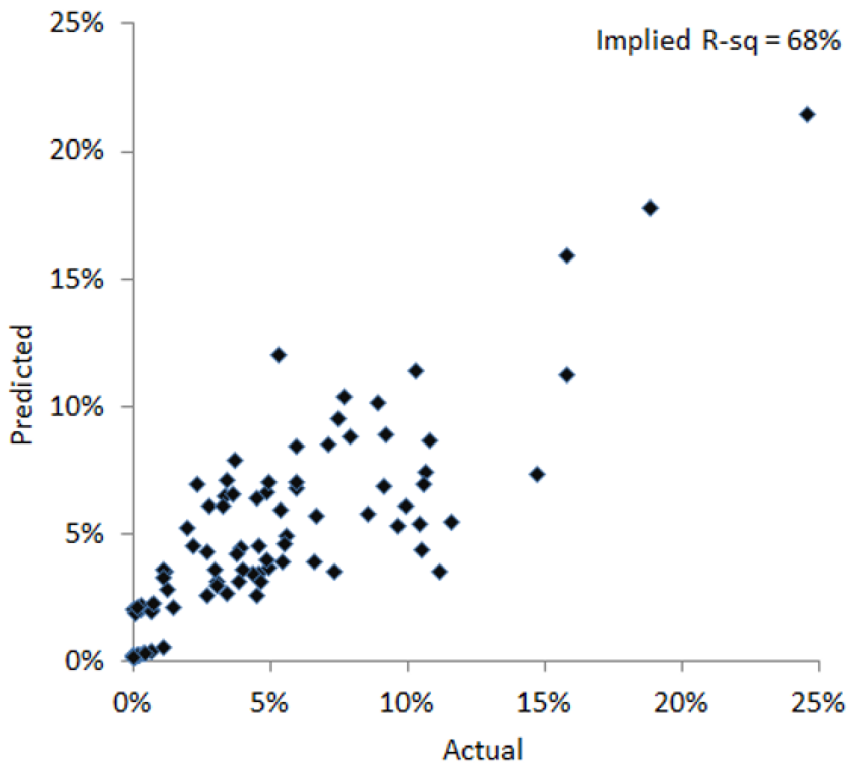


Figure D3: **Rating Prediction Model**

As a large fraction (40%) of firms in our sample are unrated, we construct company ratings from characteristics using the methodology in Koijen and Yogo 2015. We proceed in two steps. In the first step, we use credit ratings for the sample of rated firms and project them onto observable firm characteristics. We consider a firm's organizational structure (mutual vs stock), company size, leverage ratio, liquidity, profitability (return on assets), and solvency (risk-based capital ratio). In the second step, we use observable firm characteristics and the loadings estimated in the first stage to predict credit ratings for the sample of unrated firms.

First Stage: we collect data on ratings and firm characteristics for the subset of rated UK insurance companies over the period 1997 to 2007. In column I, letter ratings are converted into a linear score ranging from 10 (AAA) to 1 (CCC-) in 0.5 increments. In Column II, letter ratings are converted into a non-linear scale using Standard and Poor's historical default probabilities. Then for every rated company i at time t, we take time series averages of both the ratings scores S and firm characteristics X, and run a cross-sectional regression in the time series averages:

$$\bar{S}_i = \bar{\mathbf{X}}_i'\beta + \epsilon_i$$

Results reported below. Variable scales and standard errors reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively. Data on historical default probabilities from Standard and Poor's Ratings Direct (2014).

	Linear	Non-Linear
Rating Score	(1)	(2)
Ln(Assets)	0.08	0.35
	[0.17]	[0.24]
Capital Ratio	6.25**	-0.89
	[2.77]	[3.90]
Return on Assets	0.04	0.05
	[0.07]	[0.09]
Liquidity Ratio	-3.06	4.33
	[2.54]	[3.57]
Mutual (0-1)	-1.28	0.67
	[0.59]	[0.84]
Group (0-1)	1.37*	-1.78*
	[0.74]	[1.04]
Risky Assets (Share)	-1.22	-0.02
	[1.73]	[2.43]
Traditional Products (Share)	0.55	-3.25
	[1.71]	[2.41]
Reserves Reinsured (Share)	0.95	0.23
	[1.46]	[2.06]
Death & Disability Claims to Liabilities	-2.13	0.84
	[2.94]	[4.13]
Annuity Claims to Liabilities	25.86*	-6.21
	[13.32]	[18.74]
Surrender Claims to Liabilities	1.95	-1.14
	[1.53]	[2.15]
N	60	60
R2	0.28	0.11

