Shadow Insurance*

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Abstract

Liabilities ceded by life insurers to shadow reinsurers (i.e., affiliated and less regulated off-balance-sheet entities) grew from \$11 billion in 2002 to \$364 billion in 2012. Life insurers using shadow insurance, which capture half of the market share, ceded 25 cents of every dollar insured to shadow reinsurers in 2012, up from 2 cents in 2002. Our adjustment for shadow insurance reduces risk-based capital by 53 percentage points (or 3 rating notches) and raises default probabilities by a factor of 3.5. We develop a structural model of the life insurance industry and estimate the impact of current policy proposals to contain or eliminate shadow insurance. In the counterfactual without shadow insurance, the average company currently using shadow insurance would raise its price by 12 percent, and annual life insurance underwritten would fall by 11 percent for the industry.

JEL: G22, G28, L11, L51

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1. Introduction

Life insurance and annuity liabilities of U.S. life insurers were $4,068 billion in 2012, which is substantial even when compared with $6,979 billion in savings deposits at U.S. depository institutions (Board of Governors of the Federal Reserve System 2013). However, there is little research on life insurer liabilities, especially in comparison with the large banking literature. The reason, perhaps, is the traditional view that life insurer liabilities are safe (and boring) because they are more predictable, have a longer maturity, and are less vulnerable to runs. Hence, the conventional wisdom is that all of the interesting action is on the asset side of the balance sheet, where life insurers take on some investment risk.

This paper shows that developments in the life insurance industry over the last decade shatter this traditional view. As a consequence of changes in regulation, life insurers are now using reinsurance to move liabilities from operating companies that sell policies to less regulated and unrated *shadow reinsurers*. These shadow reinsurers are captives or special purpose vehicles in U.S. states (e.g., South Carolina and Vermont) or offshore domiciles (e.g., Bermuda and Barbados) with more favorable capital regulation or tax laws. In contrast to traditional reinsurance with unaffiliated (i.e., third-party) reinsurers, these transactions do not transfer risk because the liabilities stay within the holding company.

Using new data on life and annuity reinsurance agreements in the United States, we map out the financial plumbing of life insurer liabilities, paying particular attention to the shadow insurance sector. We find that liabilities ceded to shadow reinsurers grew rapidly from $11 billion in 2002 to $364 billion in 2012. This activity now exceeds total unaffiliated reinsurance in the life insurance industry, which was $270 billion in 2012.[1] Life insurers using shadow insurance tend to be larger and capture 48 percent of the market share for both life insurance and annuities. These companies ceded 25 cents of every dollar insured to shadow reinsurers in 2012, significantly up from only 2 cents in 2002.

The potential risk of shadow insurance is difficult to assess because the financial statements of shadow reinsurers are confidential to the public, rating agencies, and even to insurance regulators outside their state of domicile. Consistent with the lack of information, we find that current ratings do not appear to reflect shadow insurance. We attempt to quantify the financial risk of shadow insurance, based on publicly available information and conservative assumptions. Our adjustment reduces risk-based capital by 53 percentage points and ratings by 3 notches for the average company using shadow insurance. The adjusted ratings imply an average 10-year default probability that is 3.5 times higher than that implied by

[1] Similarly, total unaffiliated reinsurance in the property-casualty insurance industry was $155 billion in 2008 (Cummins and Weiss 2010, Table 5).

the reported ratings. This raises the expected loss for the industry to \$15.8 billion, or 28 percent of the total capacity of state guaranty funds.

On the one hand, shadow insurance imposes a social cost on the state guaranty funds, or ultimately the life insurers not using shadow insurance and state taxpayers. On the other hand, shadow insurance reduces the private cost of financial and regulatory frictions for life insurers, thereby reducing their marginal cost of issuing policies. To estimate the impact of shadow insurance on equilibrium in the retail market, we develop a structural model of the life insurance industry. Demand is determined by a standard discrete choice model of product differentiation, along both observable and unobservable company characteristics. Supply is determined by imperfectly competitive operating companies that sell policies and cede reinsurance to affiliated reinsurers for the purposes of capital management. We estimate the structural model under the identifying assumption that shadow insurance lowers prices, but it does not affect demand directly.

We use the structural model to estimate the impact of current policy proposals to contain or eliminate shadow insurance. For example, the New York State Department of Financial Services has called for a national moratorium on further approval of shadow insurance (Lawsky 2013). The Financial Stability Oversight Council has designated some life insurers as "systemically important" and placed them under Federal Reserve supervision, which could limit shadow insurance through new reporting and capital requirements (Federal Insurance Office 2013). In the counterfactual without shadow insurance, the average company currently using shadow insurance would raise its price by 12 percent in response to a 21 percent increase in marginal cost. Higher prices mean that some potential customers would stay out of the life insurance market. Consequently, annual life insurance underwritten would fall by \$9.6 billion for the industry, or by 11 percent relative to the current size of the market.

Our work on life and annuity reinsurance is related to the literature on property and casualty reinsurance. This literature finds that property and casualty reinsurance is used for a variety of reasons, including risk transfer as well as capital and tax management (Mayers and Smith 1990, Adiel 1996). Froot (2001) finds evidence for limited transfer of catastrophe event risk, which highlights the importance of capital market frictions in the supply side of reinsurance markets. For life insurers, risk transfer has always been a less important motive because of the more predictable nature of their business, which explains why there is relatively little unaffiliated reinsurance. All of the growth in life and annuity reinsurance over the last decade is within the holding company, which points to capital and tax management as the primary motive for this activity.

Our work is also related to the literature on financial and regulatory frictions in the supply side of insurance markets. In particular, some recent papers show that capital regulation and accounting rules, when they interact with financial frictions, affect investment behavior on the asset side of the balance sheet.[2] Our work complements this literature by showing that a set of capital regulation and accounting rules, which is specific to the liability side, has a profound impact on reinsurance activity and pricing behavior in the retail market.

The remainder of the paper is organized as follows. Section 2 discusses the changes in life insurance regulation and new captive laws that preceded shadow insurance. Section 3 describes the data on life and annuity reinsurance. Section 4 documents the rapid growth of shadow insurance over the last decade. In Section 5, we estimate the impact of shadow insurance on financial risk of the companies involved and expected loss for the industry. In Section 6, we develop a model of optimal insurance pricing and reinsurance for a holding company. In Section 7, we estimate the structural model and the counterfactual without shadow insurance. Section 8 concludes with broader implications of our findings.

2. Changes in Regulation that Preceded Shadow Insurance

The four basic motives of life and annuity reinsurance are risk transfer, underwriting assistance, capital management, and tax management (Tiller and Tiller 2009, Chapter 1). Over the last decade, the latter two motives have become increasingly important relative to the former two because of two related developments. On the one hand, changes in regulation after 2000 forced life insurers to hold more capital against life insurance liabilities, straining their capital positions. On the other hand, new state laws after 2002 allowed life insurers to establish captives to circumvent the new capital requirements. We now discuss these developments and related institutional background, to the extent that they are relevant for this paper.

Before we proceed, we should mention that the fundamental motive for shadow insurance is the same agency problems that lead to higher leverage, higher dividend rates, and increased risk taking in regulated financial institutions. For example, the presence of state guaranty funds lowers the cost of issuing policies from the perspective of life insurers. Investors may prefer higher leverage and higher dividend rates because portfolio decisions outside the insurance sector are not subject to capital regulation. The focus of this paper is not on why life insurers have high leverage. Rather, we focus on how they achieve higher leverage through reinsurance and how that affects financial risk and market equilibrium in the life insurance industry.

[2]See Becker and Ivashina (2012), Ellul, Jotikasthira, Lundblad, and Wang (2012), and Merrill, Nadauld, Stulz, and Sherlund (2012).

2.1. Changes in Life Insurance Regulation

In January 2000, the National Association of Insurance Commissioners (NAIC) adopted Model Regulation 830, commonly referred to as Regulation XXX. This was followed by Actuarial Guideline 38 in January 2003, commonly referred to as Regulation AXXX. These changes in regulation forced life insurers to hold much higher statutory reserves on newly issued term life insurance and universal life insurance with secondary guarantees.

These changes in regulation are a matter of statutory accounting principles and do not apply to generally accepted accounting principles (GAAP). The reserve requirements under GAAP are much lower and closer to actuarial value. Therefore, an operating company that reports under statutory accounting principles can cede reinsurance to a reinsurer that reports under GAAP, thereby reducing overall reserves. In practice, however, unaffiliated reinsurance can be expensive because of the limited supply of capital for this purpose.

2.2. New Captive Laws

Starting in 2002, South Carolina introduced new laws that allow life insurers to establish captives, whose primary function is to assume reinsurance from affiliated companies for the purpose of reducing overall reserves. Captives are governed by state law that is different from the usual insurance regulation that applies to operating companies. A captive structure that has proven especially successful is the "special purpose financial captive", which is a type of special purpose vehicle that was introduced by South Carolina in 2004 and by Vermont in 2007. There are now 26 states that have adopted a version of the captive laws, eight of which have defined special purpose financial captives (Captives and Special Purpose Vehicle Use Subgroup 2013).

Captives usually have several advantages over traditional reinsurers. First, they allow life insurers to keep the underwriting profits within the holding company. Second, they can hold less capital because they report under GAAP or are not subject to risk-based capital regulation. Third, their financial statements are confidential to the public, rating agencies, and even to insurance regulators outside their state of domicile. Finally, they have a more flexible financial structure that allows them to fund reinsurance transactions through letters of credit or securitization. In Appendix A, we provide stylized balance-sheet examples that illustrate these advantages of captive reinsurance.

Operating companies are ultimately responsible for all liabilities that they issue, even those that they cede to reinsurers. Combined with the fact that securitization is rare in practice (Stern, Rosenblatt, Nadell, and Andruschak 2007), captives do not transfer risk outside the holding company and exist solely for the purpose of capital and tax management.

Hence, captives have a function similar to asset-backed commercial paper conduits with explicit guarantees from the sponsoring bank (Acharya, Schnabl, and Suarez 2013), prior to the recent regulatory reform of shadow banking (Adrian and Ashcraft 2012).

U.S. tax laws disallow reinsurance for the primary purpose of reducing tax liabilities. However, it can be an important side benefit of captive reinsurance that motivates where a life insurer establishes its captive. Life insurance premiums are taxable at the state level, and the tax rates on premiums vary across states (Cole and McCullough 2008). In addition, profits are taxable at the federal level, so an operating company can reduce overall tax liabilities by ceding reinsurance to an offshore captive. Bermuda, Barbados, and the Cayman Islands are important captive domiciles for this purpose.

3. Data on Life and Annuity Reinsurance

3.1. Data Construction

We construct our sample of life and annuity reinsurance agreements for U.S. life insurers from the Schedule S filings for fiscal years 2002 to 2012 (A.M. Best Company 2003–2013a). These financial statements are annually reported to the NAIC according to statutory accounting principles, which are conveniently organized along with ratings information by A.M. Best Company. The relevant parts of Schedule S for our analysis are 1.1 (Reinsurance Assumed), 3.1 (Reinsurance Ceded), and 4 (Reinsurance Ceded to Unauthorized Companies).

