

Regulatory Competition in the US Life Insurance Industry

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Abstract

Competition between jurisdictions is a central feature of many public policy problems. I examine the consequences of such competition in the US life insurance industry, where states vie to attract insurers by setting lower capital requirements, but the costs of such actions are borne by other states. I develop a quantitative model of the insurance market that captures states' competition for insurers and insurers' supply-side responses. I find that competition leads regulators to set lower capital requirements, which increases default risks but also increases consumer surplus by lowering prices. On net, regulatory competition decreases total surplus and redistributes across states.

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1 Introduction

Competition between jurisdictions is a central feature of many public policy problems involving regulation and taxation. The quantitative consequences of such competition however are not well understood. A classic view is that competition allows the best regulatory policies to be chosen (Tiebout, 1956). On the other hand, if these policies have spillover effects across jurisdictions, competition could lead to a race to the bottom (Brandeis, 1933) that fails to deliver efficient outcomes. These dynamics are particularly pronounced in financial regulation, where policies set on financial intermediaries in one state or country can have systemic and global consequences.

This paper quantitatively assesses the consequences of jurisdictional competition in an \$8 trillion industry—life insurance in the US. US life insurers are regulated by individual states, which compete over capital regulations to attract insurers to be regulated by their states. The costs of this competition, however, are borne by other states, generating an externality. The size of the industry makes effective regulation vital for the financial well-being of US households and firms.

State regulators compete for insurers to be regulated by their states to raise tax revenues. States compete by setting low capital requirements on insurers' subsidiaries, called captives, allowing insurers to hold less capital by transferring liabilities to their captives. Regulators face a tradeoff: lowering capital requirements earns tax revenues for the state and reduces insurers' costs of selling insurance, but increases default risks of insurers. Importantly, the default cost is partially borne by other states, creating an externality. This is because if the insurer defaults, default costs on liabilities transferred to the captive are paid by the consumer's state guaranty fund and the consumer, not the captive's state. For example, if an insurer sells life insurance to Massachusetts consumers and transfers those liabilities to its Vermont captive, Vermont sets the capital requirements on the liabilities but Massachusetts bears their default costs.

How much does competition between state regulators affect capital requirements, default risks, and prices and quantities in the insurance market by? In addition, does competition increase or decrease total surplus, and by how much? A race to the bottom would decrease total surplus. However, if regulators were overly-strict, for example due to political incentives or agency frictions, then competition could increase total surplus by counteracting regulators' excessive strictness. To measure the strengths of these different forces, I develop a quantitative model of the insurance

market and compare the current state-based equilibrium to alternative regulatory arrangements where competition is eliminated across all states or in individual states.

To illustrate the key forces in the model, I first provide motivating evidence of the real effects of capital requirements on the supply of life insurance. Higher capital requirements may lead to higher prices if insurers face costly external financing frictions of raising capital. I show this in a difference-in-differences specification exploiting plausibly exogenous variation in capital requirements across products generated by a regulatory change in 2000 called Regulation XXX. I find that prices increased and quantities decreased for products that had larger increases in capital requirements relative to less affected products, consistent with increased capital requirements leading to an inward shift of the supply curve.

Turning to the competition between states, I show that insurers are more likely to choose states with lower captive capital requirements to set up captives. In response, state regulators have begun competing for captives, with 22 states having passed laws allowing captives to be set up in their states as of 2019. In addition, states that bear less default risks are more likely to allow captives and set lower captive capital requirements, consistent with the presence of default cost externalities. Using new data on captives' financial positions, I show that this competition has potentially large consequences on insurers' overall capital levels, decreasing risk-based capital of the median insurer using a captive by 24% in 2019.

Motivated by these empirical relationships in the data, I develop a structural model of the insurance market to evaluate the effects of regulatory competition. In the model, consumers buy life insurance from insurers, who engage in imperfect competition, endogenously default, and select which states to set up captives in. In addition, state regulators compete by setting capital requirements on captives to attract insurers to maximize state-level tax revenues and consumer and producer surplus, which involves trading off default costs against tax revenues and costs of raising capital. The model allows me to compare the current state-based equilibrium to counterfactual equilibria under alternative regulatory arrangements. A key object that the model recovers is the regulators' objective function, which captures regulators' agency frictions and dictates how regulators would behave under different regulatory arrangements. The model also provides demand and supply-side estimates needed to characterize both consumer demand, which determines consumer surplus and insurers' profitability, and pricing and default decisions

of insurers. Conceptually, my model introduces regulatory competition and insurers' strategic responses to existing work on the life insurance market (Kojien and Yogo, 2015, 2016) and banking competition (Egan, Hortaçsu, and Matvos, 2017).

My model assumes several frictions in the life insurance market relative to a perfectly competitive Modigliani and Miller (1958) benchmark. First, insurers sell differentiated products, making insurance markets imperfectly competitive. Second, insurer defaults are socially costly, for example due to the costs of systemic financial instability. Third, insurers face costs of external financing, which could arise from information asymmetries or agency frictions. Fourth, governments regulate insurers and guarantee insurance policies. The first three frictions imply a fundamental trade-off for regulators between lowering default costs and raising prices when setting capital requirements. Additionally, unlike a utilitarian social planner who maximizes total surplus subject to this trade off, regulators also are state-based and face agency frictions such as political incentives that make them value some components of social welfare more than others. Because regulators are state-based, they compete for captives to earn taxes and do not bear the full default costs, which incentivizes them to set lower capital rates. The net effect of competition on total surplus depends on the strengths of these competing forces. For example, if regulators are too strict, lowering capital rates can be beneficial because regulators would have set capital requirements too high without competition.

My model begins on the demand side, where consumers in each state market choose amongst differentiated life insurance products in a discrete choice demand system (Berry, 1994) based on prices and product characteristics.

On the supply side, insurers set up captives, set prices to sell insurance products, and choose to default. Insurers first choose states to set up captives in and allocate liabilities to captives in response to states' captive capital requirements, which I model using discrete choice frameworks. Captives decrease insurers' capital levels because captives are subject to less stringent capital requirements than operating companies. Insurers then sell differentiated life insurance products in state-level markets by setting prices in Bertrand-Nash competition. These products are subject to stochastic costs to the insurers, which can be volatile due to changes in the values of embedded financial products (Kojien and Yogo, 2018), investment returns (Chodorow-Reich, Ghent, and Haddad, 2021), and policy payouts. After these stochastic costs are realized, insurers decide

whether to continue operating or default in a Leland (1994)-style framework, which governs how capital requirements affect insurers' default risks.

On the regulator side, state regulators compete to attract captives by setting capital requirements, accounting for insurers' and consumers' endogenous responses. I model the regulator's problem by starting with a utilitarian social planner who maximizes social welfare, which is the sum of consumer and producer surplus, tax revenues, and default costs. I then add the two forces that lead regulators to deviate from a social planner. First, each state regulator only cares about welfare in their own state, which begets both competition for tax revenues between states and default externalities. Second, regulators face agency concerns and incentives that make them value certain components of social welfare more than others, which I represent as weights on each component in the regulators' utility functions. For example, regulators could face political backlash from consumers in their states if insurance prices were too high, which could lead them to over-value consumer surplus.

After developing the model, I estimate it using data on the US life insurance market. On the demand side, I estimate a discrete choice model of consumer demand using state-level sales, prices, and product characteristics data. The estimates imply an average price elasticity of demand of 2.4 for life insurance products. The demand estimates discipline the quantitative impact of capital requirements on product markets.

On the supply side, I use insurers' optimal pricing and default conditions to obtain closed-form solutions for the unobserved parameters of insurers' stochastic cost distributions. To measure how insurers choose which states to set up captives in and how their liabilities allocations to captives respond to capital requirements, I estimate a discrete choice model using insurers' observed choices of states and allocations.

On the regulator side, I use the revealed preferences of state regulators to recover their objective functions based on regulators' utility maximization problems. I calibrate regulators' tradeoff weights from numerical perturbations around their first-order conditions. I find that consistent with their incentives, state regulators prefer higher tax revenues, higher consumer surplus, and lower default risks.

Quantitatively, I estimate that state regulators are willing to trade off \$1 of default costs against \$3.5 of tax revenues and \$0.59 of consumer surplus. These estimates show that regulators' objective

functions deviate meaningfully from a social planner's, who values all components equally. The fact that regulators value consumer surplus more than default costs suggests that political concerns from consumers in particular may influence regulators' decisions.

In the third part, I use the estimated model to quantify the effects of regulatory competition and to evaluate alternative regulatory arrangements. I first study the effects of eliminating competition, modeled as federalizing insurance regulation, which is a proposal that has drawn significant public interest after the 2008 financial crisis (e.g., Federal Insurance Office, 2013). To focus on the effects of competition, I compare the current state-based equilibrium to a federal regulator that sets a uniform capital rate on all insurers, holding fixed regulators' frictions. I find that competition leads regulators to decrease capital requirements by 19% (3 p.p.). Federalizing insurance regulation would decrease default risk and lower expected default costs by \$2.4 billion. The effect is driven by a federal regulator setting a higher capital requirement to internalize the default externality from the competition. On the other hand, higher capital requirements would lead to higher insurance prices and lower consumer surplus by \$880 million. In sum, total surplus would increase by \$1.5 billion, and regulator's utility would increase by \$3.3 billion in equivalent tax revenues.

I next consider what would happen if both competition and regulators' frictions were eliminated, i.e., if there were a social planner. I show that whether eliminating competition increases social welfare depends on whether competition undoes or exacerbates the effects of regulators' frictions. In my baseline estimates, I find that competition between regulators decreases total surplus, and that a social planner would set an even higher capital rate than a federal regulator. This is because regulators over-value consumer surplus relative to default costs, so their agency frictions lead them to set lower capital rates. By also incentivizing regulators to lower capital rates, competition exacerbates the effects of these agency frictions. I also report the results under different assumptions to examine the sensitivity of these results and to understand when regulatory competition may be beneficial. Combined, the results provide a "menu" for policymakers that maps different assumptions into quantitative statements about the positive and normative effects of regulatory competition.

Given the potential gains to regulators' utilities from federalizing insurance regulation, it is perhaps puzzling why states do not do so. I provide a potential explanation by showing that federalizing would lead to significant distributional consequences across states, making some states

worse off. Large states such as California and New York would benefit the most from federalizing because those states bore substantial default risks, while states with large captive market shares like Vermont would be worse off from federalizing because they would lose captive tax revenues. These gains and losses align with actual policy positions individual states have adopted on captives: New York has called for a national ban on captives (Lawsky, 2013), and California forbids insurers from setting up captives there, while Vermont is the most prominent state in attracting captives.

Lastly, I study the effects of bans on competition by individual states. The lack of federal coordination has led some individual states to propose bans on insurers from using captives or from setting up captives in their states. For example, New York regulators have proposed a ban on captives by insurers selling in New York, while lawsuits have been filed against individual states domiciling captives such as Iowa. I estimate the effects of these unilateral bans and find that they have limited equilibrium consequences. A unilateral ban by New York on insurers selling in New York from using captives would achieve 23% of the decrease in national default costs as federalizing. A unilateral ban by Vermont on insurers setting up captives in Vermont, home to almost half of captives in the US, would only achieve 10% of the decrease in national default costs as federalizing, as insurers would shift their captives to states that do not ban captives. These results further shed light on the importance of competition and coordination between jurisdictions.

Contributions to literature. This paper contributes to several strands of literature in financial regulation, insurance, and industrial organization. The main contribution of the paper is to develop a quantitative model of competition between regulators to measure its impact on financial stability and the supply and demand of consumer financial products.

This paper contributes to a growing literature on the financial economics of insurance by introducing a new source of regulatory friction—competition between regulators—to existing work on the effects of supply-side frictions on insurance provision (e.g., Froot and O’Connell, 1999, Kojen and Yogo, 2015, 2018, Ge, 2020, Oh, Sen, and Tenekedjieva, 2021).¹ This regulatory competition directly affects the financial stability of insurers, a topic of increasing interest in the aftermath of the 2008 financial crisis. On the use of captives, this paper closely relates to

¹Other strands of the insurance literature have studied how regulations affect insurers’ investment behaviors (e.g., Becker and Opp, 2013, Ellul, Jotikasthira, Lundblad, and Wang, 2015), risk hedging (e.g., Sen, 2019, Foley-Fisher, Narajabad, and Verani, 2020, Giambona, Kumar, and Phillips, 2021), and brokerage of insurance products (e.g., Bhattacharya, Illanes, and Padi, 2019, Egan, Ge, and Tang, 2020).

Koijen and Yogo (2016), who document life insurers' use of captives and its effect on insurance prices and default risks. Relative to this literature, the main contribution of this paper is to study the competition between regulators, their actions and incentives, and the externalities and consequences of their policies. In addition, this paper also shows how regulators' and insurers' choices jointly determine the stringency of financial regulations.

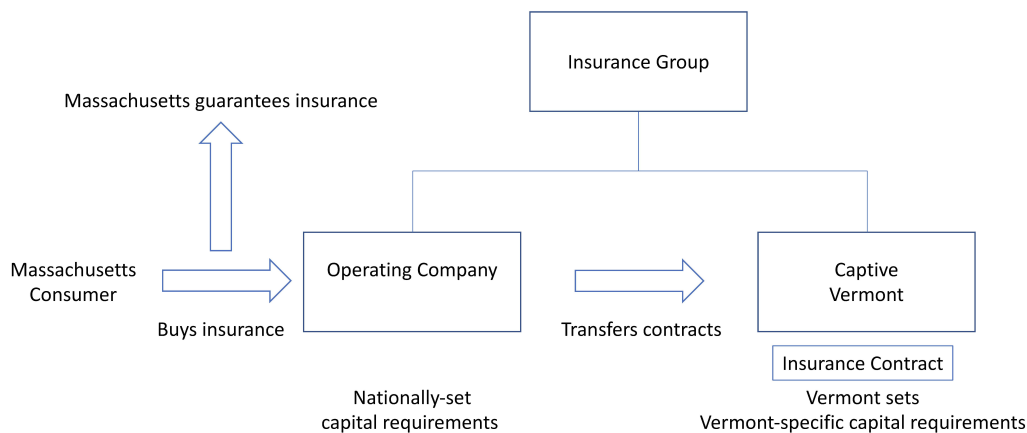
Through studying the regulation of financial intermediaries, this paper builds on a large literature on banking regulation, shadow banking, and financial regulation (e.g., Agarwal, Lucca, Seru, and Trebbi, 2014, Egan, Hortaçsu, and Matvos, 2017, and Buchak, Matvos, Piskorski, and Seru, 2018). Methodologically, this paper contributes to recent works that use methods from industrial organization to examine counterfactual regulatory policies and competition between firms in financial markets (e.g., Hortaçsu and Kastl, 2012, Allen, Clark, and Houde, 2014, Benetton, 2018, Robles-Garcia, 2019, Jiang, 2019, Agarwal, Grigsby, Hortaçsu, Matvos, Seru, and Yao, 2020). Most closely related to this paper, Egan, Hortaçsu, and Matvos (2017) use a structural model of banking competition to study multiple equilibria and fragility in the banking sector. Relative to this literature, the main contribution of this paper is to develop a new quantitative model of competition between regulators, and measuring its impact on an \$8 trillion market. This paper also provides a new way of recovering regulators' objective functions from their revealed preferences, which sheds light on the tradeoffs regulators face when setting financial policies.

Lastly, the phenomenon of jurisdictional competition resonates with a large body of work in public finance and political economy on competition and coordination between countries or states in international taxation, regulations, and economic policies. A classic literature (e.g., Tiebout, 1956, Oates, 1972) studies the allocative consequences of local vs. federal governments, which this paper quantifies in the US life insurance industry. A more recent literature (e.g., Suárez Serrato and Zidar, 2016 and Slattery, 2020) studies how local tax and economic policies affect firms' decisions on where to locate and their effects on the real economy. Relative to these works, this paper highlights capital regulations as a channel through which local jurisdictions can compete and fail to coordinate and uses detailed market data to quantify its effects in the insurance industry.

2 Institutional setting and data

Life insurers sell insurance products to households and firms. Their two main types of products are life insurance and annuities. In both types of products, the insurer collects premiums from policyholders and pays out policy claims either periodically until death for annuities or upon death for life insurance. Insurers are often structured as an insurance group with operating companies through which they sell insurance. Operating companies are domiciled in one of the 50 states or DC and are licensed by each state where it sells insurance. Insurers can also have captives, which are wholly-owned subsidiaries that reinsure the policies sold by the operating companies, which moves them off of the operating companies' balance sheets.²³ Figure 1 summarizes the key institutional features of life insurance regulation and captives in the US for a sample insurer, which I describe in detail in this section.

Figure 1: Institutional Setting



Note: Figure 1 summarizes the key institutional features of life insurance regulation and captives in the US for a sample insurer.

²Reinsurance is an insurance transaction where the insured is an insurance company, in this case the operating company, and the insurer is another reinsurance company, in this case the captive, and the risk covered by the reinsurance transaction is the liability on the policies sold by the operating company.

³Figure A1 illustrates the organizational structure of for one insurer, Lincoln Financial Group. Lincoln's main operating company is the Lincoln National Life insurer domiciled in Indiana and it has captives in Vermont and South Carolina.

Insurance is regulated by individual states, rather than the federal government, due to historical legal precedents, most notably the McCarran-Ferguson Act of 1945 (see Appendix A.1 for details). States regulate insurers' solvency, which could be motivated by information frictions for consumers and systemic consequences of financial instability of insurers.

Role of each state: There are three key states in the regulation of each insurer: the consumer's state, where the policyholder buys insurance, the domicile state, where the operating company is domiciled, and the captive state, where the captive is domiciled. For example, when Lincoln sells life insurance in Massachusetts through its Indiana operating company and transfers the policy liabilities to its Vermont captive through a reinsurance transaction, Massachusetts is the consumer state, Indiana is the domicile state, and Vermont is the captive state.

The consumer's state's (Massachusetts) guaranty fund and consumers bear default costs of insurers selling in the state. For example, if Lincoln defaults, then the shortfall on policies sold in Massachusetts would be backed by the Massachusetts state guaranty fund up to a maximum amount and the rest borne by consumers in Massachusetts.⁴ Massachusetts also collects a sales tax on the policy premiums sold in its state.

The domicile state (Indiana) regulates the operating company's solvency following regulations set cooperatively by all states through the National Association of Insurance Commissioners (NAIC) that are largely uniform across states.

The captive state (Vermont) sets solvency requirements on captives and collects tax revenues from captives in its state, but does not bear the default costs on liabilities reinsured by the captive. Unlike operating companies, captives are subject to solvency regulations set by the captive state individually, rather than uniformly by the NAIC. For example, Lincoln's captive in Vermont is subject to Vermont capital requirements that are different than the uniform national requirements for its operating company in Indiana. Solvency regulations for captives are less stringent than for operating companies, which benefits insurers by lowering the total required capital, which is costly to hold if insurers face external financing frictions.

In summary, when the insurer does not use a captive, the consumer's state (Massachusetts) collects tax revenues on policies sold, bears the default costs, and sets the solvency requirements

⁴Guaranty funds are indirectly financed by the state's taxpayers because they pay for the shortfalls from insolvencies from assessments on insurers selling in the state, which are tax deductible. The maximum guaranty amount is \$300,000 in most states on life insurance policies.

in cooperation with other states through the NAIC, which is implemented by the domicile state (Indiana). When the insurer uses a captive, the captive state (Vermont) sets the solvency requirement on the captive and collects tax revenues on liabilities transferred to the captive, while the consumer's state (Massachusetts) still collects its tax on policies sold and still bears the default costs. The insurer pays the additional captive tax to the captive state (Vermont) and lowers its required capital.

Captives' costs and benefits to states: The captive state (Vermont) benefits from attracting captives by earning tax revenues on liabilities transferred to the captives, as well as other economic benefits that accrue to the state or the regulators themselves (e.g., Stigler, 1971, Peltzman, 1976, Tenekedjieva, 2020), and by lowering consumer product prices as lower capital requirements decrease insurers' costs of raising capital.⁵

Captive states' laws exclude captives from the captive state's guaranty fund, so any default costs are borne by the consumer's state's guaranty fund and consumers. This means that the cost to the captive state is the default cost only on policies sold to consumers in its own state by insurers that use the captives. For example, if Lincoln sets up a captive in Vermont to reinsure its policies, Massachusetts' guaranty fund and consumers bear the default costs on policies sold in Massachusetts reinsured with the Vermont captive, but Vermont's guaranty fund and consumers only bear the default costs on policies sold in Vermont.

States compete to attract captives based on these benefits and costs. One key dimension that states compete on is capital regulation. This competition creates a spillover effect because the captive states can set less stringent solvency regulations to attract captives to earn tax revenues, but does not bear the full default costs, which are borne by other states' consumers and guaranty funds. Furthermore, the consumer's state is prohibited by federal law (Nonadmitted and Reinsurance Reform Act of 2010) from banning insurers selling policies in their state from using captives. For example, Massachusetts cannot prohibit Lincoln from reinsuring policies sold in Massachusetts with its Vermont captive.⁶

⁵The captive state has the right to tax captive reinsurance transactions based on a 1962 US Supreme Court ruling that states can only tax insurance transactions that occurred within the state, and captive reinsurance transactions are considered to have occurred in the captive state (State Board of Ins. v. Todd Shipyards Corp.).

⁶Political frictions may also prevent Coasian bargaining between states, for example Massachusetts cannot pay Vermont to stop allowing captives, because such payments may be politically unpopular.

Other dimensions of regulatory competition: States do not generally compete over tax rates on captives, in part because US federal tax laws (Section 845 of The Deficit Reduction Act of 1984) prohibit insurers from using reinsurance to reduce tax liabilities. States also do not compete over solvency requirements of operating companies because operating companies' choices of domiciles are primarily driven by other factors such as the locations of their customers and employees (e.g., Grace and Martinez-Vazquez, 2006) Domicile states also do not compete over tax rates on operating companies because they do not collect sales taxes on the operating companies. On the other hand, other state characteristics could affect its attractiveness as a captive domicile for insurers, including the state's business and political environments, the appointment or electoral process of the insurance regulators, geographical proximity to the insurer's operations and headquarters, and idiosyncratic relationships between the state regulators and the insurer.

In summary, before captives were developed, there was minimal regulatory competition between domicile states for operating companies, and states cooperated through the NAIC to set uniform capital regulations. This led to minimal spillover effects because the consumer's state both set uniform capital requirements through the NAIC and bore the default risk. Uniform solvency regulations benefited all states because the underlying risks of life insurance contracts, conditional on policyholder characteristics, were similar across states and because uniformity mitigated the risk of federal preemption. The development of captives as legal technologies allowed states to effectively earn tax revenues on liabilities sold in other states, incentivizing states to compete.

Capital regulations: Operating companies are required to hold capital to ensure solvency. Capital regulations are implemented through two tools: reserves and risk-based capital. Reserves are liabilities that account for future policy payouts calculated using NAIC valuation formulae. Reserves generally exceed the actuarial value of the policy payouts, where the excess amount is its excess reserves. Risk-based capital is the amount of capital insurers hold in addition to excess reserves, determined as a function of the riskiness of its assets, liabilities, and operations.

State captive regulators can set capital regulations on captives differently than on operating companies in three ways: first, states can set lower reserves for captives than for operating companies. Second, captives are not subject to risk-based capital requirements and states can set their own required capital, if any, beyond excess reserves. Third, states can allow captives to report certain types of securities as assets that are not admissible for operating companies,

such as conditional letters of credit and parental guarantees, whose reported values may exceed their actuarial values due to liquidity risk or default risk of the parent company.⁷ Appendix B.3 provides a stylized example of an insurer's balance sheet to illustrate how capital requirements are implemented and how captives affect insurers' capital. Appendix A.1 describes the institutional setting in further detail, including key insurance laws, the political economy of state-based insurance regulation, relevant tax laws, international insurance, and states' costs and benefits.

2.1 Data

The data comes from five main sources: insurers' annual NAIC filings from S&P, CompuLife, A.M. Best, SEC filings, and state legislative statutes and public records requests. My sample consists of 66 US life insurers from 2005 to 2020, with total liabilities of \$1.9 trillion, which is about 25% of the total life insurance sector. Data on insurers' financial statements and reinsurance agreements are from S&P. Data on insurers' financial ratings and the default transition probabilities come from A.M. Best.