Appendix E: Additional European Evidence

E1. Border Discontinuity Design

To further narrow down the set of candidate explanations for the observed variation in insurance ownership, we exploit individual residential location histories. This allows us to zoom into regulatory jurisdiction boundaries and exploit a border discontinuity design. Specifically, we restrict the sample to all people born or residing in strict regulation countries or in NUTS2 regions (the US equivalent of a collection of counties) located in lax regulation countries but bordering strict regulation countries. Let lax be a dummy = 1 whenever the individual resides in lax (rule-based capital) domicile. We ask, controlling for respondent individual characteristics (demographics and self-reported preferences and beliefs), does residing (or being born) in a lax (as opposed to a strict) regulation country affect the ownership for guaranteed life insurance contracts. The results are presented in Table EIV Column 1 and suggest that even between similar individuals in regime border regions, guaranteed life insurance ownership is 10.3pp larger in lax regulation domiciles. Importantly, note that the coefficient is almost identical to the overall effect documented in Table **??** Column 2 (12.3pp), indicating that much of the gap in insurance ownership originates not away from but precisely around the regulatory regime boundary.

Second, this is not just an average effect. In Table EV, we look at the lax jurisdiction regions bordering Switzerland – a strict regulation country – to find that border by border (Austrians and Germans vs Swiss Germans, French vs Swiss French, Italians vs Swiss Italians respectively), residing in the lax jurisdiction is associated with 11-19pp higher guaranteed life insurance ownership. Collectively, the evidence presented in this section suggests that it is either regulation or factors discontinuously shifting around regulatory jurisdiction boundaries that must drive variation in insurance ownership.

E2. Cultural Norms

A literature in political economy (Acemoglu and Robinson 2025) suggests that slow moving and hard to observe cultural norms and inherited preferences may drive both economic outcomes (in our case insurance ownership) and institutions (risk regulation). To separate local regulation from cultural norms, we exploit the fact that a subset of the respondents in our sample are first generation immigrants. Specifically, we restrict the sample to all third-country (Eastern or non-European) immigrants moving to lax and strict regulation countries and compare *same* country immigrants across regimes. We ask the following question: controlling for respondent observable characteristics, reported preferences and beliefs, taxation and retirement outside options, controlling for the length of stay and citizenship status, controlling for family composition to reflect the extent to which financial decisions might be taken by the local partner, controlling for unobserved origin-related time-invariant characteristics (such as cultural norms) through country of origin fixed effects, does residing in a lax (as opposed to a strict) regulation country affect the ownership of guaranteed life insurance? The answer is yes. Given two immigrants coming from the same country, the immigrant arriving in the lax regulation country is still substantially (+10pp) more likely to hold guaranteed life insurance (Table EIV Column (2)).

E3. Khmer Rouge War Refugees

Nevertheless, migrants may self-select into different countries based on unobserved characteristics. To alleviate selection concerns, we repeat the analysis on a subset of migrants whose destination was plausibly exogenous. Between 1974 and 1989, the UN High Commissioner for Refugees resettled more than 250,000

Indochinese refugees fleeing the Khmer Rouge by sea (the so called boat people) across European countries. While a minority of refugees were French speakers and were relocated to France, the great majority were quasi-randomly allocated across multiple countries based on a quota system. Decades later, in 2013, boat people allocated to a lax regulation country record a 15pp higher guaranteed insurance ownership (Table EIV, Column (3)). The coefficient is robust to controlling for post-immigration differences in local opportunities (their success in obtaining full citizenship, starting a family, getting a mortgage, buying a house (homeownership), finding work (employment status and industry), and investing (stock market participation))

E4. Asset or Liability Risk

By construction, insurers reported risk exposures could originate from both the liability side from the risks they assume in the product markets as well as from the asset aside from the risks they assume in the financial markets, and are subject to netting, hedging and reinsurance. To isolate variation in product-specific risks, we exploit a unique feature of the Solvency II regulation. The regulation requires insurance companies to compute a product-level capital requirement called a risk margin. The regulation defines the risk margin as the discounted value of all the equity that would be needed to fund the capital requirements stemming from insurance contracts over the life of those contracts, discounted at the euro swap rate. The idea is that a troubled insurance company would have to transfer its insurance contracts to the regulator (who would set up something equivalent to a bad bank) who would then have to ensure compliance with the regulation (cover the capital requirement) over the remaining life of those contracts. The risk margin then measures the amount of capital that the receiving party would need to set aside to take over those liabilities — importantly — assuming the bad bank would be set up from scratch (no other assets or liabilities) and invest the receiving reserves and capital in the same portfolio of risk-free assets earning the euro swap rate. By holding all other aspects of an insurance balance sheet fixed, variation in risk margin purely captures variation in product risk – the amount of risks they assume from households. The riskier the products and the longer they stay on the balance sheet, the higher the risk margin.