The data contain all reinsurance agreements (both ceded and assumed) at each fiscal year-end for any operating company or authorized reinsurer that faces the same reporting and capital requirements as an operating company. In particular, the data contain reinsurance ceded by an operating company to an unauthorized reinsurer, such as a domestic captive or a foreign reinsurer. However, we do not observe reinsurance ceded by unauthorized reinsurers that do not report to the NAIC.

For each reinsurance agreement, we observe the identity of the reinsurer, the type of reinsurance, the effective date, reserve credit taken (or reserves held), and modified coinsurance reserve.[3] We know the identity of the reinsurer up to its name, domicile, whether it is affiliated with the ceding company, whether it is authorized in the domicile of the ceding company, and whether it is rated by A.M. Best Company. We define *shadow reinsurers* as affiliated and unauthorized reinsurers without an A.M. Best rating. Our definition is stricter than "captives" because some captives are actually authorized.

[3]The types of life reinsurance agreements in the data are coinsurance, modified coinsurance, combination coinsurance, yearly renewable term, and accidental death benefit. The types of annuity reinsurance agreements are coinsurance, modified coinsurance, combination coinsurance, and guaranteed minimum death benefit.

3.2. Description of the Sample

Table 1 reports summary statistics for our sample of life and annuity reinsurance agreements, by whether they were ceded to unaffiliated or affiliated reinsurers. The table also reports the same statistics for shadow reinsurers, which are a subset of affiliated reinsurers that are unauthorized and do not have an A.M. Best rating.

Although there are fewer affiliated reinsurance agreements, the typical amount ceded is significantly higher than that for unaffiliated reinsurance. For example, there were 456 new unaffiliated reinsurance agreements in 2009. In comparison, there were only 120 new affiliated reinsurance agreements, 67 of which were ceded to shadow reinsurers. Average unaffiliated reinsurance ceded was $37 million, which is much lower than $1,199 million for affiliated reinsurance and $2,003 million for shadow insurance. The average shadow insurance agreement has generally grown from $60 million in 2002 to $502 million in 2012.

Table 2 describes the characteristics of the life insurers in our sample, by whether they were using shadow insurance.[4] Most life insurers do not use shadow insurance. However, the ones that do tend to be larger, either by market share or total liabilities. In 2012, 78 companies used shadow insurance, while 443 companies did not. However, the life insurers using shadow insurance captured 48 percent of the market share for both life insurance and annuities, and their average liabilities were 317 percent higher.

The life insurers using shadow insurance are mostly stock companies, instead of mutual companies. They also tend to be more leveraged, have assets with lower liquidity, and have higher profitability. In 2012, the average leverage ratio was 89 percent for the life insurers using shadow insurance, compared with 72 percent for the other companies.

4. New Facts about Shadow Insurance

We now document the rapid growth of shadow insurance over the last decade, as a consequence of changes in life insurance regulation and new captive laws, discussed in Section 2. We start with a case study of the MetLife group, which is the largest insurance group in the United States by total assets. We then show that the rapid growth of affiliated reinsurance, especially with unrated and unauthorized reinsurers, stands in sharp contrast to the behavior of unaffiliated reinsurance over the same period.

[4] We refer to Appendix B for a description of the company characteristics.

4.1. A Case Study of the MetLife Group

Table 3 lists the U.S. operating companies of the MetLife group and their affiliated reinsurers in 2012. The operating companies all have an A.M. Best rating of A+ and cede reinsurance to the rest of the group. The reinsurers are all unrated and assume reinsurance from the rest of the group. The reinsurers are also unauthorized, except for MetLife Reinsurance of Delaware and MetLife Reinsurance of Charleston since 2009. Quite strikingly, the liabilities disappear from the balance sheets of operating companies that sell policies and end up in less regulated and nontransparent reinsurers.

Net reinsurance ceded by Metropolitan Life Insurance (the flagship operating company in New York) was $39.1 billion, which was nearly three times their capital and surplus. In the same year, net reinsurance assumed by Missouri Reinsurance (a captive in Barbados) was $28.4 billion. The sum of net reinsurance ceded across all companies in Table 3, which is total reinsurance ceded outside the MetLife group, was $5.7 billion. This shows that most of the reinsurance activity is within the MetLife group, rather than with unaffiliated reinsurers.

4.2. Growth of Affiliated Reinsurance

Figure 1 reports total reinsurance ceded by U.S. life insurers to affiliated and unaffiliated reinsurers. Affiliated reinsurance grew rapidly from $90 billion in 2002 to $572 billion in 2012. In contrast, unaffiliated reinsurance peaked at $287 billion in 2006 and has been flat since then. Affiliated reinsurance has exceeded unaffiliated reinsurance since 2007.

Figure 2 breaks down Figure 1 into life versus annuity reinsurance. Affiliated life reinsurance grew rapidly from $36 billion in 2002 to $375 billion in 2012. This trend is consistent with changes in life insurance regulation and new captive laws, as discussed in Section 2. In contrast, affiliated annuity reinsurance shows little growth prior to 2007. It then grew rapidly from $91 billion in 2007 to $197 billion in 2012. This timing is consistent with the hypothesis that life insurers faced capital constraints during the financial crisis and, therefore, used affiliated reinsurance to boost their capital positions (Koijen and Yogo 2012).

4.3. Geographic Concentration of Reinsurance

Figure 3 decomposes life and annuity reinsurance ceded by domicile of the reinsurer, separately for affiliated and unaffiliated reinsurance. As discussed in Section 2, South Carolina and Vermont are the most important domiciles for domestic captives because of their capital regulation. Bermuda, Barbados, and the Cayman Islands are the most important domiciles for offshore captives because of their capital regulation and tax laws.

The geography of affiliated reinsurance is characterized by increasing concentration, which is not present in unaffiliated reinsurance. The share of affiliated reinsurance ceded to South Carolina and Vermont grew rapidly from essentially none in 2002 to 19 percent in 2012. In contrast, the share of unaffiliated reinsurance ceded to these two states remained low throughout this period. Similarly, the share of affiliated reinsurance ceded to Bermuda, Barbados, and the Cayman Islands grew from 9 percent in 2002 to 46 percent in 2012. In contrast, the share of unaffiliated reinsurance ceded to these offshore domiciles shrank slightly during the same period.

4.4. Reinsurance with Unrated and Unauthorized Reinsurers

Figure 4 decomposes life and annuity reinsurance ceded by A.M. Best rating of the reinsurer, separately for affiliated and unaffiliated reinsurance. The share of affiliated reinsurance ceded to unrated reinsurers grew rapidly from 21 percent in 2002 to 76 percent in 2012. In contrast, the share of unaffiliated reinsurance ceded to unrated reinsurers shrank slightly during the same period.

Figure 5 decomposes life and annuity reinsurance ceded by whether the reinsurer is authorized in the domicile of the ceding company, separately for affiliated and unaffiliated reinsurance. The share of affiliated reinsurance ceded to unauthorized reinsurers grew rapidly from 19 percent in 2002 to 70 percent in 2012. In contrast, the share of unaffiliated reinsurance ceded to unauthorized reinsurers has been relatively constant throughout this period.

4.5. Growth of Shadow Insurance

Figure 6 reports total reinsurance ceded by U.S. life insurers to shadow reinsurers. Shadow insurance grew rapidly from $11 billion in 2002 to $364 billion in 2012. In particular, growth accelerated during the financial crisis from 2006 to 2009. As a share of the capital and surplus of the ceding companies, shadow insurance grew from 0.22 in 2002 to 2.49 in 2012. This represents significant leverage in a less regulated and nontransparent part of the insurance industry.

Figure 7 documents the rapid growth of shadow insurance from the perspective of retail customers that buy policies. As discussed in Section 3, the life insurers using shadow insurance capture 48 percent of the market share for both life insurance and annuities. These companies ceded 25 cents of every dollar insured to shadow reinsurers in 2012, significantly up from only 2 cents in 2002.

5. Impact of Shadow Insurance on Financial Risk and Expected Loss

We first show that current ratings do not appear to reflect shadow insurance. We then estimate the impact of shadow insurance on financial risk of the companies involved by adjusting their risk-based capital, ratings, and default probabilities. Finally, we estimate the impact of shadow insurance on expected loss for the industry.

5.1. Relation between Ratings and Shadow Insurance

Ratings, especially those of A.M. Best Company, are important determinants of reputation in the retail market and ultimately demand. Therefore, we first ask whether the current rating methodology has kept pace with the recent developments in shadow insurance, which is economically different from traditional reinsurance. To do so, we estimate the relation between the numerical counterpart of A.M. Best ratings and company characteristics, including a dummy for shadow insurance.[5] We refer to Appendix B for a description of the numerical ratings and company characteristics that we use in our analysis.

The first column of Table 4 reports the estimated relation based on ordinary least squares. The conventional determinants of ratings, as discussed in A.M. Best Company (2011), explain an impressive 62 percent of the cross-sectional variation. The most important determinant is company size, captured by log liabilities and dummies for A.M. Best financial size category, which are not reported for brevity. Ratings increase by 0.17 standard deviations per one standard deviation increase in log liabilities. Risk-based capital is also an important determinant of ratings. Ratings increase by 0.13 standard deviations per one standard deviation increase in risk-based capital. Ratings are unrelated to shadow insurance, after controlling for these other characteristics. The coefficient on shadow insurance is zero and statistically insignificant.

The coefficient on shadow insurance could be biased if there are omitted characteristics that are key determinants of ratings (e.g., soft information that is only available to A.M. Best Company). We address this concern by instrumental variables, where our instrument for shadow insurance is the market share for term life insurance in 1999, interacted with a dummy for stock company in 1999. The motivation for our instrument is that Regulation XXX had a stronger effect on life insurers with more presence in the term life insurance market. The interaction accounts for the fact that among those companies affected by Regulation XXX, the stock companies have a stronger incentive to take advantage of the captives laws after 2002 (Mayers and Smith 1981). The market share in 1999 is plausibly

[5] We have also examined the share of gross life and annuity reserves ceded to shadow reinsurers as an alternative measure of shadow insurance with similar results.

exogenous because Regulation XXX applies only to new policies issued after 2000 and does not apply retroactively to existing liabilities.

Table 4 reports that the term life share is a significant predictor of whether a life insurer uses shadow insurance. In the first stage of instrumental variables, the likelihood of shadow insurance increases by 5 percentage points per one standard deviation increase in the term life share. The coefficient on shadow insurance in the second stage is positive and statistically insignificant. Therefore, we conclude that ratings do not appear to reflect shadow insurance, even after addressing the concern of omitted variables bias.

5.2. Impact of Shadow Insurance on Financial Risk

The potential risk of shadow insurance is difficult to assess because the financial statements of shadow reinsurers are not publicly available. In particular, we do not know the risk profile of their assets and liabilities, the amount of excess capital held, and the fragility of their funding arrangements. We make our best attempt to assess the financial risk of shadow insurance, based on publicly available information and conservative assumptions. The mere fact that such fundamental assessments are difficult calls for more transparent reporting requirements for captives.

We make the following assumptions.

1. The risk profile of reinsurance ceded is identical to existing life and annuity reserves on balance sheet, so that required capital rises proportionally. This is a conservative assumption because reinsurance ceded to shadow reinsurers is likely to be riskier than the liabilities that remain on balance sheet.