I assemble a dataset of historical and current insurance regulations and laws of all US states and the District of Columbia.⁸ For each state, I collect data on whether the state allows captives, and if it does, its captive tax rate, and other state characteristics.

Data on life insurance product prices comes from CompuLife, a pricing software used by insurance agents. Prices are available for each product type (e.g., different term lengths for term life insurance) offered by each insurer each month given the consumer's characteristics (e.g., age, sex, and health condition). I use a 30-year-old non-smoking male with regular health purchasing a \$250,000 face amount as the representative policyholder. Prices are almost always the same nationally for each product type for a given insurer (see Appendix C.1 for details on national pricing).

Data on capital levels of captives: I assemble a novel dataset on captives' capital levels and asset information from three sources: (1) insurers' SEC filings, primarily 10-K annual reports and Forms N-4 and 485BPOS, which are annual filings of insurers selling variable annuities (see

⁷These differences in state captive regulations are corroborated in industry discussions, for example insurers stated that "[s]ome states are more liberal than others in permitting GAAP accounting for Captive cessions and/or the use of non-admitted assets for Redundant Reserves" (American Conference, 2014).

⁸I do not have data on captives' financial positions and insurance market data in non-US domiciles, so I focus on variation across US states. I discuss non-US domiciles in detail in Appendix A.1.

Egan, Ge, and Tang, 2020 for a detailed description of Forms N-4 and 485BPOS), (2) captives' financial statements released by the Iowa Insurance Department, and (3) insurers' Supplemental Term and Universal Life Insurance Reinsurance Exhibits, which report the types of assets captives have. Because the financial statements of captives are confidential under state statutes, the existing literature has studied the capitalization of captives under plausible assumptions. To the best of my knowledge, this dataset is a novel contribution to the insurance literature.

I define a state's capital rate for captives as the sum of capital divided by the sum of liabilities of all captives in the state each year, so higher capital rates for captives represent more stringent capital regulations. The mean capital rate is 4% and the standard deviation is 3%. Appendix B reports summary statistics, variable definitions, and additional details on captives' capital rates, including how I convert insurers' statutory balance sheet data into economic values.

3 Motivating evidence

In this section, I report motivating evidence in the data on competition between state regulators for captives and its real effects on the life insurance market. I begin by studying how capital requirements affect the supply of life insurance. I leverage a natural policy experiment, the introduction of Regulation XXX, which generate plausibly exogenous variation in capital rates across life insurance products, to show that the costs of raising required capital are passed through to insurance prices. I then show that insurer defaults are not rare and that higher capitalization is associated with lower default rates.

Next, turning to the competition for captives, I show that insurers are more likely to set up captives in states with low capital requirements. Using new data on captives' financial positions, I then show that this competition has potentially large effects on insurers' capital levels. In response, states compete for captives, with state for which it is less costly if insurers default setting lower capital requirements for captives.

3.1 Capital requirements affect the supply of life insurance

I begin by presenting new evidence on how capital requirements affect the supply of life insurance. Theoretically, higher capital requirements could increase insurers' marginal costs if they face external financing frictions that make it costly to raise capital. I test this using a regulatory change that increased capital requirements on certain life insurance products called Regulation

XXX on January 1, 2000. Regulation XXX increased capital requirements on products based on mechanical accounting rules, with greater increases for longer-term products, which generated plausibly exogenous variation in the cost of supplying life insurance (see Appendix A.2 for details on Regulation XXX). I exploit this variation by estimating a difference-in-differences specification to compare prices of products differentially affected by Regulation XXX:

$$\text{Price}_{i,h,t} = \sum_{h,t} \beta_{h,t} \cdot 1(\text{Month} = t)_t \cdot 1(\text{h-year term})_h + \mu_{i,h} + \mu_t + \epsilon_{i,h,t} \quad (1)$$

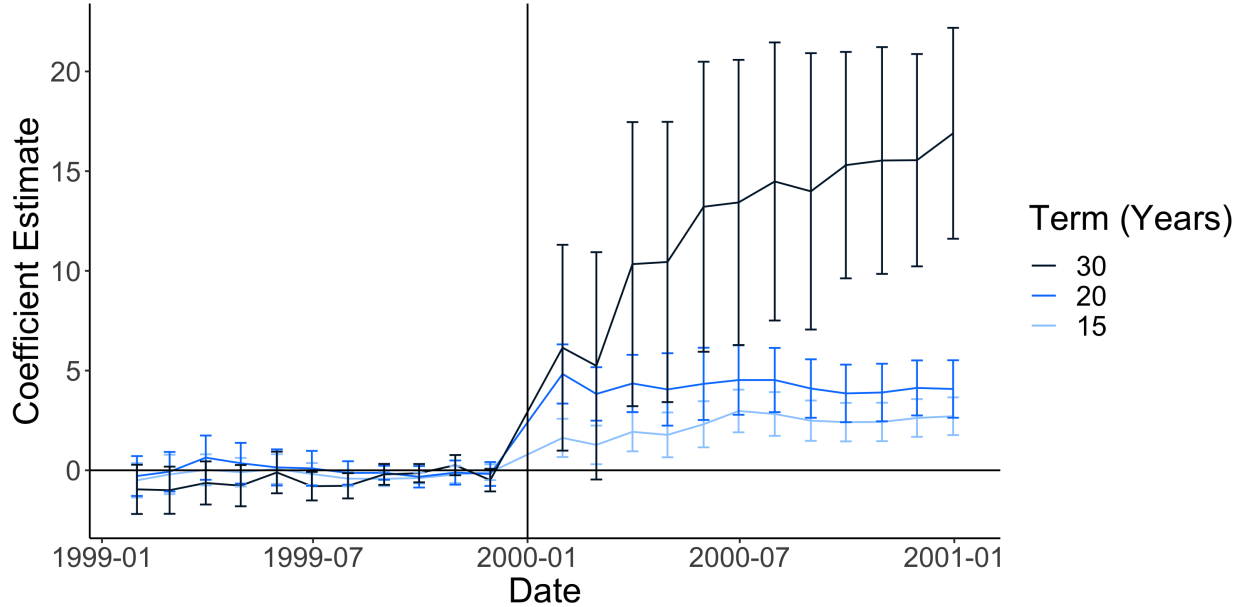
where observations are at the insurer i by product h by month t level from 1999 to 2001. $\text{Price}_{i,h,t}$ is the markup relative to the actuarial value, defined as the net present value (NPV) of premiums divided by the NPV of expected policy payouts. $1(\text{Month} = t)_t$ are indicator variables for month t . $1(\text{h-year term})_h$ are indicator variables for term lengths, i.e., 10, 15, 20, and 30-years, which are the most common product term lengths. I define the 10-year product as the reference group, so $\beta_{h,t}$ measure changes in prices relative to the 10-year product's price. $\mu_{i,h}$ are insurer-product fixed effects, which account for time-invariant differences in prices, so the identifying variation comes from price changes of the same product around Regulation XXX. μ_t are month fixed effects.

Figure 2 presents the estimates of $\beta_{h,t}$ in eq. (1). The figure shows a sharp increase in longer-term product prices immediately after Regulation XXX relative to the 10-year product, with monotonically larger price increases for products that had larger capital requirement increases, i.e., those with longer terms. To summarize the results, Table A3 reports the estimates of $\beta_{h,t}$ for all products three months after Regulation XXX, i.e., $t = \text{March } 2000$. For example, 30-year term products, which had the largest capital requirement increases, experienced an average price increase of 10.3% relative to 10-year term products.

To further ascertain that the effects are due to a supply shift, Figure A4 plots the change in quantities, defined as shares of policies sold, of products of each term length after Regulation XXX. The figure shows that quantities decreased monotonically for longer-term products relative to shorter-term products, which combined with the monotonic increase in prices of longer-term products, is consistent with an inward shift of the supply curve. These effects on supply are corroborated by a contemporaneous survey of insurers, which reported that “Regulation XXX significantly impacted the way companies price and manage their product lines” (Actuaries, 2002).

As is standard in difference-in-differences empirical designs, the key identifying assumption is

Figure 2: Effect of Capital Requirements on Product Prices: Regulation XXX



Note: Figure 2 displays the difference-in-differences coefficient estimates of life insurance product prices of each term length around the adoption of Regulation XXX, corresponding to the regression specification in eq. (1). Observations are at the insurer by product by month level. Coefficient Estimate is in percentage points of the actuarial value of liabilities of each product, e.g., 5 means 5 percentage points. The reference product is 10-year guaranteed term life insurance. Standard error bars correspond to 95% confidence intervals with standard errors two-way clustered at the insurer and month levels.

parallel trends in the outcome variable, i.e., the markup, in the absence of the policy change. The markup is comprised of market power and operating costs. The fact that products with different term lengths are sold through the same insurers to the same policyholders alleviates concerns that market power changed dramatically across products. Additionally, operating costs include commissions, which are often sticky over time and other expenses, which are generally fixed and similar across products (e.g., Egan, Ge, and Tang, 2020, Ge, 2020). Furthermore, the markup already accounts for changes in the present value of expected cash flows, e.g., mortality risk or discount rates. The Online Appendix also shows that the results hold using price changes in dollars or percentages as the outcome variable.

Capital and default risks: I also note that insurer defaults are not rare occurrences. The unconditional default rate of insurers from 1977 to 2015 is 1.6% over a 10-year period. During

the 2008 financial crisis, multiple large US life insurers applied for and received bailout funding totaling over \$60 billion (Kojien and Yogo, 2015, McDonald and Paulson, 2015). Furthermore, textbook corporate finance theory implies that higher levels of capital, all else equal, should lead to lower levels of default. I confirm that this relationship holds in my sample. Figure A5 plots the average 10-year default rate by A.M. Best capital ratios, which shows a clear negative relationship, meaning that insurers with lower capital ratios are more likely to default. Table A10 shows that the negative correlation holds controlling for a broad set of insurer characteristics and time fixed effects in an insurer-year panel regression of actual insurer insolvencies. In Section 4, I leverage a dynamic Leland (1994)-style model to formally quantify the relationship between capital levels and default risks.

3.2 Insurers' responses to states' capital requirements

Next, I examine whether insurers choose where to set up captives in response to states' capital requirements. I estimate a linear probability model of insurers' choices of states to set up captives:

$$1(\text{Captive})_{i,s,t} = \beta \cdot \text{CapitalRate}_{s,t} + \gamma_1 \cdot X_{s,t}^{\text{State}} + \gamma_2 \cdot X_{i,s,t}^{\text{Insurer}} + \mu_{i,t} + \epsilon_{i,s,t} \quad (2)$$

where observations are at the insurer by state by year level. $1(\text{Captive})_{i,s,t}$ is an indicator variable for whether insurer i has a captive in state s in year t . $\text{CapitalRate}_{s,t}$ is the state's captive capital rate. $X_{s,t}^{\text{State}}$ includes state characteristics such as the captive tax rate, business environment as proxied by number of new business incorporations per capita, past presidential election vote share, and whether the insurance commissioner is elected or appointed. $X_{i,s,t}^{\text{Insurer}}$ includes whether the insurer sells policies in the state and the share of the insurer's liabilities that were sold in the state.⁹ $\mu_{i,t}$ are insurer-year fixed effects, which absorb any insurer characteristics that affect their decisions to use captives each year. Intuitively, the regression compares the propensity of insurers to set up captives in states with different capital rates.

Table A4 reports the estimates corresponding to eq. (2). The main coefficient of interest is β , which captures how insurers' use of captives responds to states' captive capital rates. I find that insurers are more likely to set up captives in states that have lower captive capital rates. A 1 percentage point (p.p.) increase in the captive capital rate is associated with a 1.2 p.p. decrease in

⁹The set of state and insurer-state controls is chosen based on factors that industry participants and regulators indicate as affecting insurers' choices of where to set up captives, as discussed in Section 2. Appendix B contains further details on the construction and data sources of each of these variables.

the probability that the insurer chooses to set up a captive in the state (vs. 1.1 p.p. unconditional probability). Appendix C.2 reports additional results that address concerns about omitted variables and sensitivity to rule out alternative explanations, including a partial identification approach (Oster, 2019).

Insurers also choose whether to set up captives or not, and not all insurers use captives. For example, setting up captives requires fixed legal and administrative costs. Table A9 reports an insurer-year panel regression of whether an insurer set up a captive each year as a function of the insurer's characteristics. The results suggest that larger insurers are more likely to set up captives, consistent with fixed costs being important in determining captive use.

New facts on the magnitude of regulatory arbitrage: I next report how much captives affect insurers' capital levels using the new dataset I assembled on captives' financial positions. I compute adjustments to the insurer's risk-based capital by consolidating captives with the operating companies following Koijen and Yogo (2016). I find that the median insurer's risk-based capital would decline by 24% in 2019 upon consolidation of captives with operating companies' balance sheets. Translated into default probabilities, this adjustment represents an increase in the default probability from 1.0% to 2.9% over 10 years based on historical insurer default rates, assuming A.M. Best ratings do not already account for the financial positions of captives.

3.3 States' competition for captives

State regulators' competition for captives is widely acknowledged by both regulators and insurers. For example, Vermont states on its captive division homepage that "[t]he mission of the Captive Insurance Division is to maintain a regulatory system that attracts quality business to Vermont." In addition, a captive management firm stated that "[t]here is a healthy competition, as states want to be sure they don't lose business to other states" (Geisel, 2015). As of 2019, 22 states allow captives. Figure A2 plots the number of states competing for captives, which I define as having passed laws allowing captives, over time, showing a clear influx of states since the early 2000s. Despite the number of states vieing for captives, captives are highly geographically-concentrated: Vermont, the state with the most captives, has 54% of all liabilities transferred to captives in the US.

I explore how states respond to one source of variation in the costs and benefits they face in this competition: the default costs each state's guaranty fund and consumers bear. States that are

less exposed to default costs should be more willing to attract captives because it is less costly for them if under-capitalized insurers default, but they can still earn similar tax revenues. I provide suggestive evidence for this by showing how states' captive policies vary across states with their default exposures in a state-year panel:

$$\text{CaptivePolicy}_{s,t} = \beta \cdot \text{StateDefaultExposure}_{s,t} + \gamma \cdot X_{s,t}^{\text{State}} + \mu_t + \epsilon_{s,t} \quad (3)$$

where $\text{CaptivePolicy}_{s,t}$ is one of two measures: whether the state competes for captives and the state's captive capital rate if it competes. $\text{StateDefaultExposure}_{s,t}$ is the state's default exposure, measured by the total dollars of life insurance premiums sold in the state each year. $X_{s,t}^{\text{State}}$ is the same set of state characteristics as in eq. (2). μ_t is year fixed effects.

Table A5 reports the correlations of the captive policies with state default exposure following eq. (3). I find evidence consistent with states setting captive policies in response to their default exposures. States with more default exposure are less likely to allow captives (column 1) and more likely to set higher captive capital rates (column 2). The economic magnitudes are also meaningful: a 1-sd increase in the default exposure of a state (\$0.9 billion in premiums each year) decreases the probability of a state allowing captives by 4 percentage points. Combined, the facts that insurers choose states with low capital rates to set up captives (column 1 in Table A4) and that states less exposed to default set lower capital rates (column 2 in Table A5) imply that insurers are more likely to set up captives in states less exposed to default, which I confirm in column (2) in Table A4, which replaces the independent variable $\text{CaptivePolicy}_{s,t}$ with $\text{StateDefaultExposure}_{s,t}$ in eq. (2).

4 Model

I next develop a structural model of the insurance market. The goal of the model is to quantify the equilibrium effects of regulatory competition and evaluate alternative regulatory arrangements. My model assumes several key frictions in the life insurance market relative to a perfectly competitive Modigliani and Miller (1958) benchmark. First, insurers sell differentiated products, which makes insurance markets imperfectly competitive. Second, insurer defaults are socially costly, for example due to costs of systemic financial instability. Third, insurers face costs of external financing, which could arise from information asymmetries or agency frictions. Fourth, governments regulate insurers and guarantee insurance policies. Because regulators are state-based, they compete for

captives to earn taxes and do not bear the full default costs. The fundamental tension that regulators face in setting capital rates is between lowering default costs and raising prices due to costs of raising capital and market power. Regulators also face agency frictions, and competition can either counteract or exacerbate these agency frictions.

I first describe the structure of the model and each type of agent's actions, then solve for the equilibrium conditions. The model is in discrete time with infinite periods and three types of agents: insurers i , regulators in states s , and consumers c . In each time period t , the following actions occur in sequence:

1. State regulators set capital requirements on captives in their states.
2. Insurers choose states to set up captives and allocate liabilities to captives.
3. Insurers set product prices.
4. Consumers choose insurance products to purchase.
5. Insurers decide to default or to continue operating after stochastic costs are realized.

Note that I do not model tax competition between states on captives because US tax laws prohibit reinsurance for the purpose of reducing tax liabilities. I also do not model competition over tax rates or capital requirements for operating companies because operating companies' states of domicile are determined primarily by the locations of the insurers' operations (e.g., Grace and Martinez-Vazquez, 2006) and because operating companies' states do not collect premium taxes or bear default costs. I assume that both insurers and state regulators know the distributions of insurers' stochastic costs.

4.1 Consumers

Consumers choose to purchase differentiated insurance products in state-level markets from insurers based on price $P_{i,t}$ and observable insurer characteristics $X_{i,t}$. Consumers also care about unobservable (to the econometrician) insurer characteristics $\xi_{i,s,t}^{\text{Cons}}$ and have idiosyncratic preferences for individual insurers represented as i.i.d. consumer-insurer-specific demand shocks $\epsilon_{i,s,c,t}^{\text{Cons}}$. Each consumer c in state s chooses to buy one insurer i 's product to maximize her utility, which is given as

$$u_{i,s,c,t} = -\alpha P_{i,t} + \gamma X_{i,t} + \xi_{i,s,t}^{\text{Cons}} + \epsilon_{i,s,c,t}^{\text{Cons}} \quad (4)$$

where α is the consumer's marginal utility of income. In the model, consumers do not care about default risks of insurers because the products are guaranteed by the state guaranty funds. As such, insurers' use of captives only affects consumer demand through its effect on product prices.

4.2 Insurers

The insurer is organized as a holding company that has an operating company that sells insurance products in all states and a captive it transfers policies to. The insurer maximizes its total value $T_{i,t}$ by choosing a state to set up its captive in and allocating to the captive, setting product prices, and deciding whether to default or not.

Captive state choice: The insurer makes two decisions on captives. First, it chooses a state s to set up its captive in to maximize total value $T_{i,t}$:

$$T_{i,t} = \max_s E_{i,t}(s) + \xi_{i,s,t}^{\text{Ext}} \quad (5)$$

where $E_{i,t}(j)$ is the equity value of the insurer if it chooses state s to set up a captive. $\xi_{i,s,t}^{\text{Ext}}$ is an insurer-state-specific demand shock that captures other costs and benefits to insurers for choosing different states, such as political environment, geographic proximity to the insurer's operations, or amenities, as discussed in Section 2, which I assume vary across insurer-state pairs but are exogenous and constant over time. $\xi_{i,s,t}^{\text{Ext}}$ is a fixed cost (or benefit) incurred at the beginning of the period. I do not include fixed setup or switching costs because these costs are often very low.

Captive liabilities allocation: Having chosen a domicile, the insurer then chooses to transfer a share $B_{i,t}$ of its operating company's liabilities to the captive to maximize equity value:

$$\max_{B_{i,t}} E_{i,t}(B_{i,t}, \kappa_{s,t}, \xi_{i,s,t}^{\text{Int}}) \quad (6)$$

where $\kappa_{s,t}$ is state s 's capital rate on captives. $\xi_{i,s,t}^{\text{Int}}$ is an insurer-state-specific demand shock that captures unobserved (to the econometrician) utility to the insurer of allocating liabilities to the captive in state s , which includes factors such as administrative costs or the availability of professional services. The insurer also pays a tax τ per dollar of liabilities allocated to the captive to the captive state's regulator, so the total amount of tax paid is $\tau B_{i,t} Q_{i,t}$.

The insurer's overall capital rate is thus

$$\kappa_{i,t} = B_{i,t} \kappa_{s,t} + (1 - B_{i,t}) \kappa_{h,t} \quad (7)$$

where $\kappa_{h,t}$ is the capital rate on the operating company.

Price setting and default: Each insurer sells a single type of life insurance product that matures at the end of the time period.¹⁰ Each insurer's total liabilities are subject to i.i.d. stochastic costs $\widetilde{L}_{i,t} \sim N(\mu_{i,t}, \sigma_{i,t}^2)$, which include policy payouts, operating costs, investment returns, and changes in the values of return guarantees or other embedded financial products, the latter two of which can generate substantial volatility in the financial stability of insurers (e.g., Koijen and Yogo, 2018, Sen, 2019, Chodorow-Reich et al., 2021).

The insurer sets a national insurance price $P_{i,t}$ to maximize equity value. It sells in state-level markets and has market share $S_{i,s,t}$ in each state. Each state has market size $M_{s,t}$, which is the total actuarial value of life insurance liabilities in the state. So the insurer's total quantity sold nationally is $Q_{i,t}(P_{i,t}) = \sum_s M_{s,t} S_{i,s,t}(P_{i,t})$. The insurer's profit each period is

$$\Pi_{i,t}(P_{i,t}; \widetilde{L}_{i,t}) = Q_{i,t}(P_{i,t})(P_{i,t} - \widetilde{L}_{i,t}).$$

Price $P_{i,t}$ and stochastic costs $\widetilde{L}_{i,t}$ are both in units of the actuarial value per policy. For example, in a market with 10 consumers who each wishes to purchase life insurance with \$100 of annual expected payouts, the market size $M_{s,t}$ would be \$1000, and a 50% market share $S_{i,s,t}$ would mean that the insurer sold $Q_{i,s,t} = \$500$ of actuarial value of life insurance in the market. $P_{i,t} = 1$ would be actuarially-fair insurance pricing. $\widetilde{L}_{i,t} = 1$ would mean that the realized payouts equal actuarial value.

The insurer is also financed by debt and equity. Debt holders receive a coupon payment $b_{i,t}$ each period. Equity holders receive the residual cash flow. If there is a shortfall, i.e., $\Pi_{i,t} - b_{i,t} < 0$, then equity holders can either continue operating, by paying the shortfall or default, i.e., not pay the shortfall and stop operating, at which time the insurer is sold to new owners with the same capital structure. An alternative interpretation of default is that state regulators take the insurer into receivership (e.g., Gallanis, 2009).

Operating companies and captives are also subject to capital requirements. I model capital requirements as insurers having to hold capital equal to a share $\kappa_{i,t}$ of their policy liabilities and

¹⁰This means that my model does not account for the effect of insurers' pricing decisions in one period on quantities in future periods. In reality, because life insurance policies are outstanding for multiple years and the premiums are fixed over the term, prices set in the current period will affect premiums collected in subsequent periods. One interpretation of the model is that the consumer can choose not to renew the policy (i.e., lapse) but the insurer only guarantees the premiums for one year.

debt payments, denoted as $\kappa_{i,t}(b_{i,t} + Q_{i,t})$, where $\kappa_{i,t}$ is determined by the insurer's allocation of liabilities to captives in eq. (7). Capital requirements have two effects: first, the insurer loses the capital upon default, so they act as collateral that makes it costly to default. Second, equity capital is costly to raise, which could arise from information asymmetries or agency frictions. I model this cost as insurers paying θ to raise each dollar of required capital, that captures external financing frictions, and the raised capital is invested with a rate of return r_t equal to the discount rate. This cost of raising capital also makes it costly for a regulator to set high capital requirements. Both the cost of raising equity capital $\theta\kappa_{i,t}(b_{i,t} + Q_{i,t})$ and tax $\tau B_{i,t}Q_{i,t}$ are paid before stochastic costs are realized, so they are sunk costs when the insurer decides whether to default or not.