We have two main results. First, there is a strong positive correlation between the amount of risk initially assumed in the product markets (as coming from product level risk margins) and the amount of risk eventually retained by insurers (as coming from company level capital requirements) (Figure E2). Companies with large amounts of risks assumed (as percentage of assets) also tend to retain those risks after netting and hedging. Second, companies operating in lax regulation countries (which tend to sell more traditional products) assume substantially more risk from households than their strict regulation counterparts (13.70% vs 7.10% of assets). This is true on average as well as within subsidiaries of the same insurance group, as we explain in Section 5.6, and suggests that the correlation between product shares and risk exposures documented in Figure 2 is not explained away by risks originating elsewhere in insurers balance sheet.

Table EI: **Guaranteed Life Insurance Ownership Demographics**

This table reports differences in demographics, self-reported preferences and beliefs across guaranteed life insurance owners and non-owners, both overall across Europe and within countries (controlling for country fixed effects), and across residents of lax regulation countries (where guaranteed life insurance ownership is high) and strict regulation countries (where guaranteed life insurance ownership is low), to show that the relationship between consumer characteristics and guaranteed life insurance ownership switches sign when moving from a within country to a cross country setting. Owners defined as respondents reporting they own whole life insurance. Lax defined as countries with rule-based capital regulation in 2015. Variable scales in parentheses. Data from the nationally representative and internationally harmonized 2013 Survey of Health, Ageing and Retirement in Europe (Wave 5). All estimates are population-weighted. Standard errors in parentheses.

	Owners	Non-Owners	Difference: (1)-(2)		Lax	Strict
Variable	(1)	(2)	Overall	Within	(3)	(4)
			Characteristics			
Female (%)	49.38	54.92	-5.54	-5.79	54.19	52.61
	[0.93]	[0.41]	[1.03]	[1.06]	[0.40]	[0.85]
Age (Yrs)	62.32	67.40	-5.08	-5.26	66.71	65.47
	[0.18]	[0.10]	[0.21]	[0.22]	[0.10]	[0.22]
Single (%)	24.43	36.83	-12.39	13.78	34.76	35.89
	[0.84]	[0.41]	[0.95]	[0.98]	[0.41]	[0.85]
Chronic Illness (#)	0.99	1.19	-0.20	-0.22	1.18	0.92
	[0.02]	[0.01]	[0.02]	[0.02]	[0.01]	[0.02]
Education (Yrs)	12.52	10.49	2.02	1.19	10.77	11.32
	[0.78]	[0.39]	[0.09]	[0.09]	[0.04]	[0.09]
Income Decile (1-10)	6.38	4.98	1.40	1.46	5.20	5.17
	[0.55]	[0.25]	[0.06]	[0.06]	[0.02]	[0.05]
Homeownership (%)	76.17	72.85	3.32	9.36	74.16	65.70
	[0.77]	[0.38]	[0.87]	[0.87]	[0.37]	[0.81]
Has Mortgage (%)	25.18	14.91	10.27	8.18	13.16	50.00
	[0.82]	[0.29]	[0.87]	[0.82]	[0.29]	[0.85]
Has Stocks (%)	15.95	9.10	6.85	4.86	9.45	17.52
	[0.63]	[0.22]	[0.67]	[0.70]	[0.22]	[0.64]
			Self-Reported Preferences and Beliefs			
Right Leaning (1-10)	4.95	4.95	-0.00	-0.06	4.91	5.31
	[0.04]	[0.02]	[0.04]	[0.05]	[0.20]	[0.29]
Trust (1-10)	5.65	5.48	0.17	0.21	5.39	6.63
	[0.05]	[0.02]	[0.05]	[0.05]	[0.21]	[0.46]
Risk Aversion (1-4)	3.58	3.75	-0.17	-0.15	3.74	3.64
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Pessimism (0-100)	10.42	17.04	-6.62	-4.65	16.97	6.37
	[0.56]	[0.32]	[0.65]	[0.66]	[0.31]	[0.31]
Pr(Gov Cuts Pensions) (%)	54.65	59.10	-4.45	2.16	57.77	58.93
	[1.08]	[0.64]	[1.25]	[1.19]	[0.60]	[1.29]
Pr(Gov Raise Age) (%)	54.72	58.24	-3.53	0.83	58.55	47.89
	[1.03]	[0.67]	[1.24]	[1.19]	[0.61]	[1.34]
Childhood Health (0-5)	3.85	3.73	0.11	0.16	3.75	3.83
	[0.02]	[0.01]	[0.02]	[0.03]	[0.11]	[0.27]
Perceived Health (0-5)	3.02	2.76	0.27	0.26	2.76	3.16
	[0.02]	[0.01]	[0.02]	[0.02]	[0.01]	[0.02]
Satisfied Health Ins (1-4)	3.21	3.13	0.08	0.01	3.14	3.18
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Make Ends Meet (1-4)	3.24	2.84	0.41	0.24	2.85	3.38
	[0.02]	[0.01]	[0.02]	[0.02]	[0.01]	[0.01]