2. Shadow reinsurers do not hold excess capital because they are not subject to risk-based capital regulation. For example, captives in Vermont are required to hold only $250,000 in capital and are allowed to count letters of credit as admitted assets (Captives and Special Purpose Vehicle Use Subgroup 2013).

3. The funding arrangements of shadow reinsurers, including all letters of credit, are fully secure. This is a conservative assumption because Lawsky (2013) finds widespread use of more fragile sources of funding (e.g., conditional letters of credit guaranteed by the parent company and naked parental guarantees), based on regulatory information that is not publicly available.

We then ask what would happen to the balance sheets of the life insurers using shadow insurance if both the assets and liabilities on reinsurance ceded to shadow reinsurers were moved back on balance sheet. Under our assumptions, capital and surplus would not change, but risk-based capital would fall because the capital required to support the additional liabilities (i.e., the denominator of the ratio) would rise. As we discuss in Appendix B, our assumptions yield simple adjustments to risk-based capital, ratings, and leverage based on the reported data.

Table 5 reports that our adjustment reduces risk-based capital by 53 percentage points for the average company using shadow insurance in 2012. Similarly, the average rating drops by 3 notches from A to B+. We next match both the reported and adjusted ratings to the term structure of default probabilities, which we estimate as described in Appendix B. The adjusted ratings imply an average 10-year default probability of 3.3 percent, which is 3.5 times higher than that implied by the reported ratings.

5.3. Impact of Shadow Insurance on Expected Loss

We estimate the present value of expected loss for each company, based on the balance-sheet positions and the term structure of default probabilities. We estimate a 25 percent loss conditional on default, based on the historical data (Peterson 2013). The historical default probabilities and loss ratios lead to a conservative estimate of expected loss because they are based on mostly idiosyncratic events of smaller companies. We expect the actual experience for larger companies using shadow insurance to be more systemic, leading to larger losses for the industry.

As reported in Table 6, the reported balance-sheet positions and default probabilities imply an expected loss of \$5.4 billion for the industry in 2012. The expected loss rises to \$15.8 billion when the balance-sheet positions and default probabilities are adjusted for shadow insurance. The difference between adjusted and reported expected loss is the amount due to shadow insurance, which has increased from \$0.1 billion in 2002 to \$10.4 billion in 2012. Since state guaranty funds ultimately pay off all liabilities by assessing the surviving companies, this expected loss represents an externality to the life insurers not using shadow insurance. State taxpayers also bear a share of the cost because guaranty fund assessments are tax deductible.

To put these figures into perspective, we estimate the total capacity of state guaranty funds in the last column of Table 6. All states cap annual guaranty fund assessments, typically at 2 percent of recent life insurance and annuity premiums. Following Gallanis (2009), we estimate the total capacity of state guaranty funds as the maximum annual assessment aggregated across all states, projected to remain constant over the next 10 years. As a share of the total capacity of state guaranty funds, the expected loss for the industry has grown from 8 percent in 2002 to 28 percent in 2012. The excess capacity of state guaranty funds will continue to shrink unless insurance regulators intervene to limit the growth of shadow insurance.

6. Model of Insurance Pricing and Reinsurance

Insurance regulators recognize the potential risk of shadow insurance and, as discussed in Section 1, are considering policy proposals that would contain or eliminate shadow insurance. To understand how such policy reform would affect equilibrium in the retail market, we now develop a model of the supply side of insurance markets. In our model, a holding company consists of an operating company that sells policies to retail customers and an affiliated reinsurer (i.e., captive or special purpose vehicle) that faces looser capital regulation. The holding company uses affiliated reinsurance to move capital between the two companies to reduce the overall cost of financial and regulatory frictions. In doing so, affiliated reinsurance reduces the operating company's marginal cost of issuing policies and raises its equilibrium supply in the retail market.

Our model has some elements that are familiar from existing models of reinsurance in the property and casualty literature. For example, Froot and O'Connell (2008) model the demand for unaffiliated reinsurance (with risk transfer) when insurance companies face capital market frictions and imperfect competition. In addition to these familiar elements, we add affiliated reinsurance (without risk transfer) as a powerful tool for capital management, which has become the predominant form of reinsurance for life insurers over the last decade. For simplicity, we ignore tax effects because they are difficult to model realistically and also measure. As discussed in Section 2, U.S. tax laws disallow reinsurance for the primary purpose of reducing tax liabilities.

6.1. Holding Company's Maximization Problem

The holding company consists of an operating company and an affiliated reinsurer. The operating company prices its policies, facing a downward-sloping demand curve. Let Q_t denote the quantity of policies sold in year t at the price P_t. After the sale of policies, the operating company can cede reinsurance to the affiliated reinsurer. Let $B_t \geq 0$ denote the quantity of affiliated reinsurance ceded in year t. The operating company can also cede reinsurance to unaffiliated reinsurers outside the holding company. Let $D_t \geq 0$ denote the quantity of unaffiliated reinsurance ceded at an exogenously given price $P_{D,t}$.

We denote the actuarial value, or the frictionless marginal cost per policy, as V_t. The holding company's profit in year t is

$$\Pi_t = (P_t - V_t)Q_t - (P_{D,t} - V_t)D_t. \quad (1)$$

Total profit is equal to the profit from the sale of policies minus the cost of unaffiliated reinsurance. Note that affiliated reinsurance nets out of total profit (in the absence of tax effects).

Balance Sheet Dynamics

We now describe how the sale of policies and reinsurance affect the operating company's balance sheet. Let L_t be the operating company's liabilities at the end of year t. The change in liabilities in year t is

$$\Delta L_t = V_t(Q_t - B_t - D_t). \quad (2)$$

Let A_t be the operating company's assets at the end of year t. The change in assets in year t is

$$\Delta A_t = \Delta L_t + \Pi_t = P_t Q_t - V_t B_t - P_{D,t} D_t. \quad (3)$$

The change in assets is equal to the change in liabilities plus total profit.[6]

We define the operating company's statutory capital at the end of year t as

$$K_t = A_t - (1+\rho)L_t. \quad (4)$$

Our formulation of statutory capital can be interpreted in two ways, both of which lead to equation (4). First, as discussed in Section 2, operating companies must hold additional reserves under Regulation (A)XXX. Under this interpretation, ρ is the difference between reserve and actuarial value. Second, operating companies that face risk-based capital regulation must hold additional capital to buffer shocks to their liabilities. Under this interpretation, ρ is the risk charge on liabilities. Under both interpretations, a higher ρ implies tighter capital regulation. Equations (2) and (3) imply that the change in the operating company's

[6]We could modify equation (3) to include other sources of financing, such as direct capital injections from the parent company. However, these other sources are more expensive and less preferred to affiliated reinsurance by revealed preference.

statutory capital in year t is

$$\Delta K_t = (P_t - (1+\rho)V_t)Q_t + \rho V_t B_t - (P_{D,t} - (1+\rho)V_t)D_t. \tag{5}$$

The only function of the affiliated reinsurer is to assume reinsurance from the operating company. We define the affiliated reinsurer's statutory capital at the end of year t as

$$\widehat{K}_t = \widehat{A}_t - (1+\widehat{\rho})\widehat{L}_t. \tag{6}$$

We assume that $0 < \widehat{\rho} < \rho$, which means that the affiliated reinsurer faces looser capital regulation than the operating company. The change in the affiliated reinsurer's statutory capital in year t is

$$\Delta \widehat{K}_t = -\widehat{\rho} V_t B_t. \tag{7}$$

Financial and Regulatory Frictions

The Insurance Holding Company System Regulatory Act protects the interests of existing policyholders and the state guaranty funds by restricting the movement of capital within a holding company, including through affiliated reinsurance (National Association of Insurance Commissioners 2011, Appendix A-440). In addition, increased use of shadow insurance could draw regulatory scrutiny or intervention (Lawsky 2013). We model these financial and regulatory frictions through a cost function:

$$C_t = C\left(K_t, \widehat{K}_t\right) \tag{8}$$

with negative first derivatives and positive second derivatives. That is, unusually low levels of statutory capital in either the operating company or the affiliated reinsurer draws regulatory scrutiny or intervention.

The holding company maximizes firm value, or the present value of profits minus the cost of financial and regulatory frictions:

$$J_t = \Pi_t - C_t + \mathbf{E}_t[M_{t+1} J_{t+1}], \tag{9}$$

where M_{t+1} is the stochastic discount factor. Its choice variables are the insurance price P_t, affiliated reinsurance B_t, and unaffiliated reinsurance D_t.

6.2. *Optimal Insurance Pricing*

The first-order condition for the insurance price is

$$\frac{\partial J_t}{\partial P_t} = \frac{\partial \Pi_t}{\partial P_t} + c_t \frac{\partial K_t}{\partial P_t} = Q_t + (P_t - V_t)Q_t' + c_t[Q_t + (P_t - (1+\rho)V_t)Q_t'] = 0, \tag{10}$$

where we refer to

$$c_t = -\frac{\partial \Pi_t}{\partial P_t}\left(\frac{\partial K_t}{\partial P_t}\right)^{-1} = -\frac{\partial C_t}{\partial K_t} + \mathbf{E}_t\left[M_{t+1}\frac{\partial J_{t+1}}{\partial K_t}\right]. \tag{11}$$

as the *shadow cost of capital*. It measures the marginal reduction in profits that the holding company is willing to accept to raise the operating company's statutory capital by a dollar. Alternatively, it quantifies the importance of financial and regulatory frictions, either in the present or some future period.

Rearranging equation (10), the optimal insurance price is

$$P_t = \left(1 - \frac{1}{\epsilon_t}\right)^{-1} \frac{(1 + (1+\rho)c_t)V_t}{1 + c_t}, \tag{12}$$

where

$$\epsilon_t = -\frac{\partial \log Q_t}{\partial \log P_t} > 1 \tag{13}$$

is the elasticity of demand. The first term in equation (12) is the standard Bertrand pricing formula. The second term is the marginal cost of issuing policies, which arises from financial and regulatory frictions. Marginal cost increases with the shadow cost of capital and tighter capital regulation (i.e., higher ρ).

6.3. *Optimal Affiliated Reinsurance*

Assuming an internal optimum, the first-order condition for affiliated reinsurance is

$$\frac{\partial J_t}{\partial B_t} = c_t \frac{\partial K_t}{\partial B_t} + \widehat{c}_t \frac{\partial \widehat{K}_t}{\partial B_t} = (c_t \rho - \widehat{c}_t \widehat{\rho})V_t = 0, \tag{14}$$

where

$$\widehat{c}_t = -\frac{\partial C_t}{\partial \widehat{K}_t} + \mathbf{E}_t\left[M_{t+1}\frac{\partial J_{t+1}}{\partial \widehat{K}_t}\right]. \tag{15}$$

Equation (14) says that the holding company equates the shadow cost of capital across the two companies, appropriately weighted by the tightness of capital regulation. To do so, the operating company generally cedes reinsurance to the affiliated reinsurer that faces looser capital regulation (i.e., $\widehat{\rho} < \rho$). To illustrate this point, suppose that the two companies have the same shadow cost of capital prior to affiliated reinsurance. Then equation (14) holds only if the operating company's statutory capital rises relative to the affiliated reinsurer's, so that $c_t < \widehat{c}_t$ after affiliated reinsurance.