4.3 Regulators

I describe the regulator's problem by starting with a social planner, who maximizes social welfare given the frictions in the model, and then adding frictions that lead the regulators to deviate from a social planner. A social planner would maximize social welfare, which is total consumer and producer surplus plus the captive tax revenues and default costs, summed across all states:

$$W_t^{\text{Planner}} = \sum_s (\text{Tax}_{s,t} + \text{Default}_{s,t} + \text{ConsumerSurplus}_{s,t} + \text{ProducerSurplus}_{s,t}) \quad (8)$$

$\text{Tax}_{s,t}$ is the total captive taxes paid by insurers to state regulators. $\text{Default}_{s,t}$ is the sum of the social deadweight default cost and the guaranty payout. The social deadweight default cost is η per dollar of liabilities in default, which reflects systemic financial costs and real economic consequences of insurer defaults. Guaranty payout is the shortfall to policyholders that the state guaranty funds have to cover, less the amount of insurers' required capital, which the guaranty funds use to pay for part of the shortfall. $\text{ConsumerSurplus}_{s,t}$ is the standard consumer surplus under logit demand (Berry, 1994). $\text{ProducerSurplus}_{s,t}$ is the surplus accrued to the equity and debt holders. The total taxes paid by insurers, which are subtracted from producer surplus, equal the total taxes earned by state regulators tax, so the taxes are a transfer from insurers to state regulators. The expressions for the terms are given in Appendix D.1.

Unlike a social planner, regulators face frictions such as career concerns that lead them to value certain components of social welfare differently than what a social planner would. I capture these

frictions by expressing the federal regulator's utility as:

$$W_t^{\text{Regulator}} = \sum_s (\lambda_{\text{Tax}} \text{Tax}_{s,t} + \lambda_{\text{Default}} \text{Default}_{s,t} + \lambda_{\text{Consumer}} \text{ConsumerSurplus}_{s,t} + \lambda_{\text{Producer}} \text{ProducerSurplus}_{s,t}) \quad (9)$$

where the λ 's reflect the frictions regulators face. For example, a regulator may care more about consumer surplus than a social planner because the regulator may face political backlash from consumers if prices were high. Quantitatively, the ratios of λ terms reflect how much regulators are willing to trade off different components. For example, if $\lambda_{\text{Consumer}}/\lambda_{\text{Tax}} = 2$, that would mean that the regulator values consumer surplus more than taxes, and would be willing to trade off \$1 of consumer surplus for \$2 of tax revenues. Furthermore, by definition, the social planner has all λ 's equal to 1.

Compared to the federal regulator, each state regulator sets capital rates on captives in its state $\kappa_{s,t}$ to maximize utility in its own state $W_{s,t}^{\text{Regulator}}$:

$$W_{s,t}^{\text{Regulator}} = \lambda_{\text{Tax}} \text{Tax}_{s,t} + \lambda_{\text{Default}} \text{Default}_{s,t} + \lambda_{\text{Consumer}} \text{ConsumerSurplus}_{s,t} + \lambda_{\text{Producer}} \text{ProducerSurplus}_{s,t} \quad (10)$$

State regulators only value utility in their own states, which generates competition between regulators, as state regulators earn taxes on captives in their states, and default externalities, as state regulators only bear the default costs on insurance products sold in their own state. State regulators also only value the surpluses of consumers, equity, and debt holders in their state. I assume that equity and debt holders are distributed proportional to the number of consumers in each state. In the baseline formulation, federal and state regulators face the same frictions (i.e., same λ 's), and I examine in Section 6 how the counterfactual results change under different λ 's.

The regulator's problem satisfies three internal consistency constraints. First, taxes paid by insurers equal taxes earned by state regulators. Second, each insurer's required capital is used to fund the shortfall if the insurer defaults. Third, the sum of each term in the state regulator's utility across states equals the corresponding term in the federal regulator's utility.

4.4 Equilibrium

I next describe the actions of each type of agents in equilibrium. I focus on pure strategy Nash equilibria. In equilibrium, state regulators, insurers, and consumers all behave optimally with

respect to their own objective functions. State regulators set the captive capital rates that maximize their utility. Insurers choose captive allocations and set product prices to maximize equity value, and optimally default after stochastic costs are realized. Consumers choose insurance products that maximize their utility. Since all parameters are constant, the costs $\widetilde{L}_{i,t}$ are i.i.d., and the pricing of policies and realizations of their costs all occur within each period, the equilibrium is stationary.

4.4.1 Consumers

I model consumer demand following the discrete choice framework in Berry (1994). I assume that utility shocks $\epsilon_{s,k,s,t}^{\text{Cons}}$ are i.i.d. Type 1 extreme value. Consumers' discrete choice decisions lead to the following standard logit demand market shares $S_{i,s,t}$:

$$S_{i,s,t}(P_{i,t}) = \frac{\exp(-\alpha P_{i,t} + \gamma X_{i,t} + \xi_{i,s,t}^{\text{Cons}})}{1 + \sum_{l=1}^{K_{s,t}} \exp(-\alpha P_{l,t} + \gamma X_{l,t} + \xi_{l,s,t}^{\text{Cons}})} \quad (11)$$

where $K_{s,t}$ is the number of insurers selling in state s .

4.4.2 Insurers

Default decision: I solve the insurer's problem through backward induction, beginning with the last step, the default decision. After stochastic costs $\widetilde{L}_{i,t}$ are realized, the insurer can choose to either default or to continue operating. If it continues operating, its equity holder must pay the debt coupon $b_{i,t}$ and finance any shortfall. So its value of continuing operating is equal to the profit this period $\Pi_{i,t}$ minus debt payment $b_{i,t}$ plus the discounted equity value next period $\frac{1}{1+r_t} E_{i,t}$. The equity value is constant across periods due to stationarity. If the insurer defaults, it does not pay the debt coupon or receive any profits or shortfalls, and loses its required capital $\kappa_{i,t}(b_{i,t} + Q_{i,t})$. The cost of raising equity capital and captive tax are sunk costs whether the insurer defaults or not. So the insurer continues operating if its value of staying in business is greater than its loss of required capital from defaulting:

$$\underbrace{\Pi_{i,t}(P_{i,t}, B_{i,t}, \widetilde{L}_{i,t}) - b_{i,t} + \frac{1}{1+r_t} E_{i,t}}_{\text{value of staying in business}} < \underbrace{-\kappa_{i,t}(b_{i,t} + Q_{i,t})}_{\text{loss of capital}}.$$

The optimal default decision is a threshold rule where the insurer defaults if stochastic costs $\widetilde{L}_{i,t}$ exceed a threshold $\overline{L}_{i,t}$, which is implicitly defined in the above equation as the value of $\widetilde{L}_{i,t}$ such

that it holds as an equality:

$$\Pi_{i,t}(P_{i,t}, B_{i,t}, \overline{L}_{i,t}) - b_{i,t} + \frac{1}{1+r_t} E_{i,t} = -\kappa_{i,t}(b_{i,t} + Q_{i,t}). \quad (12)$$

Higher capital rates $\kappa_{i,t}$ have two effects on the insurer's default decisions. First, they act as collaterals that increase insurers' losses from default, making insurers less likely to default. Second, they affect the value of staying in business through the insurer's optimal pricing decision. Proofs for the solutions to the insurer's problems and the continuation value $E_{i,t}$ are in Appendix D.

Price-setting: The insurer sets product prices $P_{i,t}$ to maximize equity value $E_{i,t}$:

$$E_{i,t} = \max_{P_{i,t}} \underbrace{\int_{-\infty}^{\overline{L}_{i,t}} \Pi_{i,t} - b_{i,t} + \frac{1}{1+r_t} E_{i,t} f(\tilde{L}) d\tilde{L}}_{\text{value of staying in business, if no default}} - \underbrace{\int_{\overline{L}_{i,t}}^{\infty} \kappa_{i,t}(b_{i,t} + Q_{i,t}) f(\tilde{L}) d\tilde{L}}_{\text{loss of capital, if default}} - \underbrace{\theta \kappa_{i,t}(b_{i,t} + Q_{i,t})}_{\text{cost of capital}} - \underbrace{\tau B_{i,t} Q_{i,t}}_{\text{captive tax}} \quad (13)$$

where $f(\cdot)$ is the probability density function. Equity value accounts for the state guarantee of insurance products and equity holders' limited liability. Additionally, the cost of raising equity capital and the captive taxes are paid before stochastic costs are realized, so they affect the equity value regardless of whether the insurer defaults.

Solving for the first order condition, the optimal price $P_{i,t}$ is:

$$P_{i,t} = \underbrace{(1 - \epsilon_{i,t}^{-1})^{-1}}_{\text{markup}} \left[\underbrace{\mathbb{E}[\tilde{L}_{i,t} | \tilde{L}_{i,t} < \overline{L}_{i,t}]}_{\text{actuarial cost with limited liability}} + \underbrace{\frac{\kappa_{i,t} \mathbb{P}(\tilde{L}_{i,t} > \overline{L}_{i,t}) + \theta \kappa_{i,t} + \tau B_{i,t}}{\mathbb{P}(\tilde{L}_{i,t} \leq \overline{L}_{i,t})}}_{\text{capital requirement + cost of capital + tax}} \right] \quad (14)$$

$$\text{where } \mathbb{E}[\tilde{L}_{i,t} | \tilde{L}_{i,t} < \overline{L}_{i,t}] = \mu_{i,t} - \sigma_{i,t} \Lambda\left(\frac{\overline{L}_{i,t} - \mu_{i,t}}{\sigma_{i,t}}\right).$$

$\mathbb{P}(\cdot)$ is the probability function, $\Lambda(\cdot)$ is the inverse Mills ratio $\phi(\cdot)/\Phi(\cdot)$, and $\Phi(\cdot)$ and $\phi(\cdot)$ are the CDF and PDF of the standard normal distribution, respectively. $\epsilon_{i,t} = -\partial \log(Q_{i,t}) / \partial \log(P_{i,t})$ is the price elasticity of demand. Eq. (14) says that the optimal insurance price is determined by three terms that reflect the key frictions in the insurance market. The first term is the markup from imperfect competition. The second term is the actuarial cost of the expected payout, accounting for the limited liability from equity holders' option to default. Limited liability decreases marginal cost because it reduces the insurer's expected payout to policyholders in the event of large negative shocks. The third term is the effects of potential loss of required capital, cost of raising equity capital, and captive taxes on price, all of which increase marginal cost. Loss of capital is contingent

on default, $\mathbb{P}(\widetilde{L}_{i,t} > \overline{L}_{i,t})$, while the cost of capital and tax are always paid. If the insurer never defaults, then it never loses the required capital.

Captive state choice allocation of liabilities: The insurer chooses a state s to maximize its total value $T_{i,t}$ following eq. (5). After choosing a state, the insurer chooses its allocation of liabilities to captives following eq. (6), which I model as having the following functional form:

$$B_{i,t} = \frac{\exp(\beta(\kappa_{s,t} - \kappa_{h,t}) + \xi_{i,s,t}^{\text{Int}})}{1 + \exp(\beta(\kappa_{s,t} - \kappa_{h,t}) + \xi_{i,s,t}^{\text{Int}})}. \quad (15)$$

which means that the allocation to captives is a function of the state's captive capital rate and the insurer-state specific utility shock of allocating capital to the captive in state s . The functional form can be microfounded with a discrete choice problem where the insurer allocates each dollar of liabilities to captives, and each dollar has an idiosyncratic utility shock, which could reflect differences in types of liabilities.

4.4.3 Regulators

Each state regulator chooses a captive capital rate $\kappa_{s,t}$ to maximize its utility given by eq. (10), taking the actions of other state regulators $\kappa_{-j,t}$ as given. Since the levels of utility are not identified, I normalize $\lambda_{\text{Tax}} = 1$, so the λ 's can be interpreted in terms of tax revenues. For example, $\lambda_{\text{Default}} = 2$ would mean that the regulator would be indifferent between \$2 of default costs and \$1 of tax revenues. At the equilibrium, state regulators' captive capital rates satisfy the following first order conditions:

$$\frac{\partial \text{Tax}_{s,t}}{\partial \kappa_{s,t}} + \lambda_{\text{Default}} \frac{\partial \text{Default}_{s,t}}{\partial \kappa_{s,t}} + \lambda_{\text{Consumer}} \frac{\partial \text{ConsumerSurplus}_{s,t}}{\partial \kappa_{s,t}} + \lambda_{\text{Producer}} \frac{\partial \text{ProducerSurplus}_{s,t}}{\partial \kappa_{s,t}} = 0 \quad (16)$$

where the terms for consumer surplus and producer surplus are standard and given in Appendix D.1. $\text{Tax}_{s,t}$ is:

$$\text{Tax}_{s,t} = \sum_i \tau B_{i,s,t} Q_{i,t}$$

where $B_{i,s,t}$ is the share of liabilities insurer i allocates to state s , i.e., $B_{i,t}$ if insurer i chooses state s for its captive and zero otherwise. $\text{Default}_{s,t}$ is the sum of the social deadweight cost plus the

guaranty payout:

$$\text{Default}_{s,t} = \sum_i \left(\underbrace{-\eta Q_{i,s,t} \mathbb{P}(\widetilde{L}_{i,t} > \overline{L}_{i,t})}_{\text{social deadweight cost}} + \underbrace{\int_{\overline{L}_{i,t}}^{\infty} \left[Q_{i,s,t} (P_{i,t} - \widetilde{L}_{i,t}) + \kappa_{i,t} \left(1 + \frac{b_{i,t}}{Q_{i,t}}\right) Q_{i,s,t} \right] f(\widetilde{L}) d\widetilde{L}}_{\text{guaranty payout = shortfall + required capital}} \right)$$

where for each insurer i , each state's share of default is proportional to the amount of insurance sold in the state $Q_{i,s,t}$, because each state's guaranty fund backs insurance products sold in its own state and because I assume the social deadweight cost is borne equally by each consumer.

4.4.4 Equilibrium

The equilibrium is a set of state captive capital rates $\kappa_{s,t}$, insurance prices $P_{i,t}$, default thresholds $\overline{L}_{i,t}$, and insurers' captive allocations $B_{i,t}$ where all agents behave optimally with respect to their optimality conditions:

1. State regulators maximize their own utilities: $\kappa_{s,t}$ maximizes expression (10).
2. Insurers optimally allocate liabilities to captives: $B_{i,t}$ satisfies eq. (15).
3. Consumers optimally choose insurance products: market shares $S_{i,t}$ satisfy eq. (11).
4. Insurers optimally set insurance prices: $P_{i,t}$ satisfies eq. (14).
5. Insurers optimally default: $\overline{L}_{i,t}$ satisfies eq. (12).

5 Estimation and Calibration

In this section, I describe how I estimate and calibrate the model.

5.1 Consumers

I rewrite eq. (11) to express the log market share of insurer i in state s in year t as:

$$\begin{aligned} \ln(S_{i,s,t}) &= -\alpha P_{i,t} + \gamma X_{i,t} + \underbrace{\mu_{s,t}}_{\text{market fixed effects}} + \xi_{i,s,t}^{\text{Cons}} \quad (17) \\ &= \ln\left(\sum_{l=0}^{K_{s,t}} \exp(-\alpha P_{l,t} + \gamma X_{l,t} + \xi_{l,j,t}^{\text{Cons}})\right) \end{aligned}$$

where markets are at the state by year level. $X_{i,t}$ is a set of insurer characteristics that affect consumer demand following Kojen and Yogo (2016), including the A.M. Best rating of the insurer, insurer size, risk-based capital ratios, liquidity, profitability, and leverage.¹¹

¹¹A common issue in demand estimation is defining the choice set and outside good. By including market fixed effects $\mu_{s,t}$ to absorb the non-linear utility term $\ln(\sum_{l=0}^{K_{s,t}} \exp(-\alpha P_{l,t} + \gamma X_{l,t} + \xi_{l,j,t}^{\text{Cons}}))$, I do not need to specify the outside good nor observe an investor's full choice set in order to recover consumer preferences. I discuss the outside good, which I use to estimate consumer welfare, in Section 5.3.

A common challenge facing demand estimation is that prices are endogenous. If the insurers observe demand shocks before setting prices, then prices would be correlated with demand shocks and OLS estimates of eq. (17) would be biased. To address this problem, I follow Koijen and Yogo (2016) and instrument for price using an indicator for whether the insurer uses captives and squared insurer characteristics.¹²

Table 1: Consumer Demand Estimates

	(1)
Price	-2.19*** (0.66)
ln(Size)	2.38*** (0.16)
A.M. Best Rating	0.80*** (0.24)
Risk-Based Capital Ratio	-1.47** (0.75)
Liquidity	0.27 (0.36)
Return on Equity	0.07 (0.04)
Leverage	-1.52*** (0.28)
Obs.	21588
R2	0.517
State-Year FEs	X

Note: Table 1 reports the estimates corresponding to eq. (17). The dependent variable is the market share. The independent variable Price is the price of each life insurance product as a multiple of the actuarial value of its liabilities. ln(Size) is the size of the insurer measured as the log of thousands of dollars of total liabilities of the insurer. A.M. Best Rating is the insurer's A.M. Best rating converted from a letter grade to a numeric grade following A.M. Best guidelines. Risk-Based Capital Ratio is the authorized control level capital ratio of the insurer that year. Liquidity is the insurer's cash plus short-term investments divided by its total liabilities. Return on Equity is the insurer's annualized income after taxes as a percent of average capital and surplus. Leverage is the insurer's total liabilities divided by its net total assets. All independent variables except Price are standardized. Standard errors are two-way clustered at the insurer and year levels and are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

¹²The rationale is that captives are cost shifters because they decrease the marginal cost of selling insurance. The exclusion restriction is that captive use does not affect consumer demand, conditional on insurer characteristics, which is plausible because consumers may not care about default risks of insurers since their policies are backed by state guaranty funds.

Table 1 reports the results of the demand estimates corresponding to eq. (17). Observations are at the insurer by state by year level. I estimate a negative coefficient on price, with the magnitudes implying an average price elasticity of demand of 2.4. The instruments have first-stage F statistics greatly exceeding 10, indicating that they are unlikely to suffer from the weak instruments problem.¹³ As a robustness check, I also use Hausman et al. (1994)-style instruments based on prices of annuity products sold by the same insurer in the first year it started reporting annuity prices, usually before 2005, and obtain similar results.¹⁴

5.2 Insurers

Captive liabilities allocation: I calibrate how insurers' liabilities allocations change as a function of states' captive capital rates. This allows me to study insurers' captive use under counterfactual regulatory policies. Following eq. (15), I write the share of liabilities allocated to the captive by insurer i as:

$$\ln(B_{i,t}) - \ln(1 - B_{i,t}) = \beta(\kappa_{s,t} - \kappa_{h,t}) + \xi_{i,s,t}^{\text{Int}} \quad (18)$$

where $B_{i,t}$ is the share of liabilities insurer i allocated to its captive in year t and $1 - B_{i,t}$ is the share kept in the operating company. I define the share of liabilities allocated as reserve credit taken plus modified coinsurance reserve divided by the gross life and annuities reserves, following Kojien and Yogo (2016). β measures how liability allocations change in response to the captive state s 's capital rates $\kappa_{s,t}$.

Table 2 reports the estimates corresponding to eq. (18). I estimate $\beta = -9.67$, indicating that higher capital rates (i.e., higher $\kappa_{s,t}$) correspond to lower shares of liabilities allocated by insurers to captives in the state. The magnitudes imply that a one-percentage-point increase in $\kappa_{s,t}$ decreases average liabilities allocated to captives in the state by 2 p.p. at the mean level of liabilities allocated (the mean $B_{i,t}$ is 30 p.p.).

¹³Table A11 reports estimates using Hausman et al. (1994)-style instruments. Table A12 reports the first-stage estimates for both Kojien and Yogo (2016) and Hausman et al. (1994) instruments. The elasticity is the standard logit own-price elasticity, $\alpha P_{i,t}(1 - S_{i,s,t})$ and is similar to the estimates in the literature (e.g., -2.2 in Kojien and Yogo (2016)).

¹⁴The rationale is that insurers likely face common cost shocks when selling both annuities and life insurance, such as operating and distribution costs. The exclusion restriction, as is standard for Hausman et al. (1994)-style instruments, requires demand shocks to be uncorrelated between markets, which in this case is for past demand shocks for annuities to be uncorrelated with contemporaneous demand shocks for life insurance.

Table 2: Liabilities Allocated to Captives vs. Capital Rate

	(1)
State Capital Rate	-9.67*** (3.27)
Constant	-0.37* (0.19)
Obs.	675
R2	0.011

Note: Table 2 reports the estimates corresponding to eq. (18). The dependent variable is the log share of the insurer’s liabilities transferred to the captive minus the log share of the insurer’s liabilities kept in the operating company each year. The independent variable is the state’s captive capital rate $\kappa_{s,t}$ minus the operating company’s capital rate $\kappa_{h,t}$, in decimal points. Observations are at the insurer by year level. Standard errors are two-way clustered at the insurer and year levels and are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Finally, I compute insurer i ’s capital rate $\kappa_{i,t}$ each year t following eq. (7).¹⁵ To focus on the interaction between state regulators and captives, I calibrate the capital rates on operating companies, $\kappa_{h,t}$, to be the same across all states, which I set as the industry-average capital rate of all operating companies in all states, consistent with the states adopting federally-uniform NAIC model regulations.

Captive state choice: For estimating the insurer’s stochastic cost distribution parameters, the regulator’s utility weights, and my main counterfactual where all captives are eliminated, this choice is irrelevant.¹⁶ When estimating the counterfactual where a captive state bans captives, I need to estimate this choice. For ease of exposition, I use the reduced form estimates in eq. (2) in Table A4 as an approximation for this choice in eq. (5). The intuition is that this parametrizes the firm’s equity value $E_{i,s,t}(j)$ of choosing state s as a linear function of $\kappa_{s,t}$, where the estimated coefficient on the capital rate in Table A4 is the elasticity of equity value with respect to the capital rate.

¹⁵Appendix B.3.2 describes how I impute captive capital rates for states with missing data.

¹⁶This step is not required to estimate the regulators’ utility weights because I assume that the perturbations are sufficiently small such that they do not change insurers’ choices of states, only how much they allocate.

5.2.1 Pricing and default parameters

I next use the insurer's optimal pricing and default decisions to recover its loss distribution parameters, $\mu_{i,t}$ and $\sigma_{i,t}$. I solve for the closed form solutions of these parameters as:

$$\begin{aligned} \mu_{i,t} &= \sigma_{i,t} \Lambda\left(\frac{\overline{L}_{i,t} - \mu_{i,t}}{\sigma_{i,t}}\right) + P_{i,t} + \frac{Q_{i,t}}{\sum_s M_{s,t} S_{i,s,t} (1 - S_{i,s,t}) \alpha} - \frac{\kappa_{i,t} d_{i,t} + \theta \kappa_{i,t} + \tau B_{i,t}}{1 - d_{i,t}} \\ \sigma_{i,t} &= \frac{\frac{Q_{i,t}}{\sum_s M_{s,t} S_{i,s,t} (1 - S_{i,s,t}) \alpha} - \frac{\kappa_{i,t} d_{i,t} + \theta \kappa_{i,t}}{1 - d_{i,t}} - \left(\frac{1}{\Phi\left(\frac{\overline{L}_{i,t} - \mu_{i,t}}{\sigma_{i,t}}\right)} - \frac{1}{1+r_t}\right) \tau B_{i,t} + \left(\frac{\theta - r_t}{1+r_t}\right) \kappa_{i,t} \left(1 + \frac{b_{i,t}}{Q_{i,t}}\right) + \frac{b_{i,t}}{Q_{i,t}}}{\left(\Phi^{-1}(1 - d_{i,t}) + \Lambda\left(\frac{\overline{L}_{i,t} - \mu_{i,t}}{\sigma_{i,t}}\right)\right) \left(-1 + \frac{1}{1+r_t}(1 - d_{i,t})\right)} \end{aligned} \quad (19)$$

where $d_{i,t}$ is the 1-year default probability, which is the complement of the CDF of $\widetilde{L}_{i,t}$ evaluated at the threshold $\overline{L}_{i,t}$.¹⁷ r_t is the discount rate, which I calibrate to 5%. I calibrate $b_{i,t}/Q_{i,t}$, the insurer's debt interest to policy liabilities ratio, to the industry average as of 2019, computed by adding up the total debt outstanding multiplied by an interest rate of r_t divided by the total liabilities of all publicly-traded insurers. I use the 10-year term life insurance as the representative product, with a 30-year-old non-smoking male in regular health as the representative consumer. $\tau = 0.16\%$ is the captive tax rate, which is the average captive tax rate across all states. $\theta = 5\%$ is the cost of raising equity capital.