Table EII: **Guaranteed Life Insurance Ownership: Taxation and Outside Options**

This table reports differences in personal taxation and sources of public and private retirement wealth, for guaranteed life insurance owners and non-owners, both overall across Europe and within countries (controlling for country fixed effects), and across residents of lax regulation countries (where guaranteed life insurance ownership is high) and strict regulation countries (where guaranteed life insurance ownership is low), to show that the relationship between personal taxation, retirement wealth and guaranteed life insurance ownership switches sign when moving from a within country to a cross country setting. Data on retirement wealth from the nationally representative and internationally harmonized 2013 Survey of Health, Ageing and Retirement in Europe (SHARE Wave 5). Social security wealth for retirees computed as the present mortality discounted value of future pension income, where the stream of future pension income is computed starting from the latest self-reported public old age pension benefit, then price indexed over time at growth rate of 2%. Social security wealth for workers computed as the present mortality discounted value of future pension income, assuming the individual retires immediately from the labor market and starts receiving pension income at standard retirement age, where the initial pension is computed using that individual's full income and contribution histories up to the time of the interview. Wealth expressed in 2010 euros. Conditional survival probabilities are country and gender specific from the 2009 Human Mortality Database. The discount rate is 2%. Tax variables obtained by running the 2013 version of the EUROMOD tax-benefit microsimulation model on individual level characteristics from SHARE. Marginal income tax rate defined as the extra income tax payable on the last €2000 of gross annual income, expressed in percentage points. Marginal capital gains rate defined as the extra tax payable on an additional €1000 in annual capital gains, expressed in percentage points. Displacement of social benefits defined as the reduction in social benefits resulting from an additional €1000 in annual after-tax income, expressed in percentage points. All estimates are population-weighted. Standard errors in parentheses.

	Owners	Non-Owners	Difference: (1)-(2)		Lax	Strict
Variable	(1)	(2)	Overall	Within	(3)	(4)
			Outside Retirement Savings Options			
Has Mutual Funds (%)	20.22	10.35	9.87	7.72	11.57	15.54
	[0.73]	[0.23]	[0.76]	[0.77]	[0.25]	[0.53]
Has IRA (%)	39.22	15.70	23.52	18.84	19.06	23.57
	[0.93]	[0.29]	[0.97]	[1.03]	[0.32]	[0.73]
Occup. Pension Contributor (%)	48.74	37.77	10.97	8.69	35.45	78.38
	[1.50]	[0.96]	[1.78]	[1.72]	[0.89]	[1.41]
Occup. Pension Receiver (%)	15.91	15.62	0.29	1.55	11.67	56.80
	[0.99]	[0.34]	[1.05]	[1.02]	[0.34]	[0.74]
Social Security Wealth to Income	11.45	12.80	-1.35	-0.95	12.83	10.85
	[0.30]	[0.15]	[0.33]	[0.33]	[0.15]	[0.16]
			Taxation and Social Benefits			
Marginal Income Tax (%)	25.89	19.16	6.73	6.70	19.51	42.53
	[0.32]	[0.15]	[0.36]	[0.36]	[0.14]	[0.97]
Capital Gains Tax (%)	24.48	24.21	0.27	0.38	24.01	30.68
	[0.04]	[0.06]	[0.07]	[0.06]	[0.34]	[0.21]
Displaced Social Benefits (%)	2.36	3.92	-1.55	-1.62	3.78	0.03
	[0.19]	[0.12]	[0.23]	[0.25]	[0.11]	[0.01]