When the operating company cedes reinsurance to the affiliated reinsurer, the insurance price falls due to lower marginal cost. We can show this analytically under constant elasticity of demand, which is a simplifying assumption that we maintain just for the remainder of this paragraph. Differentiating equation (12) with respect to B_t,

$$\frac{\partial P_t}{\partial B_t} = \frac{\rho^2 P_t}{(1 + c_t)(1 + (1 + \rho)c_t)V_t} \frac{\partial c_t}{\partial K_t} < 0 \tag{16}$$

since $\partial^2 C_t / \partial K_t^2 > 0$.

6.4. *Optimal Unaffiliated Reinsurance*

The derivative of firm value with respect to unaffiliated reinsurance is

$$\frac{\partial J_t}{\partial D_t} = \frac{\partial \Pi_t}{\partial D_t} + c_t \frac{\partial K_t}{\partial D_t} = -(P_{D,t} - V_t) - c_t(P_{D,t} - (1 + \rho)V_t). \tag{17}$$

This implies that the operating company cedes reinsurance to an unaffiliated reinsurer only if

$$\frac{\partial J_t}{\partial D_t} > 0 \Longleftrightarrow P_{D,t} < \frac{(1 + (1 + \rho)c_t)V_t}{1 + c_t} \tag{18}$$

at $D_t = 0$. The right side of this equation can be interpreted as the effective marginal benefit of unaffiliated reinsurance. It can be higher than the marginal benefit of affiliated reinsurance because of additional benefits that could include risk transfer and underwriting assistance.

7. Impact of Eliminating Shadow Insurance

We now complete the model of the life insurance industry by introducing additional parametric assumptions about the demand function and marginal cost. We then estimate the structural model under the identifying assumption that shadow insurance lowers prices, but it does not affect demand directly. Finally, we use the structural model to estimate the counterfactual without shadow insurance.

We estimate the structural model on the life insurance market, rather than the annuity market, for two reasons. First, as discussed in Section 4, life insurance accounts for a larger share of affiliated reinsurance than annuities because of Regulation (A)XXX. Second, variable annuities account for most of the annuity market, and data on their rider fees are not readily available. We focus on 10-year guaranteed level term life insurance for males aged 30 as representative of the life insurance market. Appendix B contains further details about the data on life insurance prices.

7.1. Empirical Specification

Parametric Assumptions

Operating companies compete in the life insurance market by setting prices, facing the random-coefficients logit model of demand (Berry, Levinsohn, and Pakes 1995). Since all companies sell the same type of policy, product differentiation is along company characteristics. Life insurance is a type of intermediated savings, so the natural alternative is all savings vehicles that are intermediated by financial institutions other than insurance companies. Therefore, we specify the "outside good" as total annual saving by U.S. households in savings deposits, money market funds, and mutual funds (Board of Governors of the Federal Reserve System 2013, Table F.100).

Let S_t denote the demand for the outside good in year t, whose utility is normalized to zero. Let $Q_{n,t}$ denote the demand for life insurance sold by company n in year t. The random-coefficients logit model implies that the market share of company n in year t is

$$q_{n,t} = \frac{Q_{n,t}}{S_t + \sum_{m=1}^{N} Q_{m,t}} = \int \widetilde{q}_{n,t}(\alpha, \beta) dF(\alpha, \beta), \tag{19}$$

where

$$\widetilde{q}_{n,t}(\alpha, \beta) = \frac{\exp\{\alpha P_{n,t} + \beta' \mathbf{x}_{n,t} + u_{n,t}\}}{1 + \sum_{m=1}^{N} \exp\{\alpha P_{m,t} + \beta' \mathbf{x}_{m,t} + u_{m,t}\}} \tag{20}$$

and N is the total number of operating companies. The vector $\mathbf{x}_{n,t}$ is a set of observable characteristics that capture the operating company's statutory capital, or reputation in the retail market more broadly. The term $u_{n,t}$ captures company characteristics that are unobservable to the econometrician, which could be correlated with the price. For simplicity, we assume that the random coefficients are independently and normally distributed, so that

$F(\alpha, \beta)$ denotes the normal distribution function with a diagonal covariance matrix.

Marginal cost in equation (12) varies across operating companies due to variation in the shadow cost of capital. We parameterize marginal cost as

$$\frac{(1+(1+\rho)c_{n,t})V_t}{1+c_{n,t}} = \exp\{\gamma \mathrm{SI}_{n,t} + \delta' \mathbf{x}_{n,t} + e_{n,t}\}. \tag{21}$$

Marginal cost depends on a dummy for shadow insurance, where the coefficient $\gamma < 0$, as well as observable characteristics and an unobservable shock $e_{n,t}$. Our baseline specification assumes that the unobservable shock is uncorrelated with shadow insurance, conditional on the observable characteristics. However, we also consider an alternative specification that relaxes this assumption.

Identifying Assumptions

Our identifying assumption is that shadow insurance lowers prices through supply (12), but it does not affect demand (19) directly. This exclusion restriction is plausible insofar as retail customers do not know about shadow insurance (at least prior to this paper). Alternatively, this exclusion restriction holds as long as retail customers do not care about shadow insurance because they expect the state guaranty funds to ultimately pay off their claims. Of course, shadow insurance could be correlated with other characteristics that retail customers do care about, such as A.M. Best rating or company size. We control for these characteristics directly in equation (19).

We estimate the structural model consistently through a two-stage method (Berry 1994). We first estimate equation (19) by generalized method of moments, computing the integral through simulation. Our instruments are shadow insurance, company characteristics, and the characteristics squared. The random-coefficients logit model implies that the elasticity of demand for each company is

$$\epsilon_{n,t} = -\frac{P_{n,t}}{q_{n,t}} \int \alpha \widetilde{q}_{n,t}(\alpha, \beta)(1 - \widetilde{q}_{n,t}(\alpha, \beta)) dF(\alpha, \beta). \tag{22}$$

We then invert equation (12) to obtain the marginal cost for each company. Finally, we estimate the logarithm of equation (21) by ordinary least squares.

7.2. Estimating the Structural Model

The first two columns of Table 7 report the estimated parameters for the random-coefficients logit model (19). We limit the random coefficients to A.M. Best rating, log liabilities, and leverage. We have also examined a larger model in which price and risk-based capital also have random coefficients. However, the standard deviations of the random coefficients on price and risk-based capital converge to zero, and the larger model turns out to be poorly identified as revealed by large standard errors.

The coefficient on price has an estimated mean of -1.55 with a standard error of 0.28. This implies a demand elasticity of 2.5 for the average company in 2012. As expected, demand is positively related to A.M. Best rating and company size. The random coefficient on A.M. Best rating has an estimated mean of 0.11 and a standard deviation of 0.28. Similarly, the random coefficient on log liabilities has an estimated mean of 2.69 and a standard deviation of 0.20.

The third column of Table 7 reports the estimated coefficients for marginal cost (21). Shadow insurance reduces marginal cost by 9 percent with a standard error of 2 percent. Other important determinants of marginal cost are A.M. Best rating and leverage. Marginal cost decreases by 6 percent per one standard deviation increase in A.M. Best rating. Similarly, marginal cost decreases by 4 percent per one standard deviation increase in leverage.

The coefficient on shadow insurance could be biased if the unobservable shock in equation (21) is correlated with shadow insurance. We address this concern by instrumental variables, where our instrument for shadow insurance is the market share for term life insurance in 1999, interacted with a dummy for stock company in 1999. The market share in 1999 is plausibly exogenous because Regulation XXX applies only to new policies issued after 2000 and does not apply retroactively to existing liabilities. As reported in the last column of Table 7, the estimated coefficient on shadow insurance is -0.43 with a standard error of 0.14. Although the coefficient is less precisely estimated under instrumental variables, we can still reject the null that shadow insurance has no effect on marginal cost.

7.3. Retail Market without Shadow Insurance

We now use the structural model to estimate the counterfactual without shadow insurance. To do so, we first adjust the ratings, leverage, and risk-based capital for shadow insurance, as described in Appendix B. We then turn off shadow insurance and plug in the adjusted ratings, leverage, and risk-based capital in equation (21). Hence, we estimate the counterfactual marginal cost for each company using shadow insurance. We next plug in the adjusted rating, risk-based capital, and leverage in equation (19). Finally, we solve for the new equilibrium that satisfies the equations for supply (12) and demand (19).

Table 8 reports that marginal cost would rise by 21 percent for the average company using shadow insurance in 2012. In response to the higher marginal cost, the average company would raise its price by 12 percent. The last three columns report the change in quantity of annual life insurance underwritten. The operating companies using shadow insurance would lose \$10.3 billion of business in 2012, while the other companies would gain \$0.7 billion due to substitution effects. Higher prices mean that some potential customers would stay out of the life insurance market. The industry as a whole would shrink by \$9.6 billion, or by 11 percent relative to its current size of \$91.5 billion in 2012.

8. Conclusion

The current size of the U.S. shadow insurance sector is \$364 billion, or 25 cents of every dollar insured by the life insurers using shadow insurance. We find this activity has important implications for both financial risk and market equilibrium in the life insurance industry. On the one hand, shadow insurance raises the expected loss for the industry by \$10.4 billion, so that current expected loss is 28 percent of the total capacity of state guaranty funds. On the other hand, shadow insurance reduces marginal cost by 21 percent for the average company, and it increases annual life insurance underwritten by \$9.6 billion for the industry.

The actual cost of shadow insurance could be higher than our estimate for two reasons. First, the lack of public disclosure by shadow reinsurers prevents accurate assessment of the risk profile of their assets and liabilities, the amount of excess capital held, and the fragility of their funding arrangements. Second, the U.S. shadow insurance sector could just be the tip of an iceberg, if there is additional activity abroad. Documenting the size of the global (or even the European) shadow insurance sector turns out to be a daunting task because of incomplete financial reporting and inconsistent regulatory standards.

Problems in the insurance industry could have broader consequences for the economy. First, the financial crisis has shown that even relatively small shocks could amplify due to the interconnectedness of financial institutions and the endogeneity of asset prices. Banks fund reinsurance transactions through letters of credit, so systemic drawdowns could put the banking sector at risk. Second, life insurers are the most important institutional investors of corporate bonds, so problems in this sector could spill over to real investment and economic activity. Finally, the insurance industry diversifies the most important sources of idiosyncratic risk in the economy, so shocks to the supply of insurance could lead to large welfare losses for households (Einav, Finkelstein, and Schrimpf 2010, Koijen, Van Nieuwerburgh, and Yogo 2011).

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Table 1: Summary Statistics for Reinsurance Agreements

	Number of reinsurance agreements ceded to			Mean reinsurance ceded (million $)		
Year	Unaffiliated	Affiliated	Shadow	Unaffiliated	Affiliated	Shadow
2002	1,493	157	53	26	77	60
2003	960	119	70	26	116	59
2004	753	149	89	101	528	502
2005	824	182	110	28	211	163
2006	681	146	85	54	227	231
2007	599	114	65	39	345	451
2008	566	132	88	25	613	717
2009	456	120	67	37	1,199	2,003
2010	410	116	56	10	509	776
2011	310	110	49	56	626	640
2012	328	120	45	89	392	502

This table reports summary statistics for life and annuity reinsurance agreements that originated in each year, by whether they were ceded to unaffiliated or affiliated reinsurers. Reinsurance ceded is the sum of reserve credit taken and modified coinsurance reserve ceded. Shadow reinsurers are affiliated and unauthorized reinsurers without an A.M. Best rating.