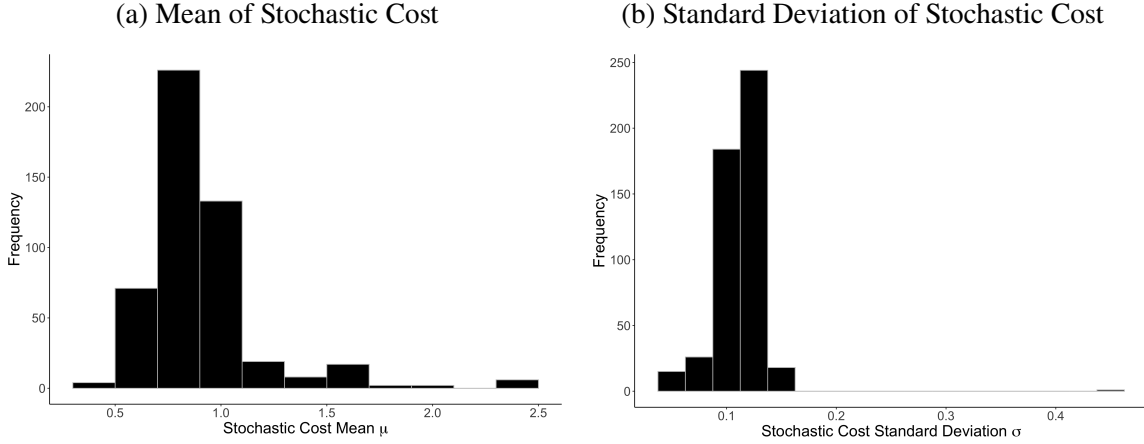
Figures 3a and 3b plot the distributions of the calibrated values of $\mu_{i,t}$ and $\sigma_{i,t}$ in the sample. The parameters are denoted in multiples of the actuarial value of policy liabilities, following the definition of stochastic costs $\widetilde{L}_{i,t}$. I find that $\mu_{i,t}$ is on average 0.89, with a similar magnitude to the average price, meaning that insurers price policies close to the actuarial value of the policy liabilities.¹⁸

I also find that $\sigma_{i,t}$, the standard deviation of stochastic policy costs, has an average of 0.11. This suggests that insurers' ex-ante policy costs are relatively volatile, potentially reflecting changes in the values of embedded financial products, such as minimum return guarantees, whose values could vary dramatically depending on market conditions, and investment returns, which can also

¹⁷ $d_{i,t} = 1 - \Phi\left(\frac{\overline{L}_{i,t} - \mu_{i,t}}{\sigma_{i,t}}\right)$. I compute default rates using historical impairment rates from A.M. Best following Kojien and Yogo (2016), as detailed in Appendix B.4. The default probabilities I obtain are objective default probabilities, not risk-neutral default probabilities as would be estimated from CDS spreads.

¹⁸ $\mu_{i,t} = 1$ is actuarially-fair pricing if consumers do not lapse. However, $\mu_{i,t}$ can be less than 1 because actuarial values are calculated without adjusting for consumer lapses, so the actuarial values are overstated, since lapsations decrease the expected total policy payouts. There is no standard model of lapsations.

Figure 3: Calibrated Supply-Side Parameters



Note: Figures 3a and 3b report the distributions of the calibrated means and standard deviations of insurers' stochastic costs. Observations are at the insurer by year level from 2005 to 2019. The means and standard deviations are inverted from insurers' optimal pricing and default conditions following eq. (19). All values are expressed as multiples of the actuarial value of liabilities.

fluctuate significantly during financial crises.¹⁹

While I do not explicitly target empirical data in my calibration of $\mu_{i,t}$ and $\sigma_{i,t}$, I compare them to costs implied by accounting measures of the operating profits and losses and investment returns of US life insurers. A caveat is that $\mu_{i,t}$ and $\sigma_{i,t}$ are parameters of the ex-ante distribution of stochastic costs, whereas accounting measures correspond to realizations of $\widetilde{L}_{i,t}$. Nonetheless, I find that the calibrated parameters are broadly consistent with the values computed from insurers' accounting statements. For example, the mean $\mu_{i,t}$ and $\sigma_{i,t}$ based on insurer-level accounting measures are 1.05 and 0.09, which are in line with the calibrated averages $\mu_{i,t}$ and $\sigma_{i,t}$.

5.3 State regulators

I use perturbations around the observed equilibrium to recover state regulators' tradeoff weights. I numerically differentiate the components in eq. (16) to calculate the partial derivatives by perturbing $\kappa_{s,t}$ by $\epsilon = 0.0001$ from the observed equilibrium, solving for the new equilibrium, and computing tax, default cost, consumer surplus, and producer surplus in the new equilibrium.

¹⁹To interpret the magnitudes, note that $\sigma_{i,t}$ captures changes to the present values of policy liabilities, which can be volatile because they have long duration. For example, suppose an insurer sold a 10-year insurance policy with an annual expected payout of \$100. If in year t , the annual expected payout increases by 1%, i.e., \$1 each year, then the insurer would incur a policy cost equal to the present value of \$1 each year over 10 years, rather than just the \$1 of payout increase in that year.

Appendix D.1 provides the expressions for each component and Appendix E details the solution method I use to solve for new equilibria. For consumer surplus, I define the outside good as life insurance policies sold by companies that are not in my sample.²⁰ In my baseline calibration, I set $\eta = 0.25$ following related estimates in the literature on the costs of bank failures (e.g., Granja et al., 2017). This means that default by an insurer with \$100 billion in liabilities would lead to \$25 billion in social costs. I also analyze how the results and interpretations change under different assumptions about η in Section 6.

In my baseline specification, I also assume $\lambda_{\text{Producer}} = 0$ under the assumption that state regulators do not value producer surplus, which is plausible if most capital owners of insurers are outside the state and thus the state regulator places no weight on their surplus. I verify this in the Appendix and show that $\lambda_{\text{Producer}}$ is not statistically or economically significantly different from zero and that the results are virtually identical if I include producer surplus in the estimates.²¹ As such, I calibrate λ_{Default} and $\lambda_{\text{Consumer}}$ in a linear regression following eq. (16):

$$\frac{\partial \text{Tax}_{s,t}}{\partial \kappa_{s,t}} = -\lambda_{\text{Default}} \frac{\partial \text{Default}_{s,t}}{\partial \kappa_{s,t}} - \lambda_{\text{Consumer}} \frac{\partial \text{ConsumerSurplus}_{s,t}}{\partial \kappa_{s,t}} + \epsilon_{s,t} \quad (20)$$

Table 3 reports the estimated tradeoff weights. I find that both λ_{Default} and $\lambda_{\text{Consumer}}$ are positive, so that state regulators' utilities are increasing in tax revenue and consumer surplus and decreasing in the amount of insurer default (since $\text{Default}_{s,t}$ is more positive if default costs are lower). The components are in the same units, i.e. millions USD, so the λ 's can be compared to a social planner's, who would have all λ 's equal to 1, as discussed in Section 4.3.

Interpretation: $\lambda_{\text{Default}} > 0$ provides quantitative evidence of the key trade-off that state regulators face between captive tax revenues and default costs. The variation in the data that informs this tradeoff is the fact that states whose captive tax revenues vary substantially with changes in captive capital rates (i.e., $\partial \text{Tax}_{s,t} / \partial \kappa_{s,t}$ being negative and large in magnitude) are those that have many captives, so changes in those states' captive capital rates have large effects on the default risks of insurers (i.e., $\partial \text{Default}_{s,t} / \partial \kappa_{s,t}$ being positive and large in magnitude).

²⁰This follows approaches used to study banking competition in Egan et al. (2017) and mortgage markets in Benetton (2018) and Robles-Garcia (2019). The outside good's quantity is the total premiums sold by companies not in my sample divided by the average product price in the same market (i.e. state and year), and their average market share is the quantity divided by the number of companies not in my sample.

²¹For example, Table A14 reports the estimates of $\lambda_{\text{Producer}}$, which is close to zero, although with the caveat that it is noisily estimated.

Table 3: Regulators' Weight Estimates

	(1)	(2)	(3)	(4)
Default Cost	-1.68*** (0.60)	-1.37** (0.56)	-3.66*** (0.76)	-3.50*** (0.82)
Consumer Surplus			-6.20*** (1.65)	-6.59*** (1.90)
Year FEs		X		X
Observations	271	271	271	271
R ²	0.11	0.24	0.16	0.29

Note: Table 3 reports the estimates corresponding to eq. (16). The dependent variable is the partial derivative of state's tax revenues with respect to the capital rate, $\frac{\partial \text{Tax}_{s,t}}{\partial \kappa_{s,t}}$. The independent variable Default Cost is the partial derivative of the state's default cost with respect to the capital rate, $\frac{\partial \text{Default}_{s,t}}{\partial \kappa_{s,t}}$. Consumer Surplus is the partial derivative of the state's consumer surplus with respect to the capital rate, $\frac{\partial \text{ConsumerSurplus}_{s,t}}{\partial \kappa_{s,t}}$. Observations are at the state by year level. Standard errors are two-way clustered at the state and year levels and are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Similarly, $\lambda_{\text{Consumer}} > 0$ means that state regulators value lower insurance prices and greater quantities. The signs on λ_{Default} and $\lambda_{\text{Consumer}}$ further imply that higher capital rates both decrease default costs (increase $\text{Default}_{s,t}$) and increase product prices (decrease $\text{ConsumerSurplus}_{s,t}$), that regulators would have to tradeoff these two competing objectives to maximize utility.

The magnitudes imply that state regulators are indifferent between a \$1 of default cost and \$3.5 of tax revenue or \$0.59 of consumer surplus. Compared to the social planner, state regulators appear to over-value consumer surplus relative to default costs, which they over-value relative to tax revenues. These magnitudes shed light on the strengths of various institutional frictions affecting regulators, in particular that agency concerns stemming from consumers, such as political backlash from high prices, play an important role in influencing regulators' decisions.

6 Counterfactual policy analysis

In this section, I use my model to compare the current state-based equilibrium to alternative regulatory arrangements and to quantify the effects of competition. I first examine what would happen if we eliminated competition between states, but held other aspects of the insurance market

constant, including the regulators' frictions and objective functions. I then study the effects of eliminating both competition and regulators' institutional frictions. Lastly, I decompose the net effect into the effects of sorting (Tiebout, 1956) and from the race to the bottom (Brandeis, 1933). I model eliminating competition as federalizing insurance regulation, a major regulatory reform which has attracted significantly policy attention (e.g., Federal Insurance Office, 2013) and extend my analysis by considering bans on captives by individual states (e.g., Lawsky, 2013).

6.1 Federal insurance regulation

In the United States, states' rights to regulate insurance are rooted in historical legal precedents. States' rights to regulate insurance were first established by the Supreme Court ruling of *Paul v. Virginia* in 1869. The ruling was briefly overturned in *United States v. South-Eastern Underwriters Association* in 1944, before being reinstated by Congress through the McCarran-Ferguson Act in 1945, which has preserved state-based insurance regulation ever since. The historical legal reasoning was that insurance contracts were not "transactions of commerce" and thus fell outside of federal interstate commerce regulations.

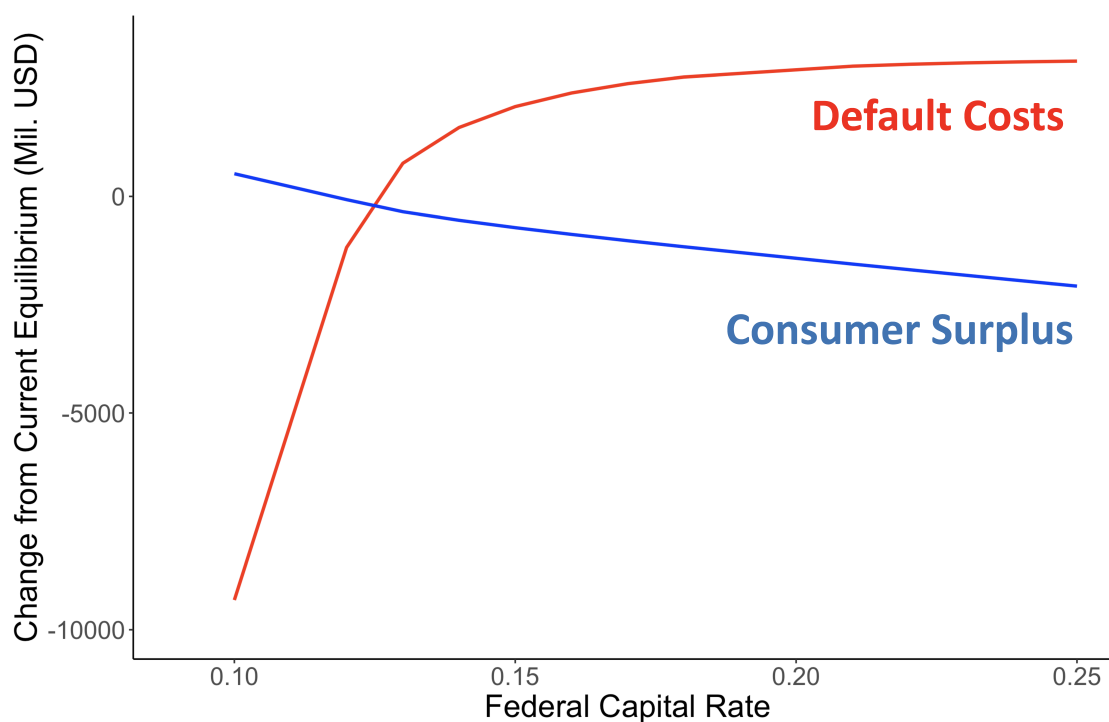
In recent decades, there has been increasing interest by the US federal government, consumers, and industry participants to federalize insurance regulation (e.g., Grace and Klein, 2009), especially after a series of insurer insolvencies in the 1980s and the financial crisis of 2008. In response, US Congress created the Federal Insurance Office within the Treasury Department through the Dodd-Frank Act in 2010 to advise state and federal governments on insurance regulations, although it has no regulatory powers.

I study how moving to a federal regulator would affect the insurance market. I model the federal regulator as setting a uniform capital rate across all insurers and banning captives.²² I first report the changes to market outcomes under different federal capital rates in 2019. I report all values as the present values over 10-year periods.

Figure 4 illustrates the effect of different capital requirements on expected default costs and consumer surplus. As the uniform federal capital rate increases, default risks decrease, which means less negative default costs, until capital rates reach about 25%, beyond which default is virtually eliminated. In addition, higher capital rates increase insurers' marginal costs. At low levels of

²²A federal regulator can do better than a uniform capital rate by setting insurer-specific capital rates. To highlight the fundamental forces of competition, I focus on a federal regulator setting a uniform capital rate.

Figure 4: Default Costs and Consumer Surplus under Different Federal Capital Rates



Note: Figure 4 report the national expected default costs and consumer surplus for different capital rates under a federal insurance regulator that sets a uniform federal capital rate. Federal Capital Rate is the uniform federal capital rate that a federal regulator sets, in decimal points. Default Cost and Consumer Surplus are estimated using 2019 market data and are changes in the respective terms relative to the observed equilibrium, in millions USD. A positive y-value in Figure 4 represents less insurer defaults, i.e., better, and higher consumer surplus, i.e., better, than the current state-based equilibrium.

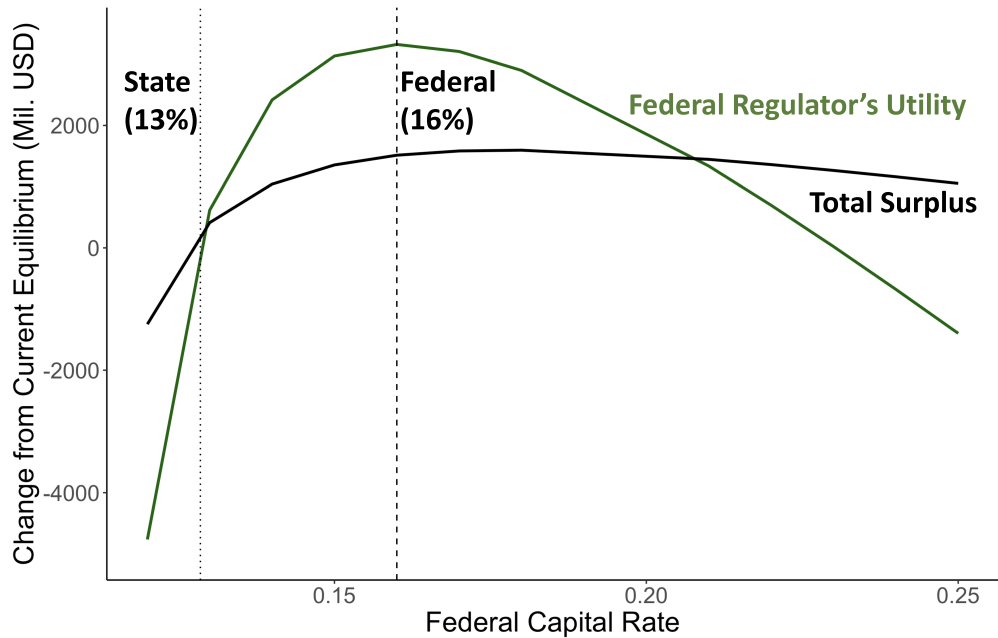
capital rates, this effect is partially offset by the effect of greater financial stability from increasing capital rates, which decreases the insurer's expected loss of capital. Overall, the counteracting effects of capital rates on default costs and consumer surplus highlight the tradeoff that regulators face in setting capital rates.²³

I use these results to measure the net effects of regulatory competition on regulator's utility and social welfare. To isolate the effects of competition, I first hold the regulators' objective functions constant and compute regulator's utility under the federal regulator using the utility weights estimated from state regulators' revealed preferences in Section 5.3. Figure 5 plots

²³Following Section 5.3, I present the main results here omitting producer surplus. Capital requirements have small effects on the levels of producer surplus, so all the results are virtually unchanged whether producer surplus is included or not.

regulators' utility over different federal capital rates. At low levels of capital, regulator's utility increases as capital rates increase because the benefits of lowering default costs outweigh costs of higher insurance prices, whereas at high levels of capital, the costs of raising additional equity capital under higher capital requirements dominate as default risk is gradually eliminated from the insurance sector.

Figure 5: Regulator's Utility vs. Capital Rate: Federal Counterfactual



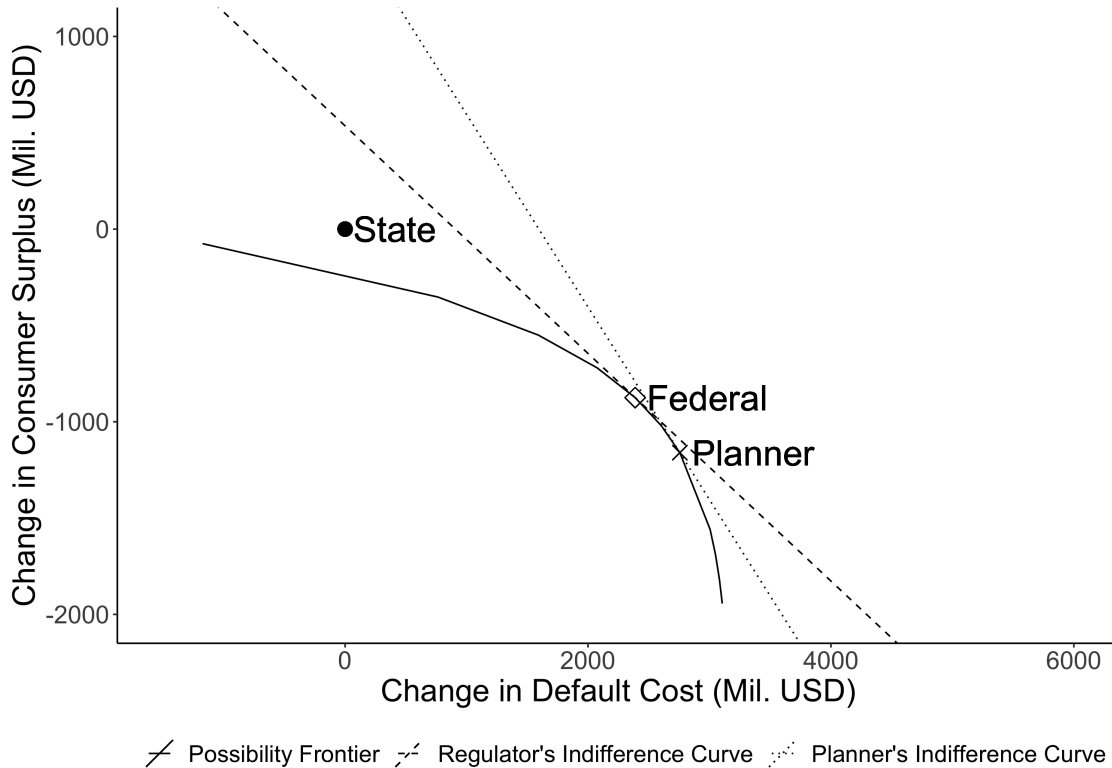
Note: Figure 5 reports total regulator's utility and total surplus for different capital rates under a federal insurance regulator that sets a uniform federal capital rate. Federal Capital Rate is the uniform federal capital rate that a federal regulator sets, in decimal points. Total Surplus is given by eq. (8), i.e., the sum of tax revenues, consumer and producer surplus, and default costs. Regulator's Utility is given by eq. (9), i.e., the weighted sum of tax revenues, consumer and producer surplus, and default costs, where the weights are the regulators' λ 's. All estimates are based on 2019 market data and are reported as the change relative to the observed equilibrium, in millions USD.

The analysis indicates that to maximize their utility, the federal regulator would set a higher capital rate, 16%, than the state-based average capital rate of 13%. This would result in a \$2.4 billion decrease in default costs and a \$880 million decrease in consumer surplus. The net effect is an increase in regulator's utility that the regulators value at \$3.3 billion in equivalent tax revenues.

I illustrate these results and the economic insights of the subsequent analyses in Figure 6. The solid line plots the production possibilities frontier of a federal regulator that sets a uniform capital

rate, i.e., the equilibrium default costs and consumer surpluses under different uniform capital rates. The x-axis is the change in default costs (more positive values mean less default) and the y-axis is the change in consumer surplus (more positive values mean higher consumer surplus), so shifting up and to the right represent better outcomes, like a standard production possibilities frontier. The negative relationship between attainable default costs and consumer surpluses represents the

Figure 6: Regulator’s Production Possibility Frontier and Indifference Curves



Note: Figure 6 plots the regulator’s production possibility frontier and indifference curves. All values are in millions USD in terms of changes from the current state-based equilibrium in 2019. The x-axis plots the change in expected default costs, where more positive values mean less default, i.e., better. The y-axis plots the change in consumer surplus, where more positive values mean more consumer surplus, i.e., better. The solid line plots the regulator’s production possibility frontier, which is the set of default costs and consumer surpluses attainable by a federal regulator that sets a uniform federal capital rate. State is the current state-based equilibrium, which by definition is at (0,0). The dashed line plots the federal regulator’s indifference curve based on the revealed preference estimates of state regulators’ λ ’s. Federal (diamond-shaped point) is the tangent point of the federal regulator’s indifference curve and the production possibility frontier, which is the equilibrium that maximizes the federal regulator’s utility. The dotted line plots the social planner’s indifference curve, which is $\lambda_{\text{Consumer}} = \lambda_{\text{Default}} = 1$. Planner (x-shaped point) is the tangent point of the social planner’s indifference curve and the production possibility frontier, which is the equilibrium that maximizes social welfare.

regulator's tradeoff, while its concavity represents the diminishing marginal gains to raising capital rates when capital rates are high and lowering them when low.

The regulators' λ weights define their indifference curves, with slope equal to the ratio $-\lambda_{\text{Default}}/\lambda_{\text{Consumer}}$. The dashed line plots the federal regulator's indifference curve based on the revealed preference estimates of state regulators' λ 's. The tangent point (diamond shape) labeled "Federal" is the equilibrium that maximizes the federal regulator's utility, with less default in the insurance sector (more positive x-value) and lower consumer surplus (more negative y-value).

Next, I decompose the net effect of competition into the effects of Tiebout (1956) sorting and Brandeis (1933) race to the bottom by comparing the current state-based equilibrium, at the point labeled "State", which by definition is at (0,0), to the production possibility frontier of the federal regulator setting a uniform capital rate. The fact that the state-based equilibrium lies beyond what is attainable by a federal regulator setting uniform capital rates shows that sorting is present in this market. Indeed, in the data, more stable insurers use captives to lower capital requirements, thus being able to offer lower insurance prices at any given level of total default risks in the insurance sector than would be attainable if all insurers were subject to the same federal capital rate.