Table EIII: **Determinants of Guaranteed Life Insurance Ownership**

This table looks at the relationship between whole life insurance ownership (the most common type of traditional insurance ownership) and capital regulation from a harmonised and representative sample of individuals aged 50 or older across European countries. The dependent variable is 100 if the respondent has equity interest in a whole life insurance contract and 0 otherwise. Lax is a dummy set to 1 if the respondent resides in a lax regulation country (defined as historically accounting insurance liabilities at historical cost). The characteristics are the respondent age, gender, domicile (urban vs rural), years in education, family status (married or single), work status (in employment and employment industry or retiree), legal status (citizen or immigrant), income, homeownership, whether the respondent has a mortgage, participates in the stock market or has supplementary health insurance. Preferences include the respondent's political leaning and risk aversion. (Potentially subjective) Beliefs include general pessimism, the self-reported health status and reported ability to make ends meet. Outside retirement savings options include whether the respondent has an individual retirement account, participates in an occupational pension plan, and his social security wealth. Tax variables include the respondent's marginal income tax rate, capital gains tax rate and the extent to which the extra insurance income in retirement displaces means-tested social benefits. Columns (1)-(4) refer to the full sample. Column (5)-(6) restricts the sample to the subset of respondents where taxes and social benefits are observable. Data from the 2013 Survey of Health, Ageing and Retirement in Europe (Wave 5). All coefficients and standard errors are population-weighted. Number of respondents and size of the population they were meant to represent both reported. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.

	Full Sample				Tax & Benefits	
Has Whole Life	(1)	(2)	(3)	(4)	(5)	(6)
Lax	4.270***	6.503***	12.380***	10.062**	9.588***	17.797***
	[0.963]	[0.958]	[1.084]	[4.589]	[2.709]	[2.874]
Characteristics	Yes	Yes	Yes	No	Yes	Yes
Pref. & Beliefs	No	Yes	Yes	No	Yes	Yes
Portfolios	No	No	Yes	No	Yes	Yes
Combined FE	No	No	No	Yes	No	No
Taxation	No	No	No	No	Yes	Yes
Social Security	No	No	No	No	No	Yes
Respondents	33,965	33,965	33,965	33,965	24,899	7,245
Population	84,334,958	84,334,958	84,334,958	84,334,958	68,555,402	18,185,870
R2	0.058	0.070	0.097	0.646	0.103	0.098

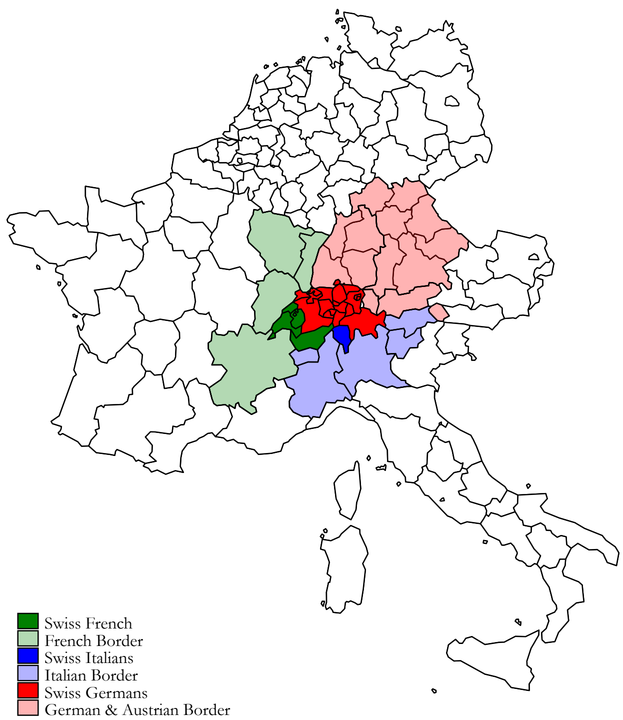
Table EIV: **Life Insurance Ownership: Borders and Immigrants**