Table 2: Characteristics of Life Insurers Using Shadow Insurance

Statistic	Not using shadow insurance	Using shadow insurance
Number of companies	443	78
Market share (percent):		
Life insurance	52	48
Annuities	52	48
Stock company (percent)	91	99
Mean:		
A.M. Best rating	A-	A
Log liabilities	0.00	3.17
Leverage (percent)	72	89
Risk-based capital (percent)	307	208
Current liquidity (percent)	158	80
Return on equity (percent)	7	18

This table reports summary statistics for life insurers in 2012, by whether they were using shadow insurance. The market shares are based on gross reserves held for life insurance and annuities, respectively.

Table 3: Affiliated Reinsurance within the MetLife Group

Company	Domicile	A.M. Best rating	Net reinsurance ceded (billion $)
Metropolitan Life Insurance	New York	A+	39.1
MetLife Investors USA Insurance	Delaware	A+	13.3
General American Life Insurance	Missouri	A+	3.9
MetLife Insurance of Connecticut	Connecticut	A+	3.6
MetLife Investors Insurance	Missouri	A+	2.6
First MetLife Investors Insurance	New York	A+	1.6
New England Life Insurance	Massachusetts	A+	1.0
Metropolitan Tower Life Insurance	Delaware	A+	0.8
MetLife Reinsurance of Delaware	Delaware		-0.4
MetLife Reinsurance of South Carolina	South Carolina		-3.1
Exeter Reassurance	Bermuda		-5.6
MetLife Reinsurance of Vermont	Vermont		-9.9
MetLife Reinsurance of Charleston	South Carolina		-12.9
Missouri Reinsurance	Barbados		-28.4
Total for the MetLife group			5.7

This table lists the U.S. operating companies of the MetLife group and their affiliated reinsurers in 2012, whose net reinsurance ceded is greater than $0.1 billion in absolute value. Net reinsurance ceded is the sum of reserve credit taken and modified coinsurance reserve ceded minus the sum of reserves held and modified coinsurance reserve assumed.

Table 4: Relation between Ratings and Shadow Insurance

Variable	OLS	IV First stage	IV Second stage
Shadow insurance	0.00		0.25
	(0.06)		(0.34)
Term life share		0.05	
		(0.01)	
Log liabilities	0.17	0.11	0.13
	(0.04)	(0.02)	(0.06)
Leverage	-0.01	-0.02	0.01
	(0.03)	(0.01)	(0.03)
Risk-based capital	0.13	0.00	0.15
	(0.02)	(0.01)	(0.02)
Current liquidity	0.08	0.01	0.06
	(0.02)	(0.01)	(0.02)
Return on equity	0.03	0.00	0.03
	(0.02)	(0.01)	(0.02)
Stock company	0.05	0.09	0.02
	(0.06)	(0.03)	(0.07)
R^2	0.62	0.19	0.63
Observations	6,641	6,351	6,351

This table reports the estimated relation between A.M. Best rating and company characteristics. Estimation is by ordinary least squares (OLS) and instrumental variables (IV), where the instrument for shadow insurance is the market share for term life insurance in 1999, interacted with a dummy for stock company in 1999. All specifications include dummies for A.M. Best financial size category and year, which are not reported for brevity. The coefficients are standardized, and robust standard errors clustered by insurance group are reported in parentheses. The sample consists of operating companies between 2002 and 2012.

Table 5: Measures of Financial Risk Adjusted for Shadow Insurance

	Risk-based capital (percent)			Rating		10-year default probability (percent)		
Year	Reported	Adjusted	Difference	Reported	Adjusted	Reported	Adjusted	Ratio
2002	160	150	-10	A+	A	0.8	1.4	1.8
2003	170	156	-14	A+	A	0.7	1.4	2.0
2004	168	146	-22	A	A-	0.9	1.7	2.0
2005	197	166	-31	A	A-	1.0	2.0	2.0
2006	190	164	-25	A+	A-	0.7	1.7	2.3
2007	199	171	-28	A	B++	1.0	2.4	2.3
2008	199	174	-25	A	B++	0.9	2.4	2.6
2009	227	182	-45	A	B++	1.0	2.7	2.8
2010	250	197	-53	A	B+	1.0	3.1	3.1
2011	238	194	-44	A	B+	1.1	3.1	2.9
2012	208	155	-53	A	B+	0.9	3.3	3.5

This table reports the average risk-based capital, A.M. Best rating, and 10-year default probability for the life insurers using shadow insurance. Our adjustment moves back on balance sheet both the assets and liabilities on reinsurance ceded to shadow reinsurers, so that capital and surplus does not change. The risk profile of reinsurance ceded is assumed to be identical to existing life and annuity reserves on balance sheet, so that required capital rises proportionally.

Table 6: Expected Loss Adjusted for Shadow Insurance

	Expected loss (billion $)			Guaranty funds
Year	Reported	Adjusted	Difference	(billion $)
2002	3.0	3.2	0.1	40.6
2003	2.8	3.2	0.4	38.0
2004	3.0	4.7	1.7	35.9
2005	3.1	4.6	1.5	33.4
2006	3.0	4.6	1.6	36.3
2007	3.4	7.2	3.8	38.7
2008	4.6	10.7	6.1	50.7
2009	4.1	12.6	8.5	47.6
2010	4.4	13.4	9.0	46.2
2011	5.2	14.8	9.6	49.2
2012	5.4	15.8	10.4	56.4

This table reports the present value of expected loss, discounted by the zero-coupon Treasury yield curve (Gürkaynak, Sack, and Wright 2007). Both reported and adjusted expected loss are based on a 25 percent loss conditional on default. The total capacity of state guaranty funds is the maximum annual assessment aggregated across all states, projected to remain constant over the next 10 years (Gallanis 2009).

Table 7: Estimated Parameters of the Structural Model

	Demand		Marginal cost	
Variable	Mean	Standard deviation	OLS	IV
Price	-1.55			
	(0.28)			
Shadow insurance			-0.09	-0.43
			(0.02)	(0.14)
A.M. Best rating	0.11	0.28	-0.06	-0.04
	(0.07)	(0.19)	(0.01)	(0.02)
Log liabilities	2.69	0.20	0.02	0.07
	(0.03)	(0.07)	(0.01)	(0.02)
Leverage	0.06	0.27	-0.04	-0.01
	(0.06)	(0.14)	(0.02)	(0.02)
Risk-based capital	-0.05		0.01	0.00
	(0.05)		(0.02)	(0.02)
Current liquidity	0.09		-0.01	0.01
	(0.06)		(0.01)	(0.01)
Return on equity	-0.19		0.04	0.04
	(0.03)		(0.01)	(0.01)
Stock company	-0.03		0.00	0.11
	(0.05)		(0.03)	(0.05)
Observations	1,711		1,711	1,684

This table reports the estimated parameters for the random-coefficients logit model (19) and marginal cost (21). Equation (19) is estimated by generalized method of moments, where the instruments are shadow insurance, company characteristics, and the characteristics squared. The model has 3 degrees of freedom with 11 parameters and 14 instruments (excluding the constant). Equation (21) is estimated by ordinary least squares (OLS) and instrumental variables (IV), where the instrument for shadow insurance is the market share for term life insurance in 1999, interacted with a dummy for stock company in 1999. The specification for marginal cost includes year fixed effects, which are not reported for brevity. The coefficients on company characteristics are standardized, and heteroskedasticity-robust standard errors are reported in parentheses. The sample consists of operating companies between 2002 and 2012, which are matched to term life insurance prices from Compulife Software.

Table 8: Retail Market without Shadow Insurance

Year	Change in marginal cost (percent)	Change in price (percent)	Change in quantity (billion $) for companies: Using shadow insurance	Not using shadow insurance	Total
2002	10.7	5.1	-2.3	0.2	-2.1
2003	13.0	5.3	-3.9	0.3	-3.6
2004	14.8	7.4	-7.1	0.6	-6.6
2005	15.9	8.6	-6.4	0.3	-6.1
2006	16.4	9.8	-5.9	0.2	-5.7
2007	18.1	10.8	-14.8	0.5	-14.3
2008	19.4	11.0	-14.9	1.1	-13.8
2009	19.8	10.8	-14.8	1.3	-13.5
2010	20.4	11.3	-8.3	1.0	-7.2
2011	20.7	11.7	-7.8	0.5	-7.4
2012	20.9	11.5	-10.3	0.7	-9.6

The structural model is used to estimate the counterfactual without shadow insurance. This table is based on the ordinary least squares estimate of equation (21) in Table 7. The average change in marginal cost of issuing policies and the average change in price are for the operating companies using shadow insurance. The change in quantity of annual life insurance underwritten is based on the change in gross life reserves.

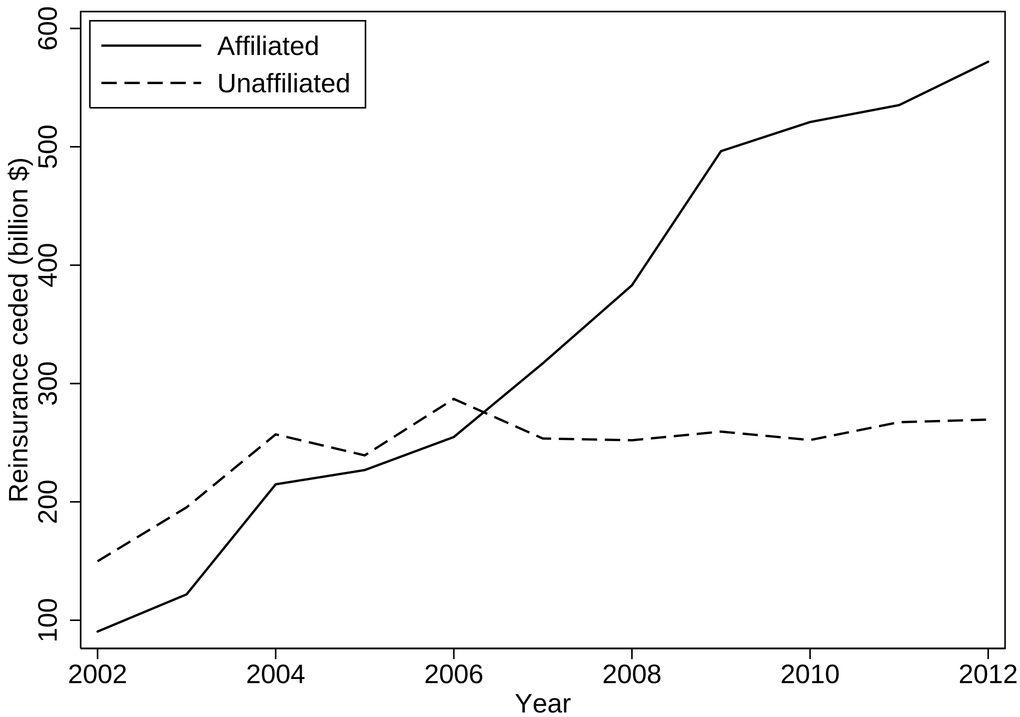

Figure 1: Reinsurance Ceded by U.S. Life Insurers

This figure reports life and annuity reinsurance ceded by U.S. life insurers to affiliated and unaffiliated reinsurers. Reinsurance ceded is the sum of reserve credit taken and modified coinsurance reserve ceded.