On the other hand, the federal regulator would set a higher capital rate than the current state-based average, illustrating the race to the bottom. Furthermore, the fact that the state-based equilibrium lies below the federal regulator's indifference curve indicates that the race to the bottom has a larger effect quantitatively than sorting, so that regulators would have higher utility if competition were eliminated.

Comparison to social planner and social welfare: My model also makes predictions about what a social planner would do, which I now explore, under the assumption that all components of social welfare are correctly measured. A social planner would eliminate both competition and regulators' institutional frictions, which means setting $\lambda_{\text{Default}} = \lambda_{\text{Consumer}} = 1$. I illustrate the social planner's indifference curve in the dotted line in Figure 6 and the social welfare-maximizing equilibrium at the tangent point (x-mark) labeled "Planner". Notably, the social planner sets an even higher capital rate at 18%, leading to less default, lower consumer surplus, and higher social welfare than the federal regulator. This means that the agency frictions the regulators face lead them to set lower capital rates, so undoing these frictions would move the market further away from the state-based equilibrium. Another way to see this is to note that regulators have $\lambda_{\text{Consumer}} > \lambda_{\text{Default}}$, i.e., they

care more about consumer surplus and lowering insurance prices than default costs.

More generally, the estimates show that competition unambiguously leads regulators to lower capital rates and increases regulator's utility. However, whether eliminating competition increases social welfare depends on whether competition undoes or exacerbates regulators' frictions. If regulators' frictions led regulators to over-value default costs relative to consumer surplus, then competition could be socially beneficial because it could counteract regulators' frictions that incentivize them to set high capital rates. In my baseline estimation, regulators' frictions incentivize them to over-value consumer surplus, leading them to set lower capital rates, which is why competition exacerbates these frictions in the baseline estimates. On the other hand, competition could undo regulators' frictions if the true social cost of default η were low, because regulators' revealed preferences (eq. 16) would imply that regulators over-value default costs relative to consumer surplus. One feature of my model is that it allows me to quantify how different assumptions lead to different conclusions on whether competition exacerbates or counteracts regulators' frictions.

Discussion and robustness: I next examine how the results change under different assumptions. To summarize these alternative results, I compute the range of each parameter in which the baseline conclusion, that competition decreases total surplus, would remain unchanged if other parameters were held constant. I find that competition decreases total surplus as long as (1) the social costs of insurer default are at least \$0.10 per \$1 of insurer's assets, (2) the social costs of insurers raising capital are not more than \$0.14 per \$1 of capital, and (3) the social welfare function does not weight consumer surplus more than four times as much as default costs (they are equally weighted, i.e., added up dollar-for-dollar, under a total-surplus-maximizing social welfare function).

Interpreting these alternative results also answers the question of when competition may be beneficial. In the model, the key social tradeoff that a social planner faces when setting capital requirements is that on one hand, requiring insurers to hold more capital is socially costly, but on the other hand, under-capitalized insurers may be more likely to default, which is also socially costly. If insurer defaults had close to zero social costs or if insurers' costs of raising capital were very high, then high amounts of capital requirements would imply that regulators are too strict, so that competition between regulators would be beneficial. Figure A6a illustrates this graphically by changing the observed equilibrium in Figure 6 to a counterfactual equilibrium where regulators

are overly-strict, with $\lambda_{\text{Default}}/\lambda_{\text{Consumer}} = 5$. In this scenario, a federal regulator would set a higher capital rate than a total-surplus-maximizing planner, since the Federal point lies below and to the right of the Planner point.

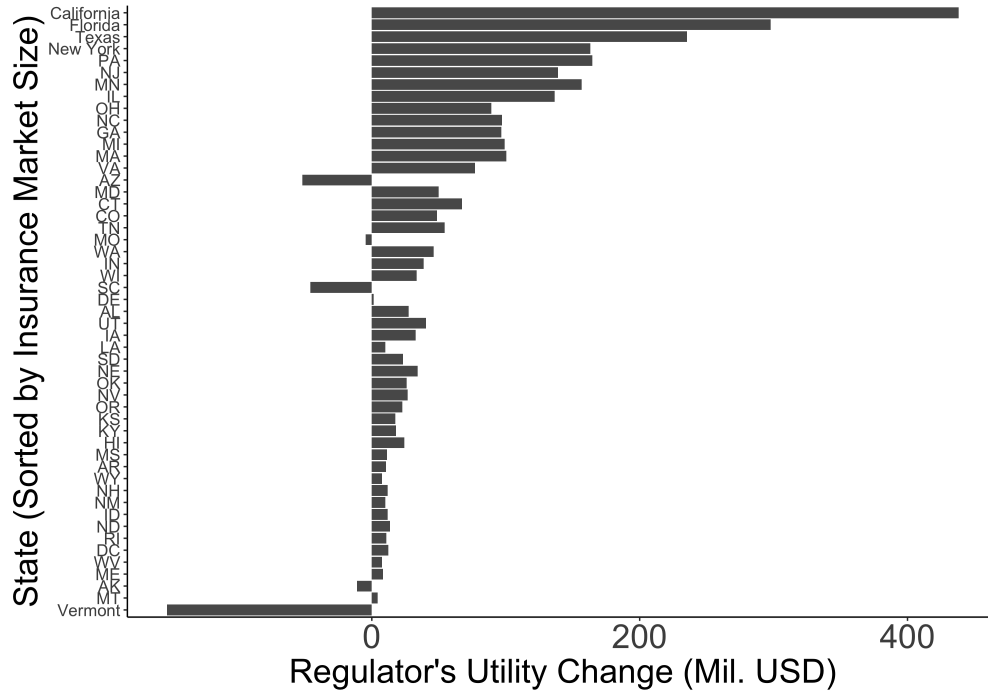
Lastly, a social welfare function which places a large weight on consumer surplus relative to default costs could also mean that competition, which lowers capital rates and lowers prices, would be beneficial. Such a social welfare function may arise if the social planner has progressive redistributive preferences, for example if the costs of default are borne by insurers' equity and bondholders, who may be wealthier than life insurance consumers. Figure A6b illustrates this by changing the observed equilibrium to a counterfactual equilibrium where the social welfare function weights consumer surplus 10 times as much as default costs. In that case, again, competition pushes the regulator to set lower capital rates, decreasing prices and increasing consumer surplus.

Why don't states coordinate? Given the potential increases in regulator's utility, it is a puzzle why coordination has been difficult to implement. One potential explanation is that not all states would derive large benefits in the presence of political frictions or switching costs that prevent states from sharing in the gains from federalizing, so some states may prefer to not coordinate or eliminate competition.

I find evidence consistent with this in Figure 7, which reports the changes in regulator's utility for each state under a federal regulator, by decreasing state insurance market size. I find that there are substantial distributional consequences across states from federalizing. Larger states like California and New York gain the most from federalizing, because they bore substantial default risks. On the other hand, smaller states had little to gain because they had minimal exposure to default, with states with many captives, most notably Vermont, being substantially worse off from federalizing because they would lose captive tax revenues.

These gains and losses also align with actual policy positions individual states have adopted on captives: New York, as one of the largest states, has called for a national ban on captive transactions (Lawsky, 2013). California has also forbidden insurers from domiciling captives. On the other hand, Vermont, the smallest state in the US by life insurance market size, has become the largest domicile for captives in the US.

Figure 7: Distributional Consequences, Regulator's Utility Change by State



Note: Figure 7 reports the changes to regulator's utility for each state under a federal regulator that sets a uniform federal capital rate to maximize the federal regulator's utility. States are sorted from largest to smallest by the amount of life insurance premiums sold in the state in 2019. All values are in terms of changes from the current state-based equilibrium in 2019. Regulator's Utility is computed for each state following eq. (10) and is in millions USD in equivalent tax revenues.

6.2 Individual state bans

An alternative set of policies that does not require cooperation is bans by individual states on captives, where either the consumer's state bans insurers selling policies in its state from using captives or the captive's state bans captives from domiciling in its state. Studying such bans also sheds light on how much cooperation and competition between states matter and informs the most efficient action to take to achieve the desired outcome. Given political constraints on federal coordination, it may be preferable to change policies in only one or a few states if doing so achieves close to the full effects of federalizing.

Ban by consumer's state: I first study a ban by the consumer's state.²⁴ This is equivalent to a ban on transferring policies sold in the state to a captive if the operating company only sells policies

²⁴Such bans are prohibited under current federal law (the Nonadmitted and Reinsurance Reform Act).

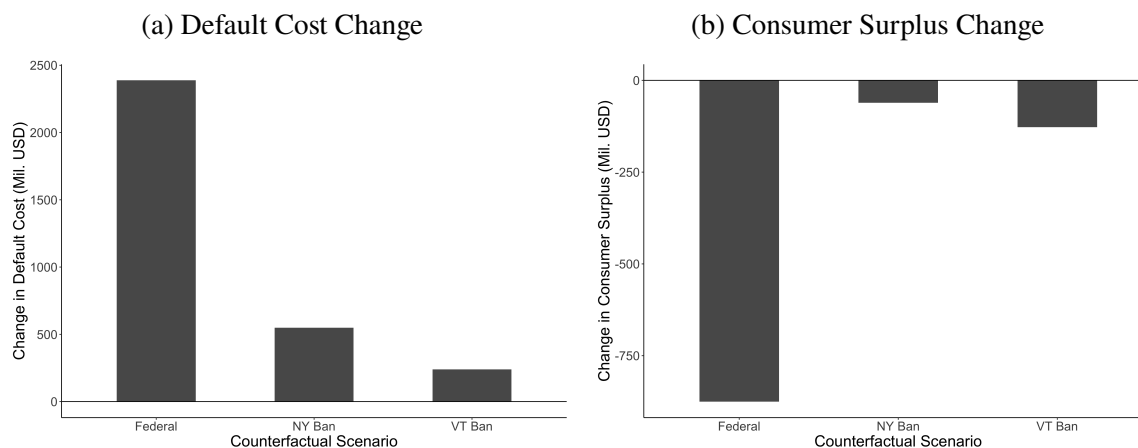
in one state and is domiciled in that state, as is the case for New York.

I study a ban by New York as the consumer’s state given its importance in the consumer insurance market and New York state regulators’ past efforts to call for a national ban on captives (Lawsky, 2013). Because New York state regulators significantly increased regulatory scrutiny on captives in 2013, I estimate the effect of a New York ban in 2012.

Ban by captives’ state: A captive’s state may implement such a ban if it faced increased political pressure or from lawsuits by consumers.²⁵ I study a hypothetical ban on captives domiciling in the state by Vermont, the state with most captives domiciled. One key effect is that insurers that previously allocated liabilities to captives in Vermont could endogenously choose another state to setup its captive. Appendix F.1 describes the details on how I solve for the equilibrium with domicile switching under such a ban.

Ban results: Figures 8a and 8b report the effects of both types of individual state bans on default costs and consumer surplus, and compare them to the federal ban. The figures show that overall, individual states’ bans have limited national consequences.

Figure 8: Unilateral Bans: Consumer’s (New York) and Captives’ (Vermont) States



Note: Figures 8a and 8b report the changes in default cost and consumer surplus under a federal regulator that sets a uniform federal capital rate (Federal), New York banning insurers selling in New York from using captives (NY Ban), and Vermont banning insurers from setting up captives in Vermont (VT Ban). A positive y-value in Figure 8a represents less insurer defaults, i.e., better, than the current state-based equilibrium. A positive y-value in Figure 8b represents higher consumer surplus, i.e., better, than the current state-based equilibrium. All values are in terms of changes from the current state-based equilibrium in 2019 and are reported in millions USD.

²⁵See e.g., *Belth vs. Iowa Insurance Division* and Nick Gerhart, Commissioner, 2016.

A ban by the consumer's state, New York, whose state market makes up 8.4% of the national market, achieves 23% of the decrease in national expected default costs as federalizing (\$538 million per year) and decreases consumer surplus by 7% (\$61 million per year).²⁶ Intuitively, the magnitude of the effect is primarily determined by the size of the banning state's domestic insurance market and how much insurers in the banning state use captives.

Likewise, the equilibrium effects of a Vermont ban on captives are limited. A ban by Vermont, which has 54% of the national captive volume, would lead to a decrease in expected default costs by \$239 million per year, which is 10% of the effect under federalizing. Consumer surplus would decrease by 15% of the effect under federalizing (\$128 million per year) as well. This is because of competition and substitutability between states: if Vermont shuts down captives domiciled in its state, insurers can respond by switching to other states such as Delaware or South Carolina, rather than having to retain liabilities on operating companies' balance sheets.

7 Conclusion

This paper studies how jurisdictional competition affects financial stability, product markets, and the effectiveness of regulatory policies. I study this question in the setting of the US life insurance industry, in which insurers operate across states but are regulated at the state-level. I focus on state regulators' capital regulations, and study the effects of competition between states regulators where states attract insurers to raise tax revenues, but do not bear the full default costs.

To quantify these effects, I develop a structural model of the US life insurance market with competition between regulators. I begin by documenting motivating evidence of competition between regulators over capital regulations, insurers' responses, and their real consequences. Then, to quantify the effects of this competition, I structurally estimate the model and use the model to examine counterfactual regulatory policies such as a federal insurance regulator. I find that federalizing increases total regulator's utility and social welfare relative to state regulators, with larger states gaining more than smaller states. On the other hand, I find that unilateral actions by individual states have limited national consequences. More broadly, the findings of this paper can provide insights into the effects of harmonizing decentralized regulation across domains beyond finance, such as corporate taxation, climate change, and public health.

²⁶Because I estimate this equilibrium based on 2012 market data, the percentage and dollar values are based on 2012 market data as well. The corresponding values for the federal counterfactual are very similar between 2012 and 2019.

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For Online Publication: Appendix

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A Additional institutional details

A.1 Legal and political background of insurance regulation

State-based insurance regulation: Insurance has historically been regulated at the state-level, dating back to as early as 1851 with the first state insurance commissioner in New Hampshire. Over the years, judicial rulings by the US Supreme Court, including *Paul v. Virginia* (1869), and legislation by the US Congress, most notably the McCarran-Ferguson Act of 1945, have upheld states' rights to regulate and tax insurance and the state-based regulatory system. One of the principal reasons for this is that insurance contracts have historically not been interpreted as "transactions of commerce" and thus fall outside of federal interstate commerce regulations (US Supreme Court, 1869).

The legal justification for regulation of insurance is based on precedent established in the US Supreme Court ruling in *German Alliance Insurance Company v. Lewis* (1914), which stated that "[t]he business of insurance is so far affected with a public interest as to justify legislative regulation of its rates." Economic rationale for regulating insurance is based on protecting the interests of consumers, who may not be fully informed or otherwise unsophisticated, and on monitoring the solvency of insurance companies to ensure that they can fulfill their obligations to consumers and to protect the stability of the financial sector, as insurers are one of the largest classes of financial intermediaries, with over \$8 trillion in assets held by life insurers in the US.

The two main objectives of modern insurance regulations are monitoring financial solvency of insurers and ensuring competitive and efficient insurance markets. States coordinate on regulations through the National Association of Insurance Commissioners (NAIC). The NAIC, officially a private organization of state insurance regulators, is the primary body that sets common regulatory standards and model insurance laws for states to adopt. One driver for cooperation between states is economies of scale of producing and setting regulations, for example the legal and actuarial expertise required to determine appropriate solvency regulations. Another driver for cooperation and uniformity between states is political pressure from the federal government to federalize insurance regulation, which would take over the regulation and taxation of insurance from the states and preempt state insurance laws, which would remove an important source of political power and tax revenue from state governments. The imperative to federalize insurance regulation

stems from concerns of insurer insolvency due to perceived inconsistencies in state regulations. Most notably, after a series of large insurer insolvencies in the 1980s, US Congress introduced the Federal Insurance Insolvency Act of 1992, which proposed to take over solvency regulations from the states. In response to this threat of federal preemption, the states proposed and adopted an accreditation standard through the NAIC that formalized uniform solvency requirements across states, allowing states to retain their rights to regulate and tax insurance. Specifically, a state can only be accredited if it adopts the NAIC's model laws or laws substantially equivalent to them. Since then, the NAIC has become the primary issuer of solvency regulations, which it drafts through working groups consisting of representatives of state regulators, who vote on, debate, and adopt these standards with industry and interest group input. Today, each insurance company is regulated by the state that it is domiciled in according to these NAIC model laws, which state legislatures largely adopt, sometimes with minor differences.

Non-US domiciles: My paper focuses on insurance regulation and operations within the US. One limitation is that I do not have data on insurance markets in non-US domiciles where insurers may have captives domiciled, i.e., primarily Bermuda. This is unlikely to substantially affect my results because foreign captives have become significantly less important after 2017, when the US introduced a base erosion tax on transfers to foreign affiliates as part of the 2017 Tax Cuts (see e.g., Tang, 2021 for related work on evidence of this in the property and casualty insurance industry). Additionally, these domiciles tend to have smaller domestic markets than virtually all US states and are more likely to have captives, so not including them in my analysis likely understates the magnitude of regulatory competition and default externality.

A.2 Regulation XXX

Regulation XXX was an accounting standard adopted by the NAIC that substantially increased the capital requirements on life insurance products by increasing the reserves. Reserve requirements are calculated as a function of the present value of all premiums in the policy and the present value of all expected death benefits. Insurance companies are required to hold more reserves against the policy if the premiums are lower or if the expected death benefits are higher. Reserves are costly for insurers to hold because they have to raise capital to finance the reserves, which may be subject to external financing frictions.

Before Regulation XXX, reserves were calculated based on present value of all future premiums without accounting for lapsations, i.e., when the policyholder does not renew the policy. This was referred to as the “unitary” reserve basis. Insurance companies in turn designed products that had a lower initial fixed-term guaranteed level premium rate that significantly increased in later years of the policy. The present value of premiums, under the unitary reserve basis which assumes the policyholder will pay the much higher premiums after the initial fixed term, was much higher than the expected death benefits, resulting in low levels of reserves required. In practice, policyholders often did not renew once the initial fixed term ended because of the high renewable premiums, making the products effectively a fixed-term guarantee product with a low present value of premiums, which would have required high levels of reserves if the reserve basis accounted for the lapse rates. In other words, the annually renewable premiums, which were rarely renewed by policyholders, decreased the reserves that the insurance companies were required to hold for the same fixed term guarantee term product.

In 2000, the NAIC adopted Regulation XXX, which required insurers to hold reserves that are the higher of the unitary reserve basis and the segmented reserve basis. The segmented reserve basis computed reserves for each segment of the policy, where segments are defined by the minimum duration “such that the ratio of the guaranteed gross premiums from one duration to the next exceeds the ratio of the valuation mortality rates at the comparable durations” (SOA 1995). In other words, segmented reserve bases would treat the initial fixed term guarantee as one segment against which insurers had to hold reserves, and the annually renewable segments as separate segments. Insurers therefore could no longer count the premiums annually renewable segments as total or unitary premiums to be collected, and so were required to hold higher reserves against the initial guaranteed term.

Regulation XXX increased reserve requirements more for longer-term products because the additional guarantee term years cover the policyholder at higher ages, so insurers are required to hold more excess reserves to pay for the policy payouts towards the end of the policy. For example, for a 30-year-old non-smoker male policyholder with regular health, a 20-year guaranteed term would cover the policyholder until age 50, while a 30-year guaranteed term would cover until age 60, and the expected policy payout, based on mortality rates, are higher per year from ages 51 to 60 than during the initial 20-year term.

A.3 Insurers' default risks

One view of insurer solvency regulation is that life insurers have very stable liabilities, and so insurer defaults are not material risks. Another view, motivated in part by life insurer insolvencies in the 1980s and the 2008 financial crisis, suggests that solvency is a material consideration for insurers. For example, the historical insolvency probability of insurers over any 10-year period is around 1.6%, and during the 2008 financial crisis, multiple large US life insurers applied for and received bailout funding.²⁷

There are several aspects of US life insurers' operations that may introduce significant volatility. On the liabilities side, life insurance companies do not just sell products with stable liabilities. The largest liability of US life insurance companies are variable annuities, which are structured products that have long-horizon (e.g., 10 years or more) minimum return guarantees. These products account for \$2 trillion, or over 35% of US life insurers' liabilities. In selling these products, insurers guarantee a minimum return and are essentially selling long-dated puts on the market, which become deeply in the money during market downturns. Insurers suffered large losses on variable annuity businesses during the 2008 financial crisis that directly led to higher default risks and the need for bailout funding. For example, the losses on the VA business for Hartford Life and Manulife, two of the largest insurers selling VAs, were close to 50% of their capital and surplus (Koijen and Yogo, 2015). On the asset side, life insurers can also face substantial investment risks, for example on non-agency RMBS in 2008 and corporate bonds.

B Additional data details

B.1 Summary statistics

Table A1a provides the summary statistics of the insurers' financial characteristics. Table A2a reports the summary statistics of the reinsurance agreements. Table A2b describes the summary statistics of the state captive insurance regulations and laws. Table A1b reports the summary statistics of the prices, quantities, and market shares at the insurer-state-year level.

²⁷Based on impairment data from A.M. Best from 1977 to 2015. Koijen and Yogo (2016) estimate the default probability conditional on impairment is 22%, which is what I use in my estimations in Section 5.2.1. Life insurers that become impaired but which do not require state guaranty fund payouts are often acquired by unimpaired companies (e.g., Harrington, 2015).

B.2 Additional variable definitions

I define life insurance price as the total premiums divided by the total expected payout. I select a 30-year-old non-smoking male in regular health buying life insurance with a \$250,000 face amount as the representative policyholder. A life insurance product's actuarial value is the dollar amount of expected policy payouts each year calculated following Koijen and Yogo (2015), where the mortality rates are based on the Society of Actuaries 2001 Valuation Basic Table. Quantities are defined as the total premiums divided by the premiums per policy. Because premiums sales data reports the total premiums across all product types, I assume that total premiums are proportional across product types for all insurance companies. I do not observe each company's market shares in each product type (e.g., if one insurer sells relatively more life insurance for males than for females than another insurer). A.M. Best rating is the financial strength rating given by A.M. Best to each insurance company each year, which I convert to a numeric grade following Koijen and Yogo (2018).

B.3 Balance sheets of insurers and captives

I now describe how captives affect insurers' balance sheets. Consider an insurer that owns an operating company and a captive. The operating company sells Q units of insurance policies at price P with actuarial value V per policy. The operating company cedes B units of policies through reinsurance to the captive.

The operating company's total assets A and liabilities L are

$$\begin{aligned} A &= A_0 + P \cdot (Q - B) \\ L &= V \cdot (Q - B) \end{aligned} \tag{21}$$

where A_0 are additional assets the operating company holds and policy liabilities are the operating company's only liabilities.

The operating company's *capital* K is equal to its assets minus liabilities:

$$K = A - L \tag{22}$$

Capital requirements are implemented through reserve requirements and risk-based capital

requirements.²⁸ I define the operating company's *statutory capital*, K^{Stat} , as

$$K^{\text{Stat}} = A - L - \underbrace{\rho_{\text{Reserve}} \cdot L}_{\text{reserves}} \quad (23)$$

equal to capital minus reserves $\rho_{\text{Reserve}} \cdot L$. Reserves are meant to account for a degree of conservatism by increasing the value of liabilities under statutory accounting. For example, $\rho = 0.1$ means that an insurance policy that has an actuarial value of \$100 would be reported as a statutory liability of \$110.