This table looks at the relationship between whole life insurance ownership and capital regulation for three subsets of the data. Column (1) restricts the sample to respondents residing in regime border regions, where the region is defined in terms of domicile at the time of interview. We add border fixed effects to make sure each region is compared against its bordering country. Column (2) restricts to the sample of third country (Eastern or non-European) immigrants across regimes. We add country of origin fixed effects to ensure variation is within the same country of origin across destination countries. Column (3) restricts to the sample of Khmer Rouge War refugees randomly allocated across European countries. The characteristics are the respondent age, gender, domicile (urban vs rural), years in education, family status (married or single), work status (in employment and employment industry or retiree), legal status (citizen or immigrant and length of stay), income, homeownership, whether the respondent has a mortgage, participates in the stock market or has supplementary health insurance. Preferences include the respondent's political leaning and risk aversion. (Potentially subjective) Beliefs include general pessimism, the self-reported health status and reported ability to make ends meet. For columns (1) and (2), results are robust to controlling for differences in retirement savings plans such as whether the respondent has an individual retirement account, participates in an occupational pension plan. For column (3), the coefficient is robust to controlling for post-immigration differences in local opportunities (their success in obtaining full citizenship, starting a family, getting a mortgage, buying a house (homeownership), finding work (employment status and industry), and investing (stock market participation)). Data from the 2013 Survey of Health, Ageing and Retirement in Europe (Wave 5). All coefficients and standard errors are population-weighted. Number of respondents and size of the population they were meant to represent both reported. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.

	Border	Immigrants	
Has Whole Life	(1)	(2)	(3)
Lax	10.334***	8.217**	15.558**
	[1.774]	[3.431]	[8.121]
Characteristics	Yes	Yes	No
Pref. & Beliefs	Yes	Yes	No
Portfolios	Yes	Yes	No
Border FE	Yes	No	No
Origin FE	No	Yes	Yes
Respondents	11,323	1,442	131
Population	18,458,907	4,742,713	298,098
R2	0.132	0.157	0.285

Table EV: **Swiss Border Setting**

This table repeats the border regression in Table EIII Column 5 separately for the different regions on one side and other of the Swiss federal border. Specifically, column 1 column compares guaranteed life insurance ownership for Austrians in North Tyrol and Voralberg (lax regime) against Swiss Germans (strict). Column 2 compares guaranteed life insurance ownership for Germans in Bayern and Baden-Wuerttemberg (lax regime) against Swiss Germans (strict). Column 3 compares guaranteed life insurance ownership for French in Rhon-Alpes, Franche-Compte, Alsace and Lorraine (lax regime) against Swiss French (strict). And finally, column 4 compares guaranteed life insurance ownership for Italians Piedmont, Val d'Aosta, Lombardia and South Tyrol (lax regime) against Swiss Italians. The characteristics are the respondent age, gender, domicile (urban vs rural), years in education, family status (married or single), work status (in employment and employment industry or retiree), legal status (citizen or immigrant), income, homeownership, whether the respondent has a mortgage, participates in the stock market or has supplementary health insurance. Preferences include the respondent's political leaning and risk aversion. (Potentially subjective) Beliefs include general pessimism, the self-reported health status and reported ability to make ends meet. Data from the 2013 Survey of Health, Ageing and Retirement in Europe (Wave 5). All coefficients and standard errors are population-weighted. Number of respondents and size of the population they were meant to represent both reported. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.



	Austria	Germany	France	Italy
Has Whole Life	(1)	(2)	(3)	(4)
Lax	17.390***	19.269***	16.213***	10.076**
	[2.833]	[3.853]	[4.796]	[4.961]
Characteristics	Yes	Yes	Yes	Yes
Preferences	Yes	Yes	Yes	Yes
Beliefs	Yes	Yes	Yes	Yes
Respondents	2,403	1,918	906	409
Population	5,337,925	1,917,175	2,638,644	2,644,483
R2	0.207	0.161	0.130	0.305

Figure E1: **Traditional Insurance Ownership across the Income Distribution**

This figure plots traditional guaranteed insurance ownership rates in the population of individuals aged 60 or older, by income decile, separately for countries under rule-based (lax) and risk-based (strict) capital regulation regimes. Allocation into income deciles is based on how a respondent household income ranks in its respective country's income distribution. Data on household income and individual insurance ownership from the 2013 Survey of Health, Aging and Retirement in Europe (Wave 5).