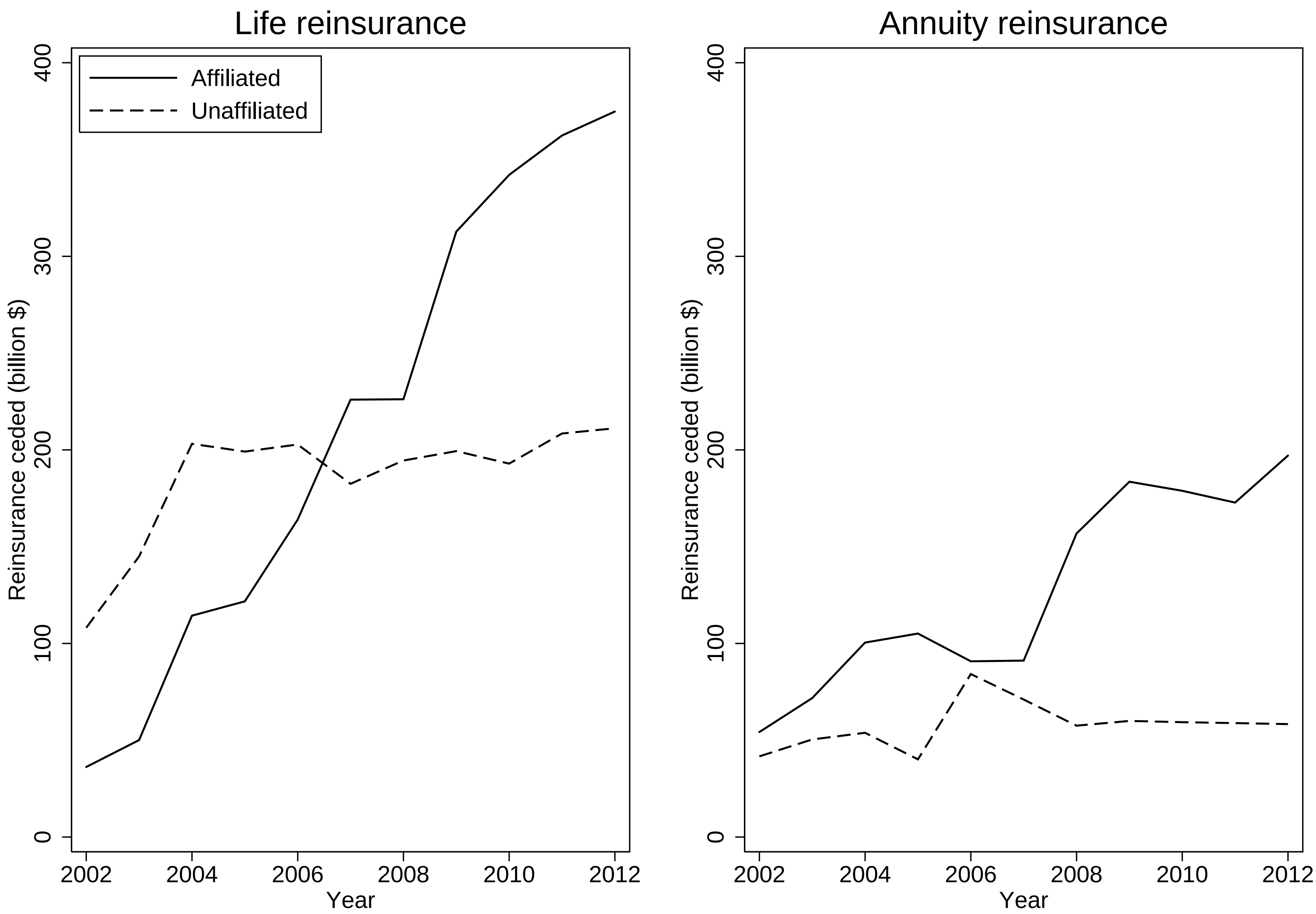

Figure 2: Life versus Annuity Reinsurance Ceded by U.S. Life Insurers

This figure reports reinsurance ceded by U.S. life insurers to affiliated and unaffiliated reinsurers, separately for life and annuity reinsurance. Reinsurance ceded is the sum of reserve credit taken and modified coinsurance reserve ceded.

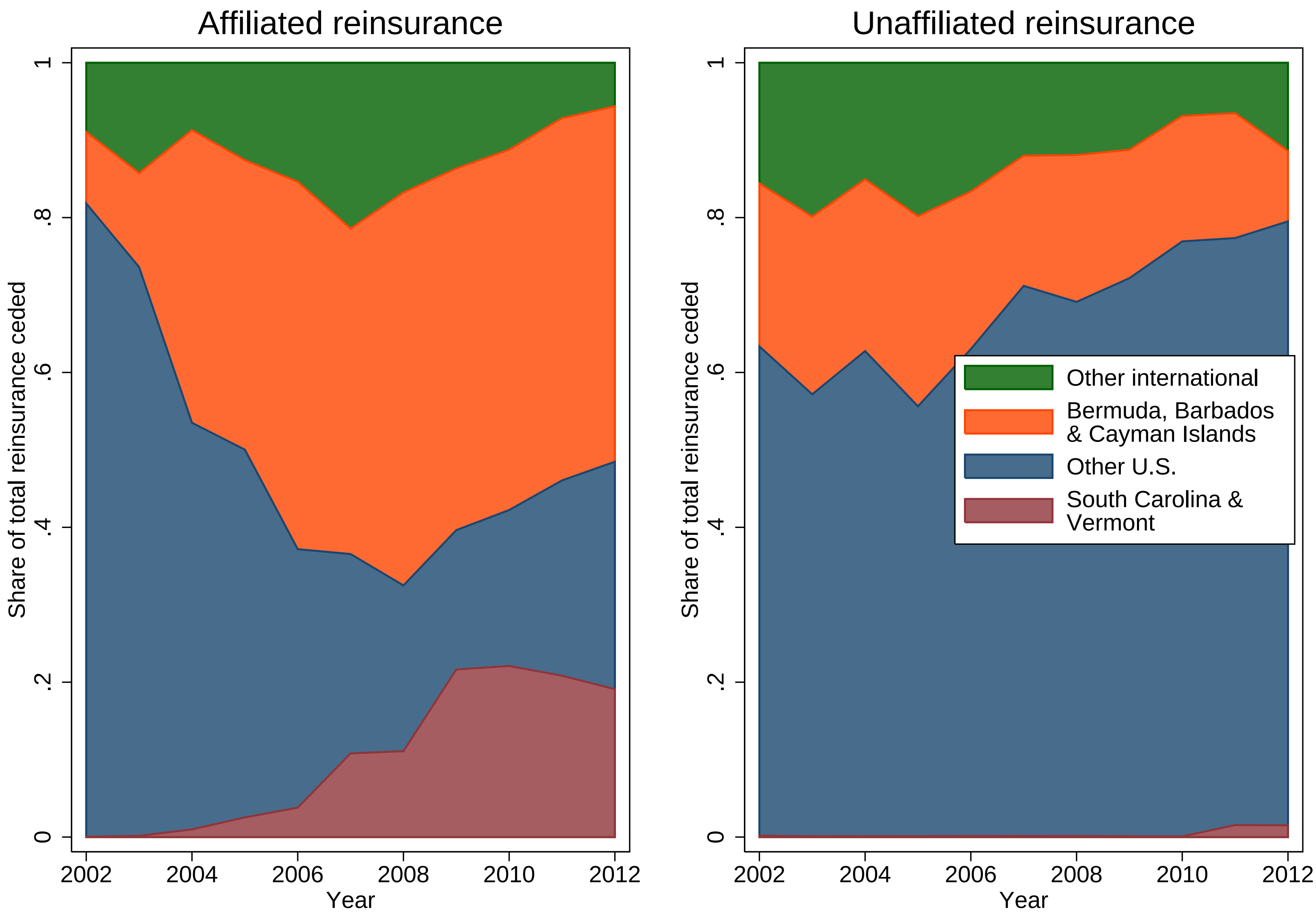

Figure 3: Reinsurance Ceded by Domicile of Reinsurer

This figure decomposes life and annuity reinsurance ceded by domicile of the reinsurer, separately for affiliated and unaffiliated reinsurance. Reinsurance ceded is the sum of reserve credit taken and modified coinsurance reserve ceded.