Under risk-based capital requirements, operating companies must hold statutory capital in excess of a minimum amount based on its operations, which I summarise as a fraction ρ_{RBC} of the actuarial value of liabilities:

$$K^{\text{Stat}} \geq \rho_{\text{RBC}} \cdot L \quad (24)$$

So the operating company's capital must exceed the sum of reserves and minimum statutory capital under risk-based capital requirements:

$$K \geq (\rho_{\text{RBC}} + \rho_{\text{Reserve}}) \cdot L \quad (25)$$

Now, the captive's assets \hat{A} and liabilities \hat{L} are

$$\begin{aligned} \hat{A} &= \hat{A}_0 + V \cdot B \\ \hat{L} &= V \cdot B \end{aligned} \quad (26)$$

where \hat{A}_0 are additional assets on the captive's balance sheet to satisfy capital requirements. The captive's only purpose is to assume reinsurance from the operating company, so it holds no other liabilities. The captive's capital is

$$\hat{K} = \hat{A} - \hat{L} \quad (27)$$

Captives' capital requirements differ from those for operating companies. First, state captive regulators can allow captives to count certain types of assets that are not admissible as assets under NAIC statutory accounting, such as letters of credit and parental guarantees, whose economic values

²⁸Reserve requirements are defined under Standard Valuation Law, Regulations XXX, and Actuarial Guidelines. Risk-based capital requirements are defined under the NAIC Risk-Based Capital (RBC) for Insurers Model Act, which requires the insurer the statutory capital to be held for each part of the insurance company's operations. The risks are classified into C-0 (Asset Risk - Affiliates), C-1 (Asset Risk - Other), C-2 (Insurance Risk), C-3 (Interest Rate Risk, Health Risk and Market Risk) and C-4 (Business Risk). For example, in C-1 (Asset Risk - Other), the insurance company is required to hold capital equal to 1.3% of the value of Class 2 (high quality) bonds.

may differ from their reported values due to liquidity risk or default risk of the parent company. For the operating company to deduct the reinsured liabilities from its balance sheet, the captive must report asset values in excess of liabilities equal to the NAIC reserve requirement, which can be satisfied with these nonadmissible assets. Denoting the captive's assets as the sum of admissible assets \widehat{A}^A and nonadmissible assets \widehat{A}^N :

$$\widehat{A} = \widehat{A}^A + \widehat{A}^N \quad (28)$$

and let $\gamma \cdot \widehat{A}^N$ be the nonadmissible assets' reported value minus actuarial value. Then the asset requirement is:

$$\underbrace{\widehat{A} + \gamma \cdot \widehat{A}^N}_{\text{reported assets}} - \widehat{L} \geq \underbrace{\rho_{\text{Reserve}} \cdot \widehat{L}}_{\text{NAIC reserves}} \quad (29)$$

Second, captives report under GAAP reserve requirements $\widehat{\rho}_{\text{Reserve}}$ which are lower than NAIC reserve requirements, $\widehat{\rho}_{\text{Reserve}} < \rho_{\text{Reserve}}$. Define the captive's *reported statutory capital* as

$$\widehat{K}_{\text{Reported}}^{\text{Stat}} = \underbrace{\widehat{A} + \gamma \cdot \widehat{A}^N}_{\text{reported assets}} - \widehat{L} - \widehat{\rho}_{\text{Reserve}} \cdot \widehat{L} \quad (30)$$

Third, captives are not subject to risk-based capital requirements. Instead, its reported statutory capital only needs to exceed a fixed minimum amount \overline{K} (\$250,000 in most states):

$$\widehat{K}_{\text{Reported}}^{\text{Stat}} \geq \overline{K} \quad (31)$$

And because $\widehat{\rho}_{\text{Reserve}} < \rho_{\text{Reserve}}$, for K sufficiently small, eq. (29) binds and eq. (31) does not bind. So eq. (29) implies that the captive's capital must satisfy:

$$\widehat{K} \geq \rho_{\text{Reserve}} \cdot \widehat{L} - \gamma \cdot \widehat{A}^N \quad (32)$$

Consolidating the operating company's and captive's balance sheets shows that captives decrease the capital the insurance company is required to hold by alleviating the risk-based capital requirement and allowing nonadmissible assets to be counted as assets:

$$\begin{aligned} K + \widehat{K} &= (\rho_{\text{RBC}} + \rho_{\text{Reserve}}) \cdot V \cdot (Q - B) + \rho_{\text{Reserve}} \cdot (V \cdot B) - \gamma \cdot \widehat{A}^N \\ &= \underbrace{(\rho_{\text{RBC}} + \rho_{\text{Reserve}}) \cdot V \cdot Q}_{\text{capital required without captives}} - \underbrace{(\rho_{\text{RBC}} \cdot V \cdot B + \gamma \cdot \widehat{A}^N)}_{\text{decrease in required capital}} \end{aligned} \quad (33)$$

B.3.1 Converting statutory capital to economic capital

I next describe the insurer's statutory balance sheet and how I convert it to economic values. To match the line items on the statutory balance sheet, let the insurance company sell Q units of a representative T -year term policy, each with annual premiums Premiums_t and expected payout Payouts_t in year t . Denote the present value of annual premiums from years t_1 to t_2 as $P_{t_1,t_2} = \sum_{s=t_1}^{t_2} \frac{1}{(1+r)^s} \text{Premiums}_s$, where r is the discount rate, and analogously the present value of expected payouts from years t_1 to t_2 as $V_{t_1,t_2} = \sum_{s=t_1}^{t_2} \frac{1}{(1+r)^s} \text{Payouts}_s$.

The insurer holds bonds with value B . So its assets in year $t = 0$ equal the present value of premiums plus the bonds. Its liabilities equal the present value of expected payouts. Its capital equals assets minus liabilities.

Assets		Liabilities	
$P_{0,T}$	Future premiums	$V_{0,T}$	Future payouts
B	Bonds	K_t	Capital

By year $t > 0$, the insurer received annual premiums P_0, P_1, \dots, P_t , and paid out payouts V_0, V_1, \dots, V_t . So its net cash from these paid premiums and payouts is $\sum_{s=0}^t (P_s - V_s)$, and the present value of future premiums is $\sum_{s=t+1}^T P_s$ and the present value of future payouts is $\sum_{s=t+1}^T V_s$. Its balance sheet now looks like the below, where it's clear that the insurer's capital is the same as

Assets		Liabilities	
$P_{t+1,T}$	Future premiums	$V_{t+1,T}$	Future payouts
$P_{0,t} - V_{0,t}$	Cash		
B	Bonds	K_t	Capital

before, it just earned the premiums from years 0 to t and paid out payouts in the same period.

The insurer's statutory balance sheet differs from the balance sheet above in two ways. First, it reports the present value of future payouts minus the present value of future premiums as reserves R_t . Second, it reports capital as the sum of excess reserves and statutory capital $K_{\text{Stat},t}$:

Assets		Liabilities	
$P_{0,t} - V_{0,t}$	Cash	$V_{t+1,T} - P_{t+1,T}$	Reserves
B	Bonds	$(V_{t+1,T} - P_{t+1,T}) \cdot \rho$	Excess reserves
		$K - (V_{t+1,T} - P_{t+1,T}) \cdot \rho$	Statutory capital

where ρ is the excess reserve requirement. Its statutory reserves is equal to reserves plus excess reserves.

The insurer's capital ratio in the model is $\kappa_{k,t} = K_t/V_{t+1,T}$, where

$$\begin{aligned}
K_t &= \underbrace{K_{\text{Stat},t}}_{\text{statutory capital}} + \underbrace{(V_{t+1,T} - P_{t+1,T}) \cdot \rho}_{\text{excess reserves}} \\
V_{t+1,T} &= \underbrace{(V_{t+1,T} - P_{t+1,T}) \cdot (1 + \rho)}_{\text{statutory reserves}} \cdot \underbrace{\frac{1}{1 + \rho}}_{\text{excess reserve req.}} \cdot \underbrace{\frac{V_{t+1,T}}{V_{t+1,T} - P_{t+1,T}}}_{\text{future payouts to reserves ratio}}
\end{aligned} \tag{34}$$

$K_{\text{Stat},t}$ is the insurer's statutory capital from statutory balance sheets. $(V_{t+1,T} - P_{t+1,T}) \cdot (1 + \rho)$ is the insurer's statutory reserves from statutory balance sheets. I compute the excess reserve requirement ρ as the sum of total statutory reserves divided by the sum of total GAAP reserves minus one for all publicly-traded insurers that only have US subsidiaries. I exclude insurers with non-US subsidiaries because GAAP reserves do not separately report reserves on policies sold only within the US, whereas statutory reserves are only for policies sold in the US. Excess reserves can then be computed as $\rho/(1 + \rho)$ times statutory reserves. I calibrate the future payouts to reserves ratio using sample data following the FASB US GAAP Financial Reporting Taxonomy Implementation Guide Series. Finally, eq. (34) also implies that capital ratio $\kappa_{k,t}$ is a linear transformation of the statutory capital rate $K_{\text{Stat},t}/L_{\text{Stat},t}$, which can be seen by defining $L_{\text{Stat},t}$ as the statutory reserves and ω as the future payouts to reserves ratio:

$$\begin{aligned}
\frac{K_t}{V_{t+1,T}} &= \frac{K_{\text{Stat},t} + L_{\text{Stat},t} \cdot \rho/(1 + \rho)}{L_{\text{Stat},t} \cdot 1/(1 + \rho) \cdot \omega} \\
&= \frac{K_{\text{Stat},t}}{L_{\text{Stat},t}} \cdot \frac{1 + \rho}{\omega} + \frac{\rho}{\omega}
\end{aligned} \tag{35}$$

completing the mapping from statutory balance sheet to economic values.

B.3.2 Imputing states with missing captive capital rates in structural estimation

For insurers which have captives in states with no captive capital rate data, I estimate the captive capital rate by assuming insurers choose states to setup captives in a discrete choice problem, so more insurers setting up captives in a state implies that the state has a lower captive capital rate, consistent with the evidence in Table A4. Specifically, I assume the utility of an insurer choosing state j is a function of the state captive capital rate: $\beta^{\text{Cap}} \cdot \kappa_{j,t} + \xi_{j,t} + \epsilon_{i,j,t}$. So the share of insurers with captives in state j in year t , $B_{j,t}^{\text{Cap}}$, is given by $\ln(B_{j,t}^{\text{Cap}}) = \beta^{\text{Cap}} \cdot \kappa_{j,t} + \ln(\sum_{l \in S} \exp(\beta^{\text{Cap}} \cdot \kappa_{l,t} + \xi_{l,t})) + \xi_{j,t}$. I then estimate this equation on the state-years with captive capital rate data, and invert it assuming $\xi_{j,t} = 0$ to get $\kappa_{j,t}$ for state-year with missing captive capital rates. I only make this imputation

for estimating the regulator’s λ_{Default} and $\lambda_{\text{Consumer}}$ weights and for the counterfactuals, not for the motivating evidence in Section 3 or the results in Table 2.

B.4 Converting impairment rates to default probabilities

Since not all impairments lead to defaults, I compute default probabilities as the impairment probability multiplied by the probability of life insurers becoming insolvent conditional on being impaired following Kojien and Yogo (2016).²⁹ I use a default probability conditional on impairment of 22% based on Kojien and Yogo (2016), which assumes that there are no defaults without impairments, and recover for each A.M. Best rating level the empirical default probability:

$$P(\text{Default}|\text{Rating})_{k,t} = P(\text{Impairment}|\text{Rating})_{k,t} \cdot P(\text{Default}|\text{Impairment})_{k,t} \quad (36)$$

I then calculate the empirical default probabilities of each insurer each year as the annual empirical default probability of the A.M. Best rating level that the insurer was assigned that year.³⁰ I compute the annual empirical default probability as the h -year impairment rate reported by A.M. Best, divided by the number of years h , and multiplied by the default probability conditional on impairment, 22%. I use $h = 15$ years which is the longest horizon reported by A.M. Best. For example, if an insurer had a 15-year impairment probability of 3%, then I calculate its default probability each year as $3\%/15 \cdot 22\% = 0.044\%$.

C Additional reduced form results

C.1 Evidence on national pricing

Insurers set national prices on life insurance products, with the exception of New York due to its extraterritoriality laws. Several factors contribute to this national pricing behavior. First, mortality risks, once controlling for other observable characteristics of the insured, do not vary substantially across geography. Second, insurers may face regulatory scrutiny and public relations concerns arising from perceived discrimination caused by differential prices by geography, which could

²⁹Impairment is defined as “official regulatory action taken by an insurance department, ... [including] involuntary liquidation because of insolvency as well as other regulatory processes and procedures such as supervision, rehabilitation, receivership, conservatorship, a cease-and-desist order, suspension, license revocation, administrative order, and any other action that restricts a company’s freedom to conduct its insurance business as normal” (A.M. Best (2015)).

³⁰This is a conservative assumption because it assumes that the ratings account for insurers’ use of captives. An alternative assumption that ratings do not account for captives, for example as discussed in Kojien and Yogo (2016), would lead to a larger estimated default cost.

violate redlining laws and the Unfair Trade Practices Act. In addition, state regulators also have the right to limit the set of factors that insurers use to price policies, including geography, and further regulatory scrutiny may be placed on insurers that use geography to price insurance, especially if geography correlates with protected factors such as race. Table A6 reports a regression of product prices on product-year and product-year-state fixed effects and shows that state fixed effects add no explanatory power.

C.2 Robustness checks for insurers' choices of captive domiciles

In this section, I conduct a battery of robustness exercises and alternative empirical strategies to rule out alternative explanations, omitted variables, and reverse causality concerns regarding the drivers of insurers' demand for captives in Section 3.2.

Table A8 reports the same estimates as eq. (2) on the intensive margin, using the log dollar amount of total liabilities reinsured with captives as the dependent variable. The economic magnitudes imply that a 1 p.p. increase in the captive capital rate decreases the amount reinsured with captives by each insurer in the state by 16.73 log points.

I also employ a partial identification approach following Oster (2019) to quantify the magnitude to which any unobservable characteristics would have to be to rationalize a null effect of capital rates on insurers' choices of states for captives. The approach estimates the relative magnitudes of selection on unobservables and selection on observables from the regression coefficient estimates and R-squared values. The threshold value $\bar{\delta}$ from the test provides a sufficient statistic that describes how important the unobservables have to be relative to observables under a zero effect. I find that my threshold value $\delta = 2.8$, which exceeds the threshold recommended by Oster (2019). Intuitively, the unobservable characteristics have to be at least 2.8 as important as the observables characteristics to rationalize captive capital rate having zero effect on insurers' choices of captive domicile, which is unlikely especially given that the characteristics that states advertise and promote that are important to insurers are already accounted for.

D Model proofs and expressions

In this section, I provide the solution to the model. For ease of notation, I provide the expressions for a given insurer i in a given time t , so I omit the i and t subscripts. I begin with the insurer's

default decision, eq. (12), which can be rewritten as:

$$\frac{1}{1+r_t}E = -Q \left(P - \tilde{L} \right) + b - \kappa(b+Q). \quad (37)$$

Substitute eq. (37) into the insurer's equity value (eq. 12):

$$\begin{aligned} E &= \int_{-\infty}^{\bar{L}} -Q \left(\tilde{L} - \bar{L} \right) f(\tilde{L}) d\tilde{L} - \kappa(b+Q) - \theta\kappa(b+Q) - \tau BQ \\ &= -Q \mathbb{E} \left[\tilde{L} - \bar{L} | \tilde{L} < \bar{L} \right] \kappa \mathbb{P} \left(\tilde{L} < \bar{L} \right) - (1+\theta)\kappa(b+Q) - \tau BQ. \end{aligned} \quad (38)$$

So the insurer's equity value can be rewritten as:

$$\begin{aligned} \frac{1}{1+r}E &= -\Pi(\bar{L}) + b - \kappa(b+Q) \\ -P + \bar{L} + b/Q - \kappa(1+b/Q) &= \frac{1}{1+r} \left[-\mathbb{E} \left[\tilde{L} - \bar{L} | \tilde{L} < \bar{L} \right] \mathbb{P} \left(\tilde{L} < \bar{L} \right) - (1+\theta)(1+b/Q) - \tau B \right]. \end{aligned} \quad (39)$$

This means that the default threshold \bar{L} can be written in terms of observables:

$$\bar{L} = \frac{P - \frac{1}{1+r}(\mu - \sigma\Lambda)\Phi + \left(1 - \frac{1+\theta}{1+r}\right)\kappa(1+b/Q) - b/Q - \frac{1}{1+r}\tau B}{1 - \frac{1}{1+r}\Phi}.$$

Next, I solve for the insurer's optimal pricing first-order condition. The insurer sets price to maximize its equity value:

$$\begin{aligned} \max_P E &= \int_{-\infty}^{\bar{L}} \left[Q \left(P - \tilde{L} \right) + \frac{1}{1+r}E - b \right] f(\tilde{L}) d\tilde{L} - \int_{\bar{L}}^{\infty} \kappa(b+Q) f(\tilde{L}) d\tilde{L} - \theta\kappa(b+Q) - \tau BQ \\ &= \left[Q \left(P - \mathbb{E} \left[\tilde{L} - \bar{L} | \tilde{L} < \bar{L} \right] \right) + \frac{1}{1+r}E - b \right] \Phi - \kappa(b+Q)(1-\Phi) - \theta\kappa(b+Q) - \tau BQ \end{aligned}$$

Solving this yields the following first-order condition:

$$P = (1 - \varepsilon^{-1})^{-1} \left[\mathbb{E} \left[\tilde{L} | \tilde{L} \leq \bar{L} \right] + \frac{\kappa(1-\Phi) + \theta\kappa + \tau B}{\Phi} \right]$$

where $\varepsilon = -\frac{\partial Q}{\partial P} \frac{P}{Q}$ is elasticity of demand, so $\frac{\partial Q}{\partial P} = -\frac{P}{\varepsilon}$. This proves the pricing first-order condition eq. (14).

Next, I solve for the means and variances of the stochastic cost distributions μ and σ . First, I

invert the CDF of \tilde{L} :

$$\Phi^{-1}(1 - \rho) = \frac{\bar{L} - \mu}{\sigma} \quad (40)$$

where $\rho = 1 - \Phi\left(\frac{\bar{L} - \mu}{\sigma}\right)$ is the default probability and $\mu = \bar{L} - \sigma\Phi^{-1}$.

Substituting the above into the expression for insurers' default condition (eq. 39) yields:

$$\begin{aligned} -(P - \bar{L} + \kappa) + (1 - \kappa)b/Q &= \frac{1}{1+r} \left[-\mathbb{E} \left[\tilde{L} - \bar{L} \mid \tilde{L} < \bar{L} \right] P \left(\tilde{L} < \bar{L} \right) - (1 + \theta) \kappa (1 + b/Q) - \tau B \right] \\ &= \frac{1}{1+r} \left[(\Phi^{-1} + \Lambda) \sigma \Phi - (1 + \theta) \kappa (1 + b/Q) - \tau B \right]. \end{aligned} \quad (41)$$

Now, combine the insurer's optimal pricing condition with the expression for the mean stochastic cost μ in eq. (40):

$$\begin{aligned} \Phi \left(P - \mathbb{E} \left[\tilde{L} \mid \tilde{L} < \bar{L} \right] + \frac{Q}{\partial Q / \partial P} \right) &= \kappa (1 - \Phi) + \theta \kappa + \tau B \\ \bar{L} &= \sigma (\Phi^{-1} + \Lambda) + \underbrace{P + \frac{Q}{\partial Q / \partial P} - \frac{\kappa (1 - \Phi) + \theta \kappa + \tau B}{\Phi}}_Z \end{aligned} \quad (42)$$

Then I first solve for μ assuming σ is known by substituting eq. (42) into eq. (40):

$$\begin{aligned} \mu &= \bar{L} - \sigma \Phi^{-1} \\ \mu &= \sigma \Lambda + P + \frac{Q}{\partial Q / \partial P} - \frac{\kappa (1 - \Phi) + \theta \kappa + \tau B}{\Phi}. \end{aligned}$$

Finally, I solve for σ by substituting eq. (42) into eq. (41):

$$\begin{aligned} -(P + \kappa) + (1 - \kappa)b/Q + \bar{L} &= \frac{1}{1+r} \left[(\Phi^{-1} + \Lambda) \sigma \Phi - (1 + \theta) \kappa (1 + b/Q) - \tau B \right] \\ -\kappa + b/Q - \kappa b/Q + \frac{1 + \theta}{1+r} \kappa (1 + b/Q) + \frac{Q}{\partial Q / \partial P} - \frac{\kappa (1 - \Phi) + \theta \kappa + \tau B}{\Phi} &= \\ \sigma (\Phi^{-1} + \Lambda) \left[\frac{1}{1+r} \Phi - 1 \right] - \frac{1}{1+r} \tau B & \end{aligned}$$

which after simplifying yields:

$$\sigma = \frac{\frac{Q}{\partial Q / \partial P} - \frac{\kappa(1-\Phi)+\theta\kappa}{\Phi} - \left(\frac{1}{\Phi} - \frac{1}{1+r}\right) B + \left(\frac{\theta-r}{1+r}\right) \kappa (1 + b/Q) + b/Q}{(\Phi^{-1} + \Lambda) \left(-1 + \frac{1}{1+r} \Phi\right)}. \blacksquare$$

D.1 Components of state regulators' utility

Consumer surplus and producer surplus are given as follows:

$$\begin{aligned} \text{ConsumerSurplus}_{j,t} &= \frac{M_{j,t}}{\alpha} \left(\ln \left(\sum_i \exp(-\alpha P_{i,t} + \gamma X_{i,t} + \xi_{i,j,t}^{\text{Cons}}) \right) + C \right) \\ \text{ProducerSurplus}_{j,t} &= \sum_i \left(\underbrace{\int_{-\infty}^{\bar{L}_{i,t}} Q_{i,j,t}(P_{i,t} - \bar{L}_{i,t}) f(\tilde{L}) d\tilde{L}}_{\text{profits, if no default}} - \underbrace{\int_{\bar{L}_{i,t}}^{\infty} \kappa_{i,t} \left(1 + \frac{b_{i,t}}{Q_{i,t}}\right) Q_{i,j,t} f(\tilde{L}) d\tilde{L}}_{\text{loss of required capital, if default}} \right. \\ &\quad \left. - \underbrace{\theta \kappa_{i,t} \left(1 + \frac{b_{i,t}}{Q_{i,t}}\right) Q_{i,j,t}}_{\text{cost of capital}} - \underbrace{\tau B_{i,t,j(i,t)} Q_{i,j,t}}_{\text{tax paid}} \right) \end{aligned}$$

where C is the Euler-Mascheroni constant.

E Additional details for structural estimation

In each year, for a given set of capital rates $\kappa_{s,t}$, I solve for the equilibrium as characterized in Section 4.4. The sufficient parameters to characterize the equilibrium are a set of liabilities allocations $B_{i,t}$, insurer prices $P_{i,t}$, and default thresholds $\bar{L}_{i,t}$, which I obtain in the following steps:

1. Solve for the shares of liabilities allocated to captives $B_{i,t}$ that satisfy the insurers' optimal liabilities allocation (eq. 18).
2. Start from an initial guess of prices $P_{i,t}$ and default thresholds $\bar{L}_{i,t}$.
3. Given guessed prices $P_{i,t}$, solve for market clearing quantities $Q_{i,s,t}$.
4. Check whether prices $P_{i,t}$ satisfy the optimal pricing condition (eq. 14) and whether default thresholds $\bar{L}_{i,t}$ satisfy the optimal default condition (eq. 12).

The equilibrium is described by $3K$ equations and $3K$ parameters, where K is the number of insurers, including K optimal captive allocation conditions that pin down the shares allocated $B_{i,t}$, K optimal pricing conditions that pin down insurer prices $P_{i,t}$, and K optimal default conditions that pin down default thresholds $\bar{L}_{i,t}$. I use a non-linear equation solver (the “nleqslv” package in R with step length tolerance 10^{-11} and function value tolerance 10^{-11}) to solve for the $3K$ parameters.