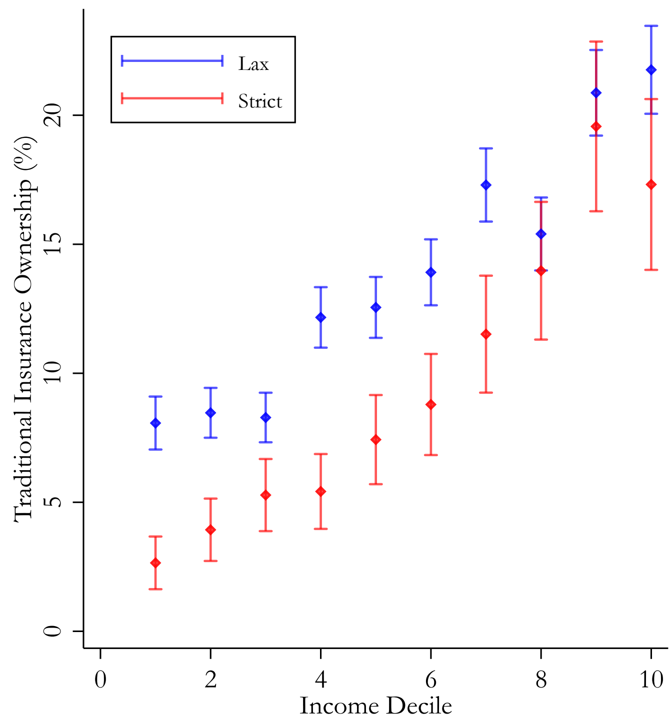


Table EVI: **Traditional Insurance Ownership across the Income Distribution**

This table looks at the relationship between whole life insurance ownership and capital regulation, but now separately across different quintiles of the income distribution. While more affluent households enjoy the same level of insurance ownership in both regimes, it is primarily poorer households in risk-based regulation countries that explain the lower insurance market participation. This survives controlling for differences in demographics, self-reported preferences and beliefs, taxation, assets and wealth, retirement savings options such as private pensions and social security. The dependent variable is 100 if the respondent has equity interest in a whole life insurance contract and 0 otherwise. Lax is a dummy set to 1 if the respondent resides in a lax regulation country (defined as historically accounting insurance liabilities at historical cost). Demographics include the respondent age, gender, domicile (urban vs rural), years in education, family status (married or single), work status (in employment and employment industry or retiree), legal status (citizen or immigrant), income, homeownership, whether the respondent has a mortgage, participates in the stock market or has supplementary health insurance. Preferences include the respondent's political leaning and risk aversion. (Potentially subjective) Beliefs include general pessimism, the self-reported health status and reported ability to make ends meet. Outside retirement savings options include whether the respondent has an individual retirement account, participates in an occupational pension plan, and his social security wealth. Tax variables include the respondent's marginal income tax rate, capital gains tax rate and the extent to which the extra insurance income in retirement displaces means-tested social benefits. Data from the 2013 Survey of Health, Ageing and Retirement in Europe (Wave 5). All coefficients and standard errors are population-weighted. Number of respondents and size of the population they were meant to represent both reported. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively.

Has Insurance	Bottom Quintile	Top Quintile
Lax	11.665***	3.719
	[4.848]	[8.881]
FE:		
Demographics	Yes	Yes
Preferences	Yes	Yes
Beliefs	Yes	Yes
Assets	Yes	Yes
Pensions	Yes	Yes
Taxation	Yes	Yes
Social Security	Yes	Yes
Respondents	1,150	1,253
Population	2,954,699	2,926,482
R2	0.101	0.108

Table EVII: **Life Insurance Supply**

This table compares the characteristics of life insurance companies in lax and strict regulation jurisdictions to assess whether lax regulation companies were in a better position to hold aggregate risk. To measure a company's ability to hold aggregate risk, we consider measures of size, competition and financial sophistication (size, concentration (Herfindahl index), whether they are affiliated to an insurance group, whether they use an internal model to compute solvency capital requirements), their ability to share aggregate risk with the financial system (organizational structure – while mutuals can share risks only among policyholders, stock companies can in principle share risk across the entire capital market – use of financial derivatives and reinsurance) and risk bearing capacity (leverage and solvency capital ratios). Column (3) shows the direction of the one-sided hypothesis test that lax regulation companies were in a better position to hold aggregate risk (more sophisticated, higher risk bearing and risk sharing capacity). Data from individual insurance companies 2016 Solvency and Financial Condition Reports available through AM Best.

Variable	Lax	Strict	Test	P-Value
	(1)	(2)	(3)	(4)
Size (Bn)	11.71	19.12	(1)>(2)	0.008
Concentration (HHI)	0.138	0.269	(1)>(2)	0.000
Mutual (%)	20.98	13.29	(1)<(2)	0.013
Affiliated (%)	79.84	82.08	(1)>(2)	0.261
Model (%)	7.94	18.50	(1)>(2)	0.000
Has Derivatives (%)	38.90	46.82	(1)>(2)	0.034
Reserves Reinsured (%)	6.51	10.66	(1)>(2)	0.015
Leverage (%)	81.68	84.73	(1)<(2)	0.963
SCR				
Overall (%)	195.15	207.71	(1)>(2)	0.112
Std Formula (%)	196.28	225.06	(1)>(2)	0.005

Insurance companies can apply to regulatory waivers and use internal models which may overstate solvency capital ratios. As a result, solvency capital ratios are defined before regulatory waivers and showed separately for companies using the regulatory prescribed standard formula.

