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ABSTRACT

Liabilities ceded by life insurers to shadow reinsurers (i.e., less regulated off-balance sheet entities) grew from $11 billion in 2002 to $363 billion in 2012. Companies that are involved in shadow insurance, which capture 50 percent of the market share, ceded 28 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 49 percentage points (or 3 rating notches) and raises expected loss by at least $15.7 billion for the industry. We develop a structural model to estimate the impact of shadow insurance on the equilibrium supply in the retail market. In the absence of shadow insurance, marginal cost would rise by 1.8 percent, and annual insurance underwritten would fall by $1.4 billion at unit demand elasticity.

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Life insurance and annuity liabilities of U.S. life insurers were $4,068 billion in 2012, which is substantial even when compared to $6,979 billion in savings deposits for 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 to the large banking literature. The reason, perhaps, is the traditional view that life insurer liabilities are safe (and boring) because they are more predictable, longer maturity, and less vulnerable to runs. Hence, all of the interesting action is on the asset side, where life insurers take on some investment risk.

This paper shows that developments in the life insurance industry over