F Additional results for structural estimation

F.1 Solving for the equilibrium for a unilateral ban by captive's state

To focus on insurers' response and for computational tractability, I hold fixed non-banning states' actions. If other states could change their actions in response to Vermont's ban, then my estimates would understate the effects of such a ban, since decreased competition between states would lead to higher capital rates. Furthermore, as discussed in Section 4.2, I do not observe the unobserved utility terms $\zeta_{i,s,t}^{\text{Ext}}$ in states' choices of captive domiciles, because I do not observe insurers' preferences over all domiciles. I address this problem following the standard in the demand estimation literature by assuming that the unobserved utility $\zeta_{i,s,t}^{\text{Ext}}$ follows a Type 1 extreme value distribution. Specifically, I model insurers' utility of choosing a state s to setup a captive as:

$$V_{i,s,t}^{\text{Ext}} = \beta^{\text{Ext}} \kappa_{s,t} + \zeta_{s,t}^{\text{State}} + \zeta_{i,s,t}^{\text{Ext}} \quad (43)$$

which implies that the log of share of insurers that choose each state, $s_{s,t}^{\text{Ext}}$, is

$$\ln(s_{s,t}^{\text{Ext}}) - \ln(s_{0,t}^{\text{Ext}}) = \beta^{\text{Ext}} \kappa_{s,t} + \zeta_{s,t}^{\text{State}} \quad (44)$$

where $s_{0,t}^{\text{Ext}}$ is the share of insurers that do not use captives, i.e., the outside option. I estimate the above equation using OLS to obtain β^{Ext} . I then implement the following estimation procedure:

1. Compute the probability of each insurer k , that had a captive in the banning state s , choosing alternative state s' to setup a captive, which can be derived as

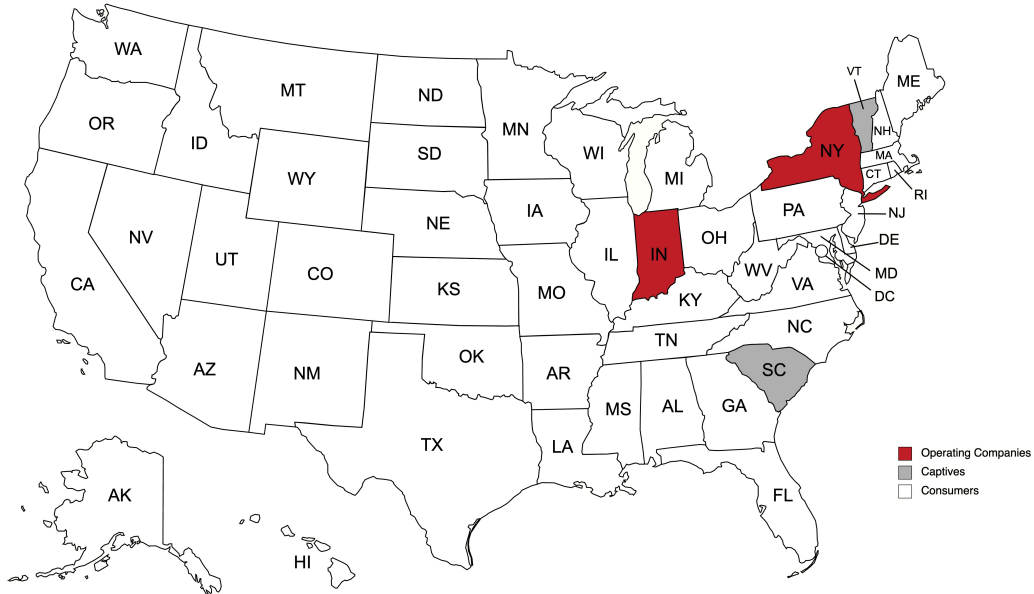
$$P(\text{Insurer } k \text{ chooses state } s') = \frac{\exp(\beta^{\text{Ext}} \kappa_{s',t} + \zeta_{s',t}^{\text{State}})}{1 + \sum_{l \in S \setminus s} \exp(\beta^{\text{Ext}} \kappa_{l,t} + \zeta_{l,t}^{\text{State}})}$$

2. Draw i.i.d. shocks from a uniform distribution from 0 to 1 for each insurer that had a captive in state s under the unilateral supply-side ban, and order the alternative states such that each alternative state s' corresponds to a closed interval within $[0,1]$ with length $P(\text{Insurer } k \text{ chooses state } s')$. The insurer domiciles its captive in state s' if the drawn i.i.d. shock is within the interval of state s' .
3. Re-solve capital allocation and optimal pricing and default for each draw.
4. Compute expected default cost, tax revenue, and consumer surplus for each draw.
5. Compute average equilibrium outcomes over 1000 draws.

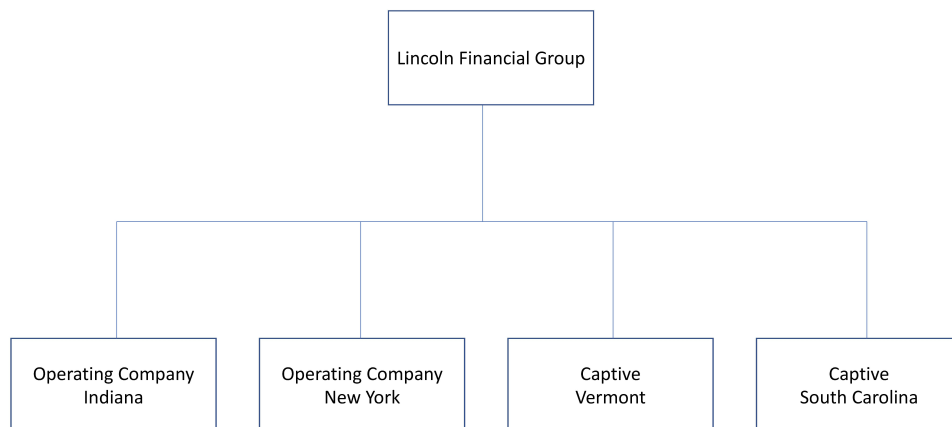
G Additional Figures and Tables

Figure A1: Organization Structure: Lincoln

(a) Geographic Locations

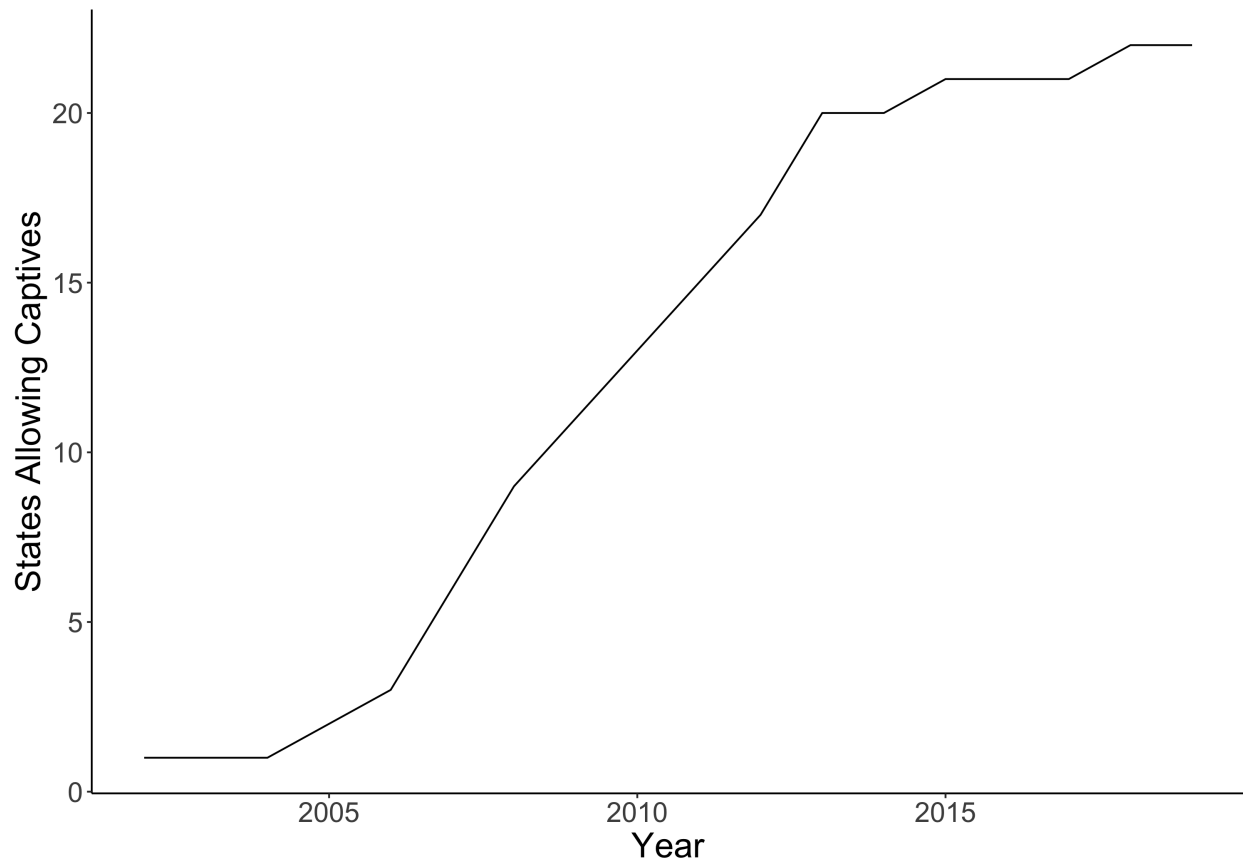


(b) Organization Structure



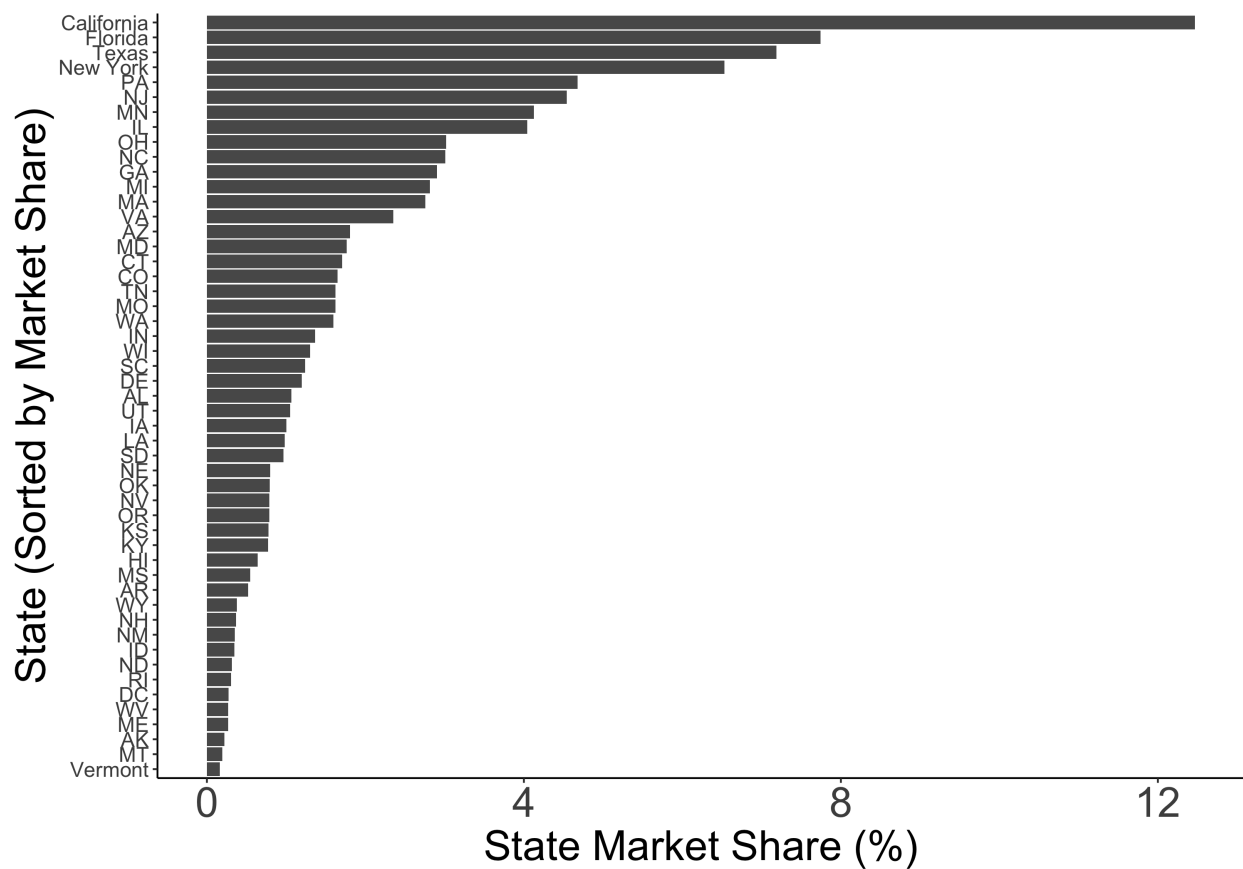
Note: Figure A1 reports the corporate structure of Lincoln Financial Group. Lincoln's main operating company is the Lincoln National Life insurer domiciled in Indiana and it has captives in Vermont, South Carolina, and Barbados (not reported). Lincoln sells insurance in all 50 states. Lincoln also has an operating company in New York that it sells policies in New York through due to extraterritoriality laws in New York.

Figure A2: States' Entry into Competition for Captives



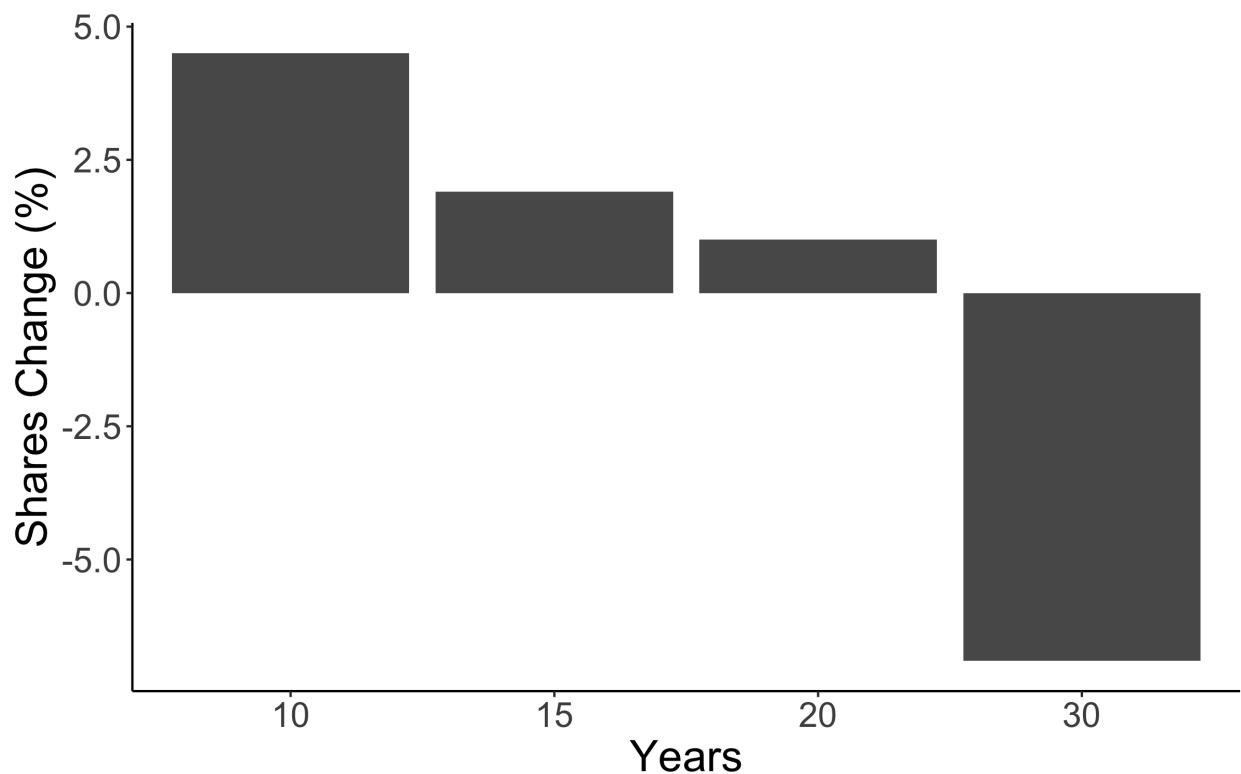
Note: Figure A2 reports the number of states competing for captives, i.e., having passed laws allowing captives to be set up in their state, each year.

Figure A3: State Insurance Market Sizes



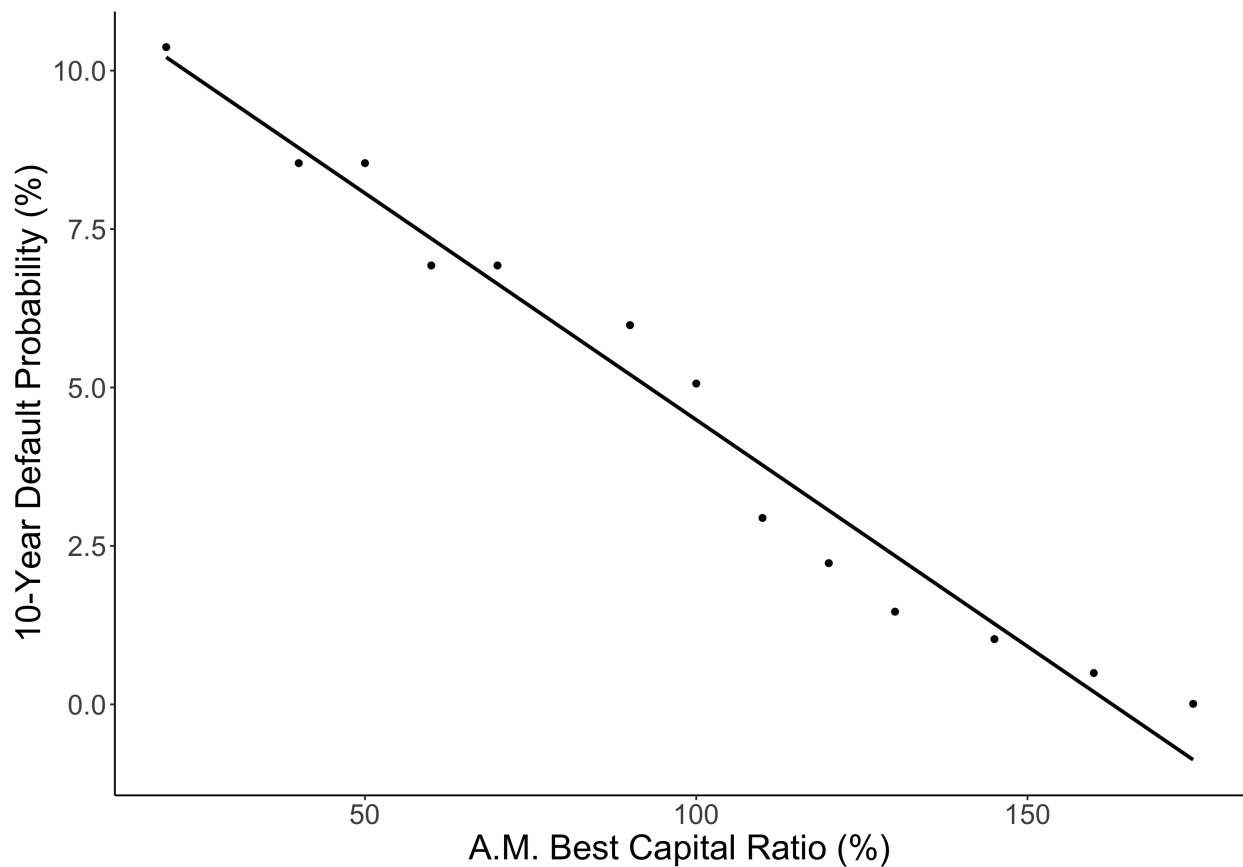
Note: Figure A3 reports the share of the total insurance premiums sold in each state in 2019. Market Share is the total dollar of life insurance premiums sold in the state divided by the total dollar of life insurance premiums sold in all states times 100. States are ranked in descending order by Market Share.

Figure A4: Effect of Capital Requirements on Quantities: Regulation XXX



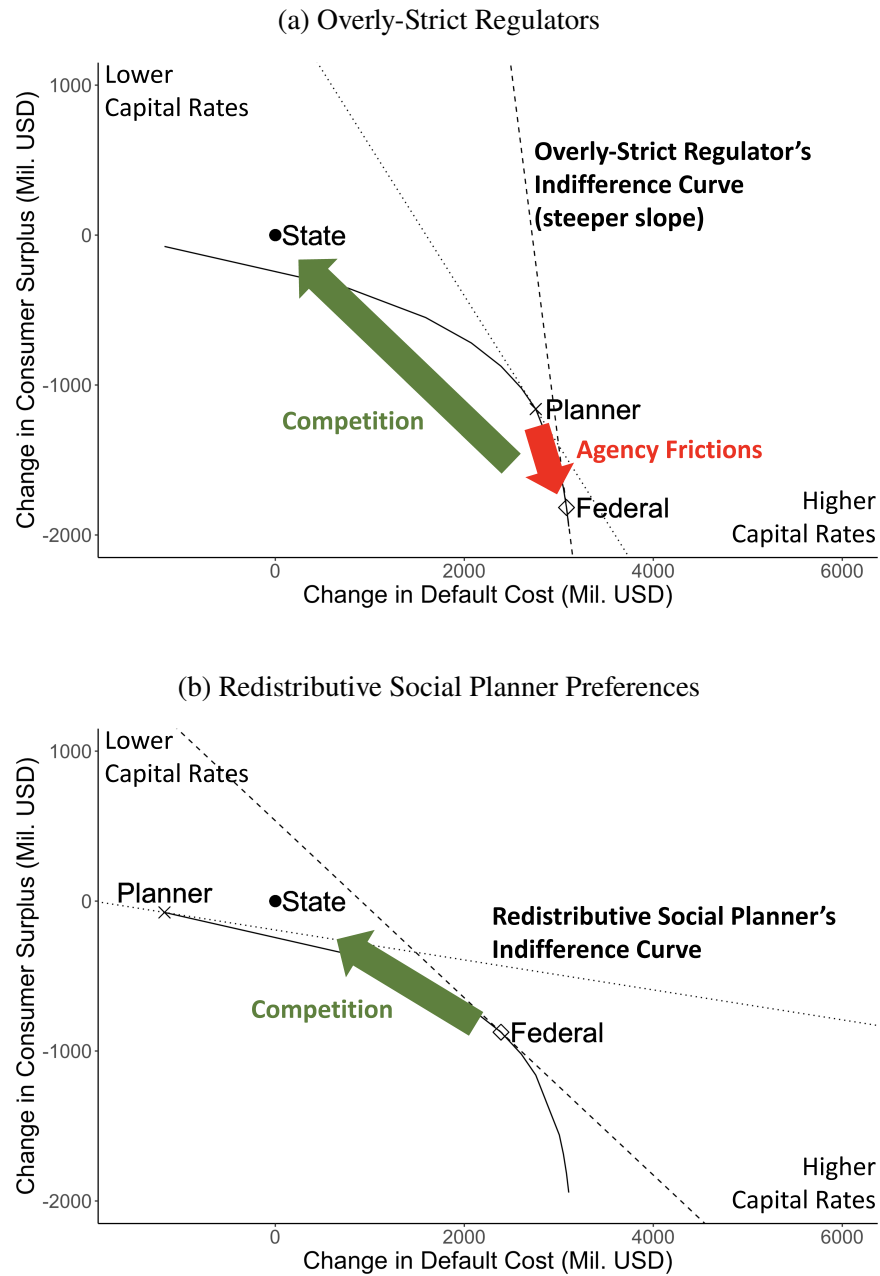
Note: Figure A4 displays the change in shares sold of products of each term length from the one year before (1999) to after (2000) Regulation XXX. Shares sold is the number of policies sold of a given term length divided by the total number of policies of all term lengths sold that year. A negative number indicates a decrease in shares sold relative to products of other term lengths.