Table EVIII: **Supply: Within-Group Analysis**

This table looks at how the composition of life insurance products and associated risk exposures varies with historical capital regulation across subsidiaries of the same insurance group. Specifically, we identify 27 insurance groups which operate subsidiaries across different regulatory regimes. For each of these subsidiaries, we record whether they operate under a lax or strict historical insurance regime, the share of products with minimum return guarantees in life insurance reserves (market value liabilities) and sales (gross written premiums), respectively (Columns (1)-(2)), as well as the associated risk exposures. For risk exposures, we observe both the total amount of aggregate risk these subsidiaries assume from households (Column (3)) as well as the total amount of aggregate risk they eventually retain, here broken down into aggregate market risk and life underwriting risk (Columns (4)-(5). Risks assumed coming from product specific capital requirements (risk margins). Risks retained (and their breakdown by source of risk) coming from subsidiary level capital requirements. Both reported as percentage of assets. We describe the methodology used to extract risks assumed from product level risk margins in Internet Appendix E4. Standard errors two way clustered at the group and country level. ***,**, and * indicate statistical significance at the 1%, 5% and, 10% level, respectively. Data from individual insurance subsidiaries 2016 Solvency and Financial Condition Reports available through AM Best.

	Guaranteed Liabilities	Guaranteed Premiums	Total Risk Assumed	Market Risk Retained	Life Risk Retained
	(1)	(2)	(3)	(4)	(5)
Lax	53.494***	43.480***	1.638***	-0.411	5.385**
	[7.028]	[6.337]	[0.518]	[0.606]	[2.092]
Group FE	Yes	Yes	Yes	Yes	Yes
Subsidiaries	153	152	151	151	151
Groups	27	27	27	27	27
Within R2	0.474	0.328	0.061	0.003	0.102

Table EIX: **Regulatory Treatment of Different Sources of Risks**

This chart plots the relative treatment of different sources of risk under risk insensitive and risk-based regulations. For every insurance company in a risk insensitive jurisdiction in our European sample, we observe their regulatory capital requirements under both the risk insensitive and risk based regulation, as well as the allocation the risk-based capital requirements into different sources of risk (market, longevity, mortality), as measured under Solvency II reporting in 2016. To compute the relative treatment of different sources of risk under different regulations, we regress:

$$\frac{SCR_{old_{ic}}}{SCR_{new_{ic}}} = \alpha + \beta M_{ic} + \delta Lo_{ic} + \epsilon_{ic}$$

where i denotes the insurer, c denotes the country, $^{SCR_{old}}/_{SCR_{new}}$ is the ratio of capital requirements under the old rule-based and new risk-based regulation, and M and Lo are the amounts of aggregate market and longevity risks per dollar of reserves as measured under the common benchmark. A $\beta < 0$ means market risk carried a lower capital requirement under the old regulation on average. $\delta > 0$ means life underwriting risk carried a higher capital requirement under the old regulation on average. The intercept measures the relative treatment of tax advantaged mutual funds under the new vs old national regulation and is a tightly identified 1 (or 100 in percentage terms) meaning they were treated about the same. Data on insurance companies reserves, capital requirements and risk exposures under the Solvency II regulation from AM Best. Standard errors clustered at the country insurer-type level.

$SCR_{old}/SCR_{new}\times100$	(1)
Market Risk (β)	-3.049***
	[0.811]
Longevity Risk (δ)	1.773***
	[0.524]
Constant (α)	99.350***
	[6.229]

Figure E2: **Risks Assumed vs Risks Retained**

The chart shows there is a strong relationship between the amount of risk that insurance companies initially assume in the product markets and the amount of risk that they eventually retain on their balance sheet after netting and hedging. This confirms that a lot of the variation in observed risk exposures across companies (and as we show elsewhere, across countries) comes from from variation in the amount of risk they assume from households. Risk assumed as coming from product-level capital requirements following the methodology in Internet Appendix E4. Risks retained as coming from company-level capital requirements. The sample is the cross-section of European life insurers in 2016. We remove companies with no reported life insurance product risk margins and companies with implausibly large risk margins (more than 50% of assets). Data from AM Best.