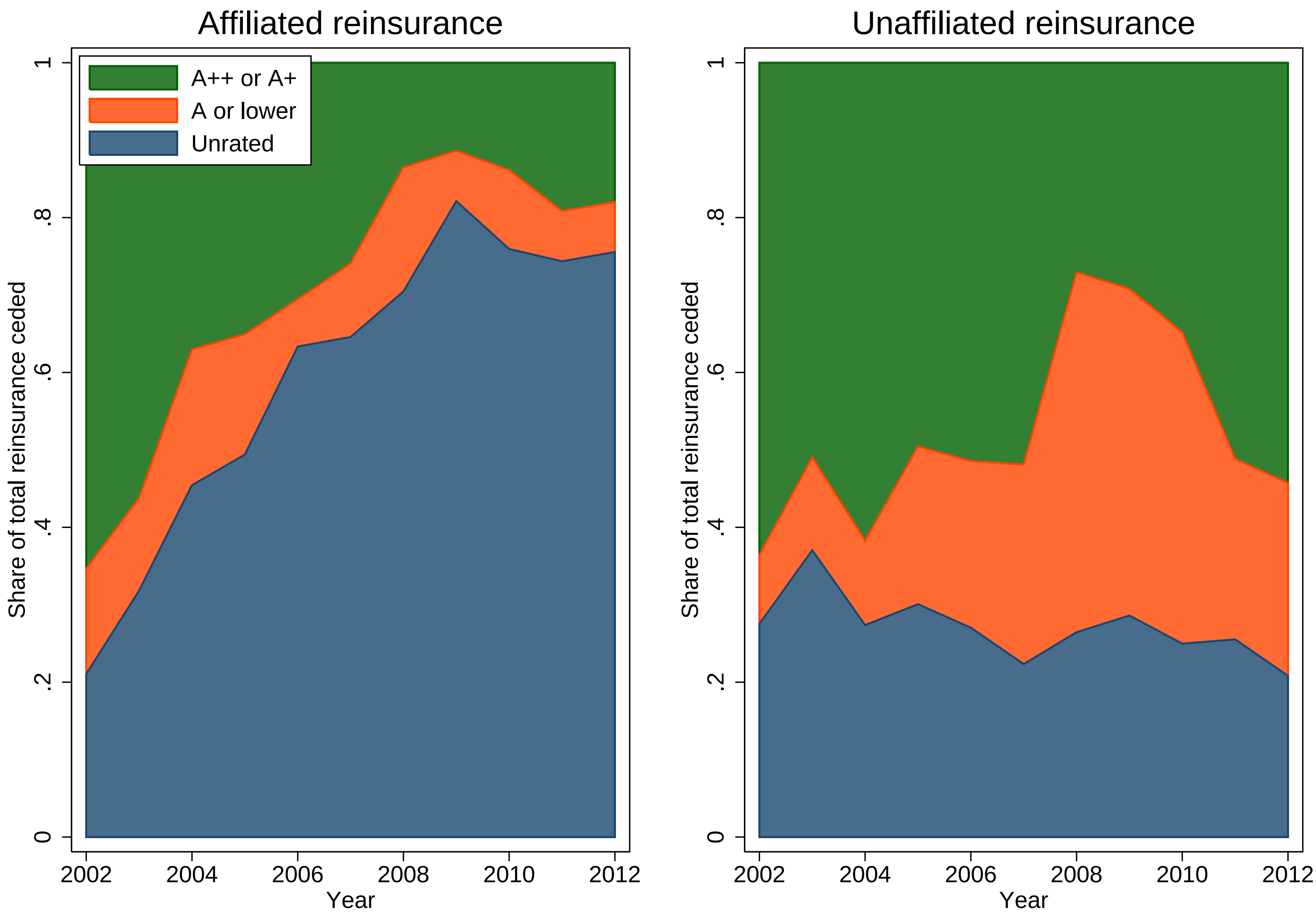

Figure 4: Reinsurance Ceded by Rating of Reinsurer

This figure decomposes life and annuity reinsurance ceded by A.M. Best rating of the reinsurer, separately for affiliated and unaffiliated reinsurance. Reinsurance ceded is the sum of reserve credit taken and modified coinsurance reserve ceded.

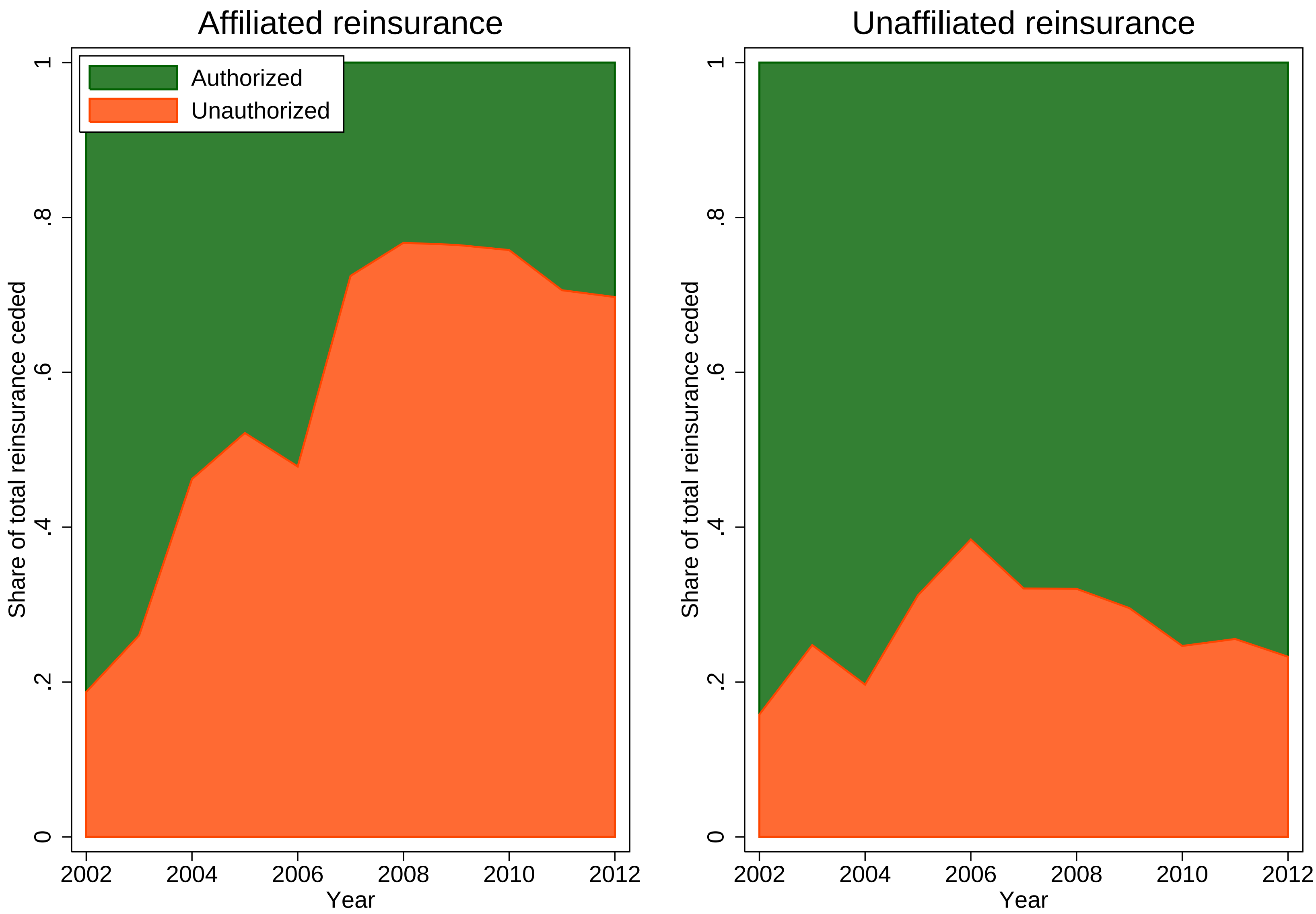

Figure 5: Reinsurance Ceded to Unauthorized Reinsurers

This figure decomposes life and annuity reinsurance ceded by whether the reinsurer is authorized in the domicile of the ceding company, separately for affiliated and unaffiliated reinsurance. Reinsurance ceded is the sum of reserve credit taken and modified coinsurance reserve ceded.

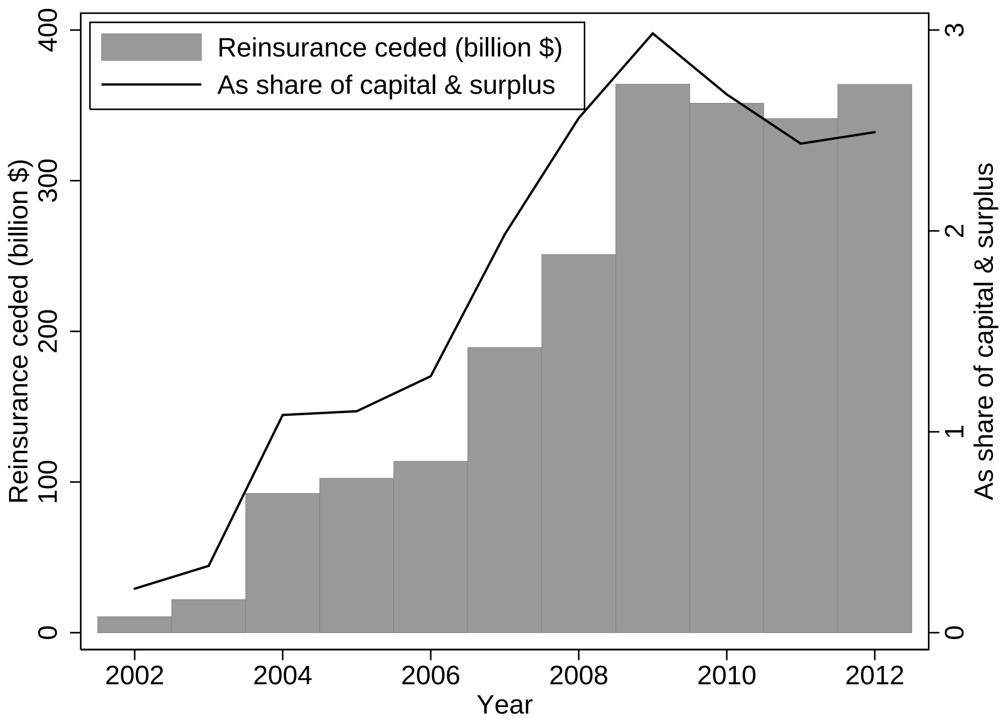

Figure 6: Reinsurance Ceded to Shadow Reinsurers
This figure reports life and annuity reinsurance ceded by U.S. life insurers to shadow reinsurers, both in total dollars and as a share of the capital and surplus of the ceding companies. Reinsurance ceded is the sum of reserve credit taken and modified coinsurance reserve ceded. Shadow reinsurers are affiliated and unauthorized reinsurers without an A.M. Best rating.

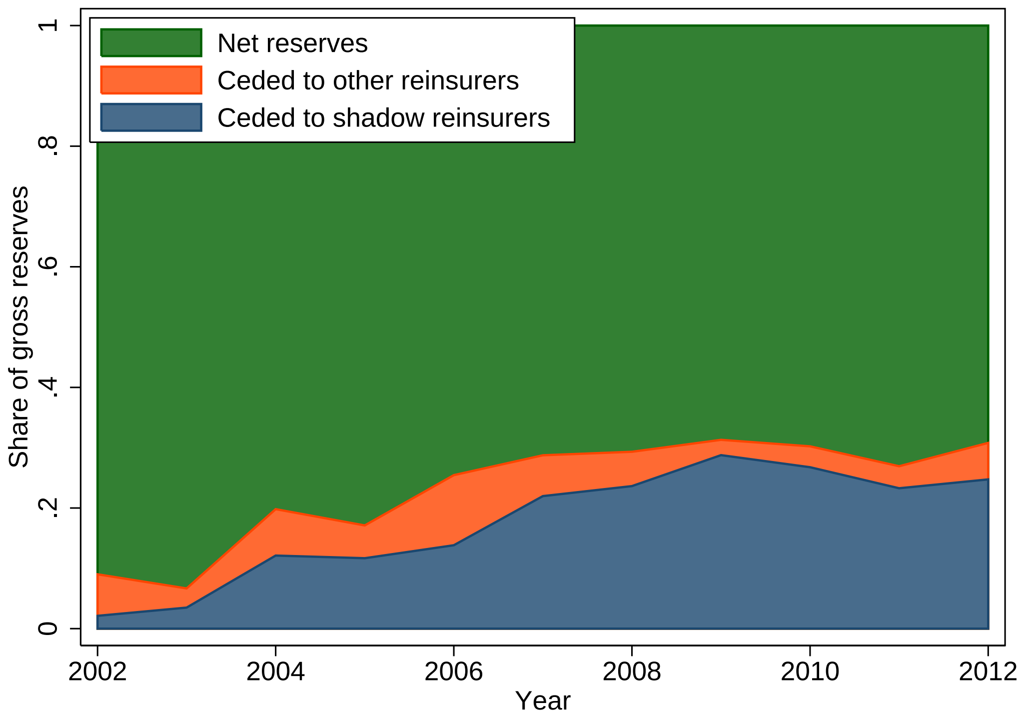

Figure 7: Decomposition of Gross Reserves for Life Insurers Using Shadow Insurance
This figure decomposes gross life and annuity reserves into reinsurance ceded versus net reserves held by the life insurers using shadow insurance. Reinsurance ceded is the sum of reserve credit taken and modified coinsurance reserve ceded. Shadow reinsurers are affiliated and unauthorized reinsurers without an A.M. Best rating.

Appendix A. Stylized Examples of Captive Reinsurance

We illustrate the balance-sheet mechanics of how an operating company can free up capital by ceding reinsurance to an unauthorized captive. We offer three examples to illustrate the three main types of reinsurance: coinsurance, coinsurance with funds withheld, and modified coinsurance. The latter two types are different from coinsurance in that the ceding company retains control of the assets, so that the captive does not need to establish a trust fund. However, the examples show that all three types can achieve the same economic outcomes. We refer to Loring and Higgins (1997) and Tiller and Tiller (2009, Chapters 4 and 5) for further details.

A.1. Coinsurance

In Table A1, the operating company starts with $10 in bonds and no liabilities, so that its equity is $10. For simplicity, the captive is initially a shell company with no assets. In the first step, the operating company sells term life insurance to retail customers for $100. The operating company must record a statutory reserve of $110, which is higher than the GAAP reserve of $90 because of Regulation XXX. Consequently, its equity is reduced to $0.

In the second step, the operating company cedes all liabilities to the captive, paying a reinsurance premium of $100. Reserve credit on reinsurance ceded to an unauthorized reinsurer requires collateral through a trust fund established in or an unconditional letter of credit from a qualified U.S. financial institution (National Association of Insurance Commissioners 2011, Appendix A-785). Hence, the captive establishes a trust fund with $90 in bonds and secures a letter of credit up to $20 to fund the difference between the statutory and GAAP reserves. For simplicity, our example ignores a small fee that the captive would pay to secure the letter of credit. On the liability side, the captive records a GAAP reserve of only $90 because it is not subject to Regulation XXX.[7]

As a consequence of captive reinsurance, the operating company's balance sheet is restored to its original position with $10 in equity. The captive ends up with an additional $10 in cash that it can use for various purposes, including a commission to the operating company or a dividend to the parent company.

[7]Our example assumes that the operating company's domicile does not require mirror reserving, and the captive's domicile does not count a letter of credit as an admitted asset. If we flip both of these assumptions, the economics of this example remains the same. The captive records the letter of credit as a $20 asset and holds a statutory reserve of $110, so that its equity remains $10.

A.2. Coinsurance with Funds Withheld

The first step in Table A2 is the same as in Table A1. In the second step, the operating company cedes all liabilities to the captive, paying a reinsurance premium of $10. The operating company withholds $90 in the transaction, investing it in bonds. The withheld assets are recorded as a "funds held" liability for the operating company and as a "funds deposited" asset for the captive. The captive secures a letter of credit up to $20 to fund the difference between the statutory and GAAP reserves. On the liability side, the captive records a GAAP reserve of only $90 because it is not subject to Regulation XXX.

A.3. Modified Coinsurance

The first step in Table A3 is the same as in Table A1. In the second step, the operating company cedes all liabilities to the captive, paying a reinsurance premium of $10. The operating company withholds $90 in the transaction, investing it in bonds. The withheld assets are recorded as a "modco reserve" liability for the operating company and as a "modco deposit" asset for the captive. The captive secures a letter of credit up to $20 to fund the difference between the statutory and GAAP reserves. On the liability side, the captive records a GAAP reserve of only $90 because it is not subject to Regulation XXX.

Table A1: A Stylized Example of Captive Reinsurance: Coinsurance

This example illustrates how coinsurance or yearly renewable term reinsurance affects the balance sheets of an operating company and an unauthorized captive, both of which are part of the same holding company. The operating company must hold a statutory reserve of $110, while the captive can hold a GAAP reserve of $90.

Operating company
(in domicile with tighter capital regulation)

Initial balance sheet:

A		L	
Bonds	$10		
		Equity	$10

⟹ *1. Sells insurance for $100. (Statutory reserve of $110 and GAAP reserve of $90.)*

A		L	
Bonds	$10		
Premium	$100	Reserve	$110
		Equity	$0

⟹ *2. Cedes reinsurance.*

A		L	
Bonds	$10		
		Equity	$10

Captive
(in domicile with looser capital regulation)

Initial balance sheet:

A		L	
		Equity	$0

⟹ *2. Assumes reinsurance. Establishes trust with $90 in bonds. Secures letter of credit up to $20.*

A		L	
Trust: Bonds	$90	Reserve	$90
Letter of credit			
Cash	$10		
		Equity	$10

Table A2: A Stylized Example of Captive Reinsurance: Coinsurance with Funds Withheld

This example illustrates how coinsurance with funds withheld affects the balance sheets of an operating company and an unauthorized captive, both of which are part of the same holding company. The operating company must hold a statutory reserve of $110, while the captive can hold a GAAP reserve of $90.

Operating company
(in domicile with tighter capital regulation)

Initial balance sheet:

A		L	
Bonds	$10		
		Equity	$10

⟹ *1. Sells insurance for $100. (Statutory reserve of $110 and GAAP reserve of $90.)*

A		L	
Bonds	$10		
Premium	$100	Reserve	$110
		Equity	$0

⟹ *2. Cedes reinsurance, paying $10 premium. Invests $90 in bonds.*

A		L	
Bonds	$100	Funds withheld	$90
		Equity	$10

Captive
(in domicile with looser capital regulation)

Initial balance sheet:

A		L	
		Equity	$0

⟹ *2. Assumes reinsurance. Secures letter of credit up to $20.*

A		L	
Funds deposited	$90	Reserve	$90
Letter of credit			
Cash	$10		
		Equity	$10

Table A3: A Stylized Example of Captive Reinsurance: Modified Coinsurance

This example illustrates how modified coinsurance affects the balance sheets of an operating company and an unauthorized captive, both of which are part of the same holding company. The operating company must hold a statutory reserve of $110, while the captive can hold a GAAP reserve of $90.

Operating company
(in domicile with tighter capital regulation)

Initial balance sheet:

A		L	
Bonds	$10		
		Equity	$10

⟹ *1. Sells insurance for $100. (Statutory reserve of $110 and GAAP reserve of $90.)*

A		L	
Bonds	$10		
Premium	$100	Reserve	$110
		Equity	$0

⟹ *2. Cedes reinsurance, paying $10 premium. Invests $90 in bonds.*

A		L	
Bonds	$100	Modco reserve	$90
		Equity	$10

Captive
(in domicile with looser capital regulation)

Initial balance sheet:

A		L	
		Equity	$0

⟹ *2. Assumes reinsurance. Secures letter of credit up to $20.*

A		L	
Modco deposit	$90	Reserve	$90
Letter of credit			
Cash	$10		
		Equity	$10

Appendix B. Data Description

B.1. Company Characteristics

We construct the following company characteristics based on the annual NAIC financial statements (A.M. Best Company 2003–2013b). The relevant parts for our construction are Liabilities, Surplus and Other Funds; Exhibit 5 (Aggregate Reserve for Life Contracts); Exhibit of Life Insurance; and Schedule S Part 6 (Restatement of Balance Sheet to Identify Net Credit for Ceded Reinsurance).

- Log liabilities: Logarithm of as reported total liabilities, except in Table 7, where it is the logarithm of gross life reserves.
- Leverage: The ratio of as reported total liabilities to as reported total assets. The adjustment for shadow insurance is

$$\text{(B1)} \qquad \text{Adjusted leverage} = \frac{\text{Reported total liabilities} + \text{Shadow insurance}}{\text{Reported total assets} + \text{Shadow insurance}},$$

  where "Shadow insurance" is reinsurance ceded to shadow reinsurers.

The following company characteristics are constructed by A.M. Best Company as part of their rating process (A.M. Best Company 2011).

- A.M. Best rating: We convert A.M. Best financial strength ratings (coded from A++ to D) to numerical counterparts (coded from 175 to 0 percent) based on risk-based capital guidelines (A.M. Best Company 2011, p. 24). The adjustment for shadow insurance is

$$\text{(B2)} \qquad \text{Adjusted rating} = \frac{\text{Reported rating} \times \text{Reported reserves}}{\text{Reported reserves} + \text{Shadow insurance}},$$

  where "Reported reserves" are aggregate reserve for life contracts less modco reserve.

- Risk-based capital: A.M. Best capital adequacy ratio, which is the ratio of adjusted capital and surplus to required capital. The adjustment for shadow insurance is

$$\text{(B3)} \qquad \text{Adjusted RBC} = \frac{\text{Reported RBC} \times \text{Reported reserves}}{\text{Reported reserves} + \text{Shadow insurance}}.$$

- Current liquidity: A measure of balance-sheet liquidity, defined as the ratio of current assets (i.e., unencumbered cash and unaffiliated investments) to total liabilities.

- Return on equity: A measure of profitability, defined as the ratio of net operating gain after taxes to the average capital and surplus in the current and prior year.
- A.M. Best financial size category: A measure of company size (coded from 1 to 15) based on the adjusted policyholders' surplus for the insurance group.

The starting point for estimating the term structure of default probabilities is historical impairment rates by A.M. Best rating, based on data from 1977 to 2012 (A.M. Best Company 2013a, Exhibit 2). A.M. Best Company designates an insurance company as financially impaired upon the first official action of an insurance regulator. Not all impairments lead to a default on policyholder claims. Therefore, we merge the list of financially impaired companies (A.M. Best Company 2013b, pp. 20–34) with those that subsequently defaulted (Peterson 2013) to estimate the probability of default conditional on impairment, which is 24 percent. Finally, we scale the historical impairment rates by 24 percent to obtain the term structure of default probabilities.

B.2. Life Insurance Prices

Our sample of life insurance premiums is from Compulife Software (2002–2012), which is a computer-based quotation system for insurance agents. We focus on 10-year guaranteed level term life insurance for males aged 30 in the paper, but we have also examined 20-year policies and older age groups. We pull quotes for all U.S. states at the end of June in each year between 2002 and 2012, for the regular health category and a face amount of $1 million. We merge the financial statements with life insurance premiums by company name. Whenever the premium is not available for an operating company, we assign the average premium for its insurance group.

We normalize the premium by actuarial value. Let $R_t(m)$ denote the zero-coupon Treasury yield at maturity m and time t, and let p_n denote the one-year survival probability at age n. We define the actuarial value of 10-year term life insurance at age n per dollar of death benefit as

$$\text{(B4)} \qquad V_t(n) = \left(1 + \sum_{m=1}^{9} \frac{\prod_{l=0}^{m-1} p_{n+l}}{R_t(m)^m}\right)^{-1} \left(\sum_{m=1}^{10} \frac{\prod_{l=0}^{m-2} p_{n+l}(1 - p_{n+m-1})}{R_t(m)^m}\right).$$

We calculate the actuarial value based on the appropriate mortality table from the American Society of Actuaries and the zero-coupon Treasury yield curve. We use the 2001 Valuation Basic Table prior to January 2008 and the 2008 Valuation Basic Table since January 2008. These mortality tables are derived from the actual mortality experience of insured pools, so they account for potential adverse selection. We smooth the transition between the two vintages of the mortality tables by geometric averaging.