Figure A5: Insurers' Capitalization vs. Default Probability



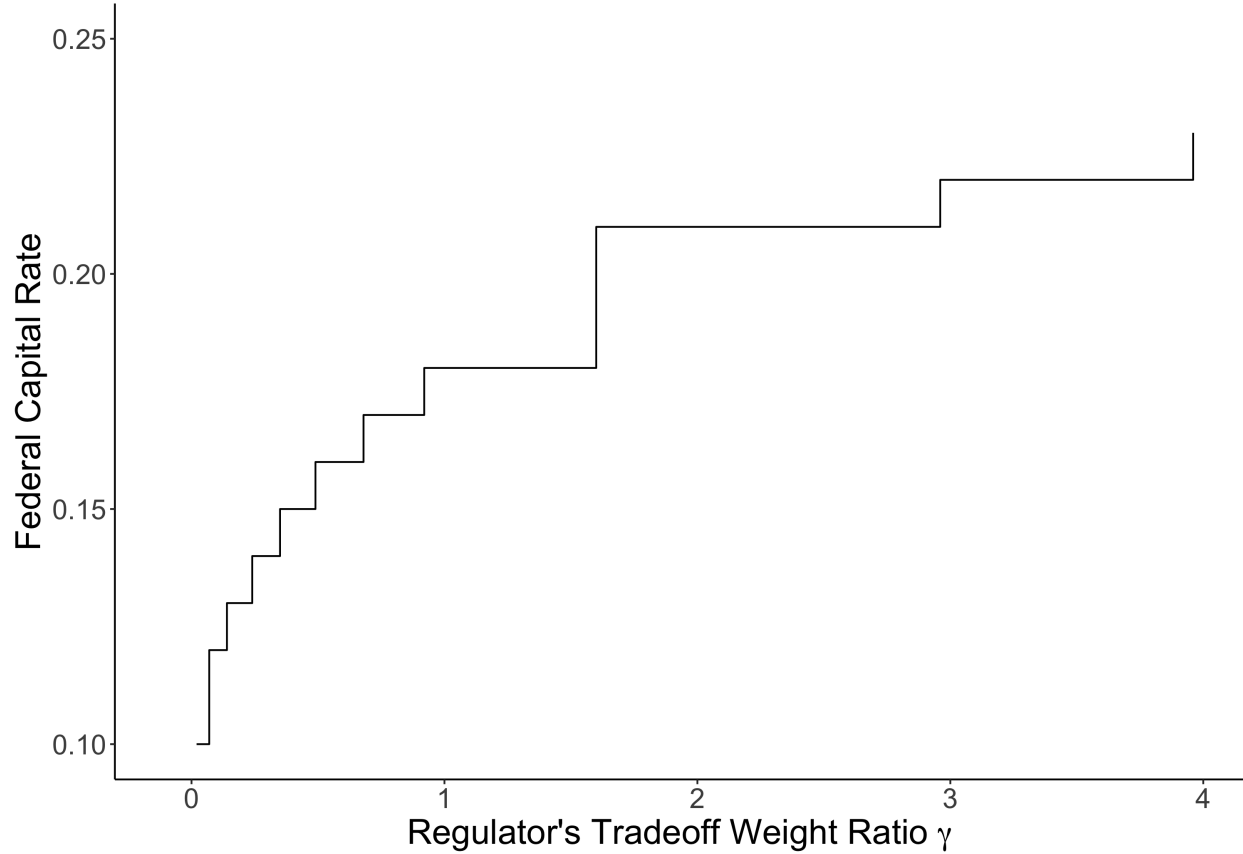
Note: Figure A5 reports the relationship between insurers' capital ratios and 10-year default probabilities. Capital ratios are converted from the A.M. Best ratings following Kojien and Yogo (2016). The ranges for bin in the binned scatterplot are equal in width, so each bin could contain different numbers of observations. Default probabilities are based on historical A.M. Best data. Observations are at the insurer-by-year level.

Figure A6: When Can Competition Be Beneficial?



Note: Figure A6 plots the regulator’s production possibility frontier and indifference curves under hypothetical scenarios when competition would increase total surplus. All values are in millions USD in terms of changes from the current state-based equilibrium in 2019. More positive x-values mean less default, i.e., better. More positive y-values mean more consumer surplus, i.e., better. The solid line plots the regulator’s production possibility frontier. State is the current state-based equilibrium, which by definition is at (0,0). Figure A6a plots a hypothetical scenario where regulators are overly restrict, i.e., care more about default costs. Figure A6b plots a hypothetical scenario where the social planner has redistributive preferences.

Figure A7: Mapping Regulators' Tradeoff Weights to Equilibria



Note: Figure A7 plots the uniform capital rate that the federal regulator would choose under different tradeoff weight ratios $\gamma = \lambda_{\text{Default}}/\lambda_{\text{Consumer}}$. Higher γ values correspond to the regulator valuing default costs more relative to consumer surplus. For example, going from $\gamma = 1$ to $\gamma = 2$ means that the regulator would go from being indifferent between \$1 of expected default costs and \$1 of consumer surplus to being indifferent between \$1 of expected default costs and \$2 of consumer surplus. Federal Capital Rate is in decimal points, discretized to the nearest 0.01.

Table A1: Summary Statistics: Supply and Demand

(a) Supply-Side								
Variable	N	Mean	SD	P10	P25	Median	P75	P90
Assets	488	49.17	72.96	1.01	3.32	17.57	48.63	163.95
Liabilities	488	46.4	69.59	0.87	2.98	15.77	45.22	152.88
A.M. Best Rating	423	155.69	10.55	145	145	160	160	160
Risk-Based Capital Ratio	488	9.32	3.57	6.01	7.34	8.69	10.26	12.71
Liquidity	487	0.08	0.37	0	0.01	0.02	0.05	0.09
Leverage	488	0.9	0.1	0.83	0.89	0.92	0.95	0.97
Return on Equity	488	0.18	0.28	0.02	0.05	0.1	0.2	0.37
Gross Reserves	488	22.24	28.99	0.98	2.8	9.96	28.26	64.5
Price	488	1.09	0.27	0.88	0.94	1.03	1.13	1.39
P(Default)	488	0.81	0.37	0.67	0.67	0.67	0.81	1.19
Captive Share	488	0.13	0.28	0	0	0	0.09	0.64
Capital Rate	488	0.11	0.03	0.08	0.12	0.13	0.13	0.13

(b) Demand-Side								
Variable	N	Mean	SD	P10	P25	Median	P75	P90
Price	21588	1.56	0.41	1.23	1.32	1.46	1.62	1.99
Quantities	21588	15644.3	36661.35	40.12	534.65	3938.58	14793.52	38489.94
Market Share	21588	0.01	0.01	0	0	0	0.01	0.02

Note: Table A1 reports the summary statistics of insurers' financial variables and market data. Observations are at the insurer by year level in panel (a) and at the insurer by state by year level in panel (b) from 2005 to 2019. Assets is the total assets of the insurer, in billions. Liabilities is the total liabilities of the insurer, in billions. A.M. Best Rating is the insurer's financial rating given by A.M. Best converted from a letter grade to a numeric grade following A.M. Best guidelines, e.g., 160 is A+. Risk-Based Capital Ratio is the authorized control level capital ratio of the insurer, e.g., 1 means 100%. Liquidity is the insurer's cash plus short term investments divided by its total liabilities. Leverage is the insurer's total liabilities divided by its total assets. Return on Equity is the insurer's annualized income after taxes as a percent of average capital and surplus. Gross Reserves is the total reserves that the insurer has, including amounts reinsured with captives or reinsurers, in billions. Price is the price of each life insurance policy as a multiple of the actuarial value of its policy liabilities. P(Default) is the 10-year default probability of the insurer, in percentage points. Captive Share is the share of the insurer's total liabilities that are transferred to the captive, defined as reserve credit taken plus modified coinsurance reserve divided by gross reserves. Capital Rate is the overall capital rate of the insurer's operating companies and captives, defined following eq. (7). Quantities is the number of policies sold, defined as total premiums sold divided by the premiums per policy. Market Share is the share of total quantity sold by a given insurer.

Table A2: Summary Statistics: Captives and State Regulations

(a) Insurer-State-Year Level

Variable	N	Mean	SD	P10	P25	Median	P75	P90
1(Insurer has Captive in State)	7002	0.02	0.15	0	0	0	0	0
Captive Capital Rate	888	0.04	0.03	0	0	0.04	0.06	0.1
Captive Tax Rate	7002	0.21	0.59	0	0	0	0.03	0.5
Business Registrations	7002	10.25	4.15	6.37	7.51	9.02	12.02	15.35
Tourists	7002	0.72	1.37	0	0.05	0.24	0.61	2.37
1(Appointed Commissioner)	7002	0.81	0.4	0	1	1	1	1
Rep. Vote Share	7002	0.51	0.13	0.37	0.44	0.52	0.61	0.64
Share Sold in State	7002	0.02	0.03	0	0	0.01	0.02	0.05
1(Sells in State)	7002	1	0.05	1	1	1	1	1

(b) State-Year Level

Variable	N	Mean	SD	P10	P25	Median	P75	P90
Captive Capital Rate	32	0.04	0.03	0	0	0.04	0.06	0.1
Premiums Written	969	2.09	2.39	0.29	0.51	1.35	2.48	4.85
Captive Tax Rate	684	0.21	0.58	0	0	0	0.02	0.5
1(Allow Captives)	969	0.26	0.44	0	0	0	1	1
Business Registrations	969	55.05	68.89	7.43	12.34	35.43	66.59	110.08
Tourists	969	0.7	1.42	0	0.07	0.22	0.51	1.32
1(Appointed Commissioner)	969	0.78	0.41	0	1	1	1	1
Rep. Vote Share	969	0.51	0.12	0.37	0.44	0.51	0.59	0.64

Note: Table A2 reports the summary statistics of insurers' use of captives and states' captive regulations. Observations are at the insurer by state by year level in panel (a) and state by year level in panel (b) from 2005 to 2019. 1(Insurer has Captive in State) is an indicator variable for whether the insurer has a captive in the state each year. Captive Capital Rate is the state's capital rate for captives each year, defined as the sum of capital divided by the sum of liabilities of all captives in the state. Premiums Written is the total dollar amount of insurance sold in the state by all insurers, in billions USD. 1(Allow Captives) is an indicator variable for whether the state allows captives for life insurers. Captive Tax Rate is the tax rate on captive reinsurance, in percentage points. Business Registrations is the number of new business incorporations per one thousand residents in the state each year. Tourists is the number of tourists visiting the state each year, in millions. 1(Appointed Commissioner) is an indicator variable for whether the state insurance commissioner is appointed as opposed to elected. Rep. Vote Share is the vote share for the Republican candidate in the preceding presidential election. Share Sold in State is the share of the insurer's total premiums that are sold in the state. 1(Sells in State) is whether the insurer sells in the state.

Table A3: Effect of Capital Requirements on Product Prices: Regulation XXX

	Price	
	(1)	(2)
15-Year X 1(3 Months Post-Reg XXX)	2.14*** (0.37)	1.93*** (0.50)
20-Year X 1(3 Months Post-Reg XXX)	3.92*** (0.43)	4.35*** (0.73)
30-Year X 1(3 Months Post-Reg XXX)	11.11*** (3.09)	10.34*** (3.63)
Product FEs	X	
Insurer FEs	X	
Product Insurer FEs		X
Observations	3,264	3,264
R ²	0.79	0.88

Note: Table A3 reports the estimates corresponding to eq. (1). Observations are at the insurer by product by month level. The dependent variable is the price of the product in each month, defined as the net present value of premiums divided by the net present value of expected policy payouts. The independent variables h -Year X 1(3 Months Post-Reg XXX) report the difference-in-differences coefficient estimates for products with an h -year term length in March 2000, three months after the effective date of Regulation XXX. The reference product is 10-year term life insurance. Product refers to the term length (e.g., 20 years). Product Insurer refers to the interaction of term length and insurer. Standard errors are two-way clustered at the insurer and month levels and are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A4: Motivating Evidence: Insurers' Choices of Captive Domiciles

	1(Captive) (1)	1(Captive) (2)
Capital Rate	-1.19** (0.51)	
Default Exposure		-0.01*** (0.002)
State and Insurer-State Controls	X	X
Insurer-Year FEs	X	X
Observations	888	7,002
R ²	0.29	0.03

Note: Table A4 reports the estimates corresponding to eq. (2). Observations are at the insurer by state by year level. The dependent variable is an indicator variable for whether the insurer has a captive in the state each year. The independent variable Capital Rate is the state's capital rate for captives each year, defined as the sum of capital divided by the sum of liabilities of all captives in the state. Default Exposure is total dollar amount of insurance sold in the state by all insurers, in billions USD, i.e., the Premiums Written. State Controls include Business Registrations, which is the number of new business incorporations per one thousand residents in the state each year, Tourists, which is the number of tourists visiting the state each year, in millions, 1(Appointed Commissioner), which is an indicator variable for whether the state insurance commissioner is appointed as opposed to elected, and Rep. Vote Share, which is the vote share for the Republican candidate in the preceding presidential election. Insurer-State Controls includes Share Sold in State, which is the share of the insurer's total premiums that are sold in the state, and 1(Sells in State), which is whether the insurer sells in the state. Standard errors are two-way clustered at the insurer and year levels and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

Table A5: Motivating Evidence: Determinants of States' Captive Policies

	1(Allow Captives)	Capital Rate
	(1)	(2)
Default Exposure	-0.05** (0.02)	0.04** (0.02)
Business Environment	0.01 (0.02)	0.01 (0.01)
Amenities	0.03 (0.04)	-0.003 (0.12)
Rep. Vote Share	-0.22 (0.45)	-0.01 (0.15)
Year FEs	X	X
Observations	969	32
R ²	0.18	0.76

Note: Table A5 reports the estimates corresponding to eq. (3). Observations are at the state by year level. The dependent variable is an indicator variable for whether the state allows captives for life insurers in column (1) and the captive capital rate of the state each year in column (2). The independent variable Default Exposure is total dollar amount of insurance sold in the state by all insurers, in billions USD, i.e., the Premiums Written. Business Registration is the number of new business incorporations per one thousand residents in the state each year. Tourists is the number of tourists visiting the state each year, in millions. 1(Appointed Commissioner) is an indicator variable for whether the state insurance commissioner is appointed as opposed to elected. Rep. Vote Share is the vote share for the Republican candidate in the preceding presidential election. Standard errors are two-way clustered at the state and year levels and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

Table A6: Evidence of National Life Insurance Pricing

	Price			
	(1)	(2)	(3)	(4)
Insurer-Product-Year FEs	X			
Insurer-Product-Year-State FEs		X		
Insurer-Year FEs			X	
Insurer-Year-State FEs				X
p-value		1		1
Observations	13,322	13,322	13,322	13,322
R ²	1.00	1.00	0.97	0.97

Note: Table A6 reports the results of a regression of life insurance product prices for the representative product (30-year-old non-smoking male in regular health buying \$250,000 of life insurance) on insurer, product type, year, and state fixed effects. Observations are at the insurer by product type by year by state level. The independent variables are interactions of the named sets of fixed effects, e.g., Insurer-Product-Year FEs are fixed effects of the interaction of insurer by product by year. p-value is for likelihood ratio tests comparing columns (1) vs. (2) in column (2), and (3) vs. (4) in column (4), respectively. The results show that life insurance product prices do not vary across states, conditional on insurer, product type, and year.

Table A7: Effect of Capital Requirements on Product Prices: Regulation XXX, Robustness

	(1)	(2)
15-Year X 1(3 Months Post-Reg XXX)	10.36*** (2.23)	
20-Year X 1(3 Months Post-Reg XXX)	27.24*** (3.77)	
30-Year X 1(3 Months Post-Reg XXX)	88.02*** (25.95)	
15-Year X 1(Post-Reg XXX)		2.35*** (0.52)
20-Year X 1(Post-Reg XXX)		4.09*** (0.81)
30-Year X 1(Post-Reg XXX)		12.64*** (3.45)
Product Insurer FEs	X	X
Specification	Dollars	Pre-Post
Observations	3,264	3,264
R ²	0.96	0.87

Note: Table A7 reports the estimates corresponding to the estimates in eq. (1) under alternative empirical specifications. Observations are at the insurance company by product by month level. The dependent variable is the price of the product in each month, as a percentage of the price of the same product offered by the same insurance company immediately before Regulation XXX, i.e., December 31, 1999 in column (1), and the net present value of premiums divided by the net present value of expected policy payouts in column (2). The independent variables h -Year X 1(3 Months Post-Reg XXX) report the difference-in-differences coefficient estimates for products with a term length equal to h -years in March, 2000, three months after the implementation of Regulation XXX. h -Year X 1(Post-Reg XXX) report the pre/post difference-in-differences coefficient estimates for products with a term length equal to h -years, where all periods before and after Reg XXX are each pooled into a single time period. The reference product is 10-year guaranteed term life insurance. Product refers to the term length (e.g., 30 years), Insurer refers to the insurance company, and Product Insurer refers to the interaction of term length and insurance company. Specification refers to an alternative specification where the outcome variable is the dollar price of the product divided by the December 1999 (i.e., month before Regulation XXX) dollar price of the same product in column (1) and an alternative specification using a pre/post specification in column (2). Standard errors are clustered at the insurance company level and are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A8: Insurers' Choice of States for Captives, Intensive Margin

	ln(Amount)
Capital Rate	-16.73* (7.46)
State and Insurer-State Controls	X
Insurer-Year FEs	X
Observations	888
R ²	0.29

Note: Table A8 reports the estimates corresponding to the estimates in eq. (2), with the dependent variable being the log amount of liabilities transferred to the captive. Observations are at the insurer by state by year level. The dependent variable is the log of dollar amount of liabilities the insurer transfers to the captive in the state each year. The independent variable Capital Rate is the captive capital rate of the state each year. State Controls include Business Environment, which is the number of new business incorporations per capita in the state each year, Amenities, which is the number of tourists visiting the state each year, 1(Appointed Commissioner), which is an indicator variable for whether the state insurance commissioner is appointed as opposed to elected, Vote Share (Republican), which is the vote share for the Republican candidate in the preceding presidential election. Insurer-State Controls includes Share Sold in State, which is the share of the insurer's total premiums that are sold in the state, and 1(Sells in State), which is whether the insurer sells in the state. Standard errors are two-way clustered at the insurer-by-year level and are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A9: Determinants of Insurers' Choice to Use Captives or Not

	(1)	(2)	(3)
ln(Size)	0.052*** (0.007)	0.051*** (0.007)	0.058*** (0.016)
A.M. Best Rating			-0.000 (0.001)
Liquidity			0.064 (0.040)
Return on Equity			0.026 (0.018)
Leverage			-0.003 (0.065)
Constant	-0.284** (0.105)		
Obs.	4626	4626	2132
R2	0.127	0.133	0.139
Year FEs		X	X

Note: Table A9 reports a linear regression of the determinants of captive use by insurers. Observations are at the insurer by state by year level. The dependent variable is an indicator variable for whether an insurer uses captives that year. ln(Size) is the size of the insurer measured as the log dollars of total liabilities of the insurer. Liquidity is the insurer's cash plus short-term investments divided by its total liabilities. Return on Average Equity is the insurer's annualized income after taxes as a percent of average capital and surplus. Leverage is the insurer's total liabilities divided by its net total assets. Year FEs indicate year fixed effects. Standard errors are two-way clustered at the insurer and year levels and are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A10: Correlation Between Capital and Default

	(1)	(2)	(3)
Risk-Based Capital Ratio	-0.28*** (0.09)	-0.28** (0.10)	-0.27** (0.10)
ln(Size)		-0.63*** (0.19)	-0.65*** (0.19)
Liquidity		-0.01 (0.01)	-0.02 (0.01)
Return on Equity		0.89 (0.82)	0.90 (0.82)
Leverage		7.40*** (2.34)	7.68*** (2.40)
Constant	1.62*** (0.41)	4.13*** (1.26)	
Obs.	19834	18704	18704
R2	0.001	0.015	0.017
Year FEs			X

Note: Table A10 reports the estimates of a linear probability model of insurer defaults. Observations are at the insurer by year level. The dependent variable is an indicator variable for whether the insurer became insolvent within 10 years, in percentage points. The independent variable Risk-Based Capital Ratio is the NAIC risk-based capital ratio of the insurer, in decimal points. ln(Size) is the size of the insurer measured as the log dollars of total liabilities of the insurer. Liquidity is the insurer's cash plus short-term investments divided by its total liabilities. Return on Average Equity is the insurer's annualized income after taxes as a percent of average capital and surplus. Leverage is the insurer's total liabilities divided by its net total assets. Year FEs indicate year fixed effects. Standard errors are two-way clustered at the insurer and year levels and are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A11: Consumer Demand Estimates, Alternative Instruments

	(1)
Price	-5.18*** (0.92)
ln(Size)	1.97*** (0.28)
A.M. Best Rating	1.42*** (0.28)
Risk-Based Capital Ratio	0.42 (1.40)
Liquidity	8.36*** (1.43)
Return on Equity	-0.06 (0.07)
Leverage	-1.90*** (0.46)
Obs.	9710
R2	0.250
State-Year FEs	X

Note: Table A11 reports the estimates corresponding to the estimates in eq. (17). Observations are at the insurance company by state by year level. The dependent variable is the market share. The independent variable Price is the price of each life insurance policy as a multiple of its reserve value. ln(Size) is the size of the insurer measured as the log dollars of total liabilities of the insurer. A.M. Best Rating is the financial strength rating given by A.M. Best to each insurance company each year converted from a letter grade to a numeric grade following Kojien and Yogo (2018). Risk-Based Capital Ratio is the authorized control level capital ratio of the insurer that year. Liquidity is the insurer's cash plus short-term investments divided by its total liabilities. Return on Average Equity is the insurer's annualized income after taxes as a percent of average capital and surplus. Leverage is the insurer's total liabilities divided by its net total assets. The instrumental variables for price of life insurance products are Hausman et al. (1994)-style instruments, which are prices of annuity products sold by the same insurer in the first year it started reporting annuity prices, usually before 2005. All independent variables except Price are standardized. Standard errors are two-way clustered at the insurance company and year levels and are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A12: Demand Estimation: First Stage

	(1)	(2)
ln(Size) Sq.	0.08*** (0.03)	
A.M. Best Rating Sq.	0.27*** (0.08)	
Risk-Based Capital Ratio Sq.	-0.92** (0.37)	
Liquidity Sq.	0.01 (0.03)	
Return on Equity Sq.	-0.00 (0.00)	
Leverage Sq.	-0.08*** (0.02)	
1(Uses Captives)	0.00 (0.03)	
Annuity Price: 50 Male		-0.79*** (0.21)
Annuity Price: 55 Male		1.38*** (0.39)
Annuity Price: 60 Male		-0.72*** (0.14)
Annuity Price: 65 Male		0.39*** (0.09)
Annuity Price: 70 Male		0.19 (0.12)
Annuity Price: 75 Male		-0.49*** (0.14)
Obs.	21588	9710
R2	0.331	0.579
F Statistic	327.64	682.33
IV	Kojien-Yogo	Hausman

Note: Table A12 reports the first-stage of the instrumental variables estimates corresponding to eq. (17). Observations are at the insurance company by state by year level. The dependent variable is the price of the life insurance policy. Sq. in the dependent variable names indicates that it is the square of the characteristic's numerical value. A.M. Best Rating is the financial strength rating given by A.M. Best to each insurance company each year converted from a letter grade to a numeric grade. A.M. Best Capital Ratio is the capital adequacy ratio reported by A.M. Best in their ratings. Leverage is the insurer's total liabilities divided by its net total assets. Liquidity is the insurer's cash plus short-term investments divided by its total liabilities. Return on Average Equity is the insurer's annualized income after taxes as a percent of average capital and surplus. Annuity Price is the price of the annuity, expressed in thousands of dollars. All independent variables except Annuity Price are standardized. Standard errors are clustered at the company-year level and are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A13: Insurers' Stochastic Cost Distribution Estimates

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
$\mu_{i,t}$	488	0.89	0.27	0.48	0.74	0.83	0.94	2.32
$\sigma_{i,t}$	488	0.11	0.02	0.05	0.11	0.11	0.12	0.46

Note: Table A13 reports summary statistics of the estimates of insurers' stochastic cost distribution parameters $\mu_{i,t}$ and $\sigma_{i,t}$ corresponding to eq. (19). The parameters are denoted in units of the actuarial value of a representative policy. Observations are at the insurer by year level.

Table A14: Regulators' Weight Estimates, with Producer Surplus

	(1)	(2)	(3)
Default Cost	-1.68*** (0.60)	-3.66*** (0.76)	-3.52*** (1.12)
Consumer Surplus		-6.20*** (1.65)	-6.32*** (1.57)
Producer Surplus			0.62 (52.40)
Observations	271	271	271
R ²	0.11	0.16	0.16

Note: Table A14 reports the estimates corresponding to eq. (16), with producer surplus. The dependent variable is the partial derivative of state's tax revenues with respect to the capital rate, $\frac{\partial \text{Tax}_{s,t}}{\partial \kappa_{s,t}}$. The independent variable Default Cost is the partial derivative of the state's default cost with respect to the capital rate, $\frac{\partial \text{Default}_{s,t}}{\partial \kappa_{s,t}}$. Consumer Surplus is the partial derivative of the state's consumer surplus with respect to the capital rate, $\frac{\partial \text{ConsumerSurplus}_{s,t}}{\partial \kappa_{s,t}}$. Producer Surplus is the partial derivative of the state's producer surplus with respect to the capital rate, $\frac{\partial \text{ProducerSurplus}_{s,t}}{\partial \kappa_{s,t}}$. Observations are at the state by year level. Standard errors are two-way clustered at the state and year levels and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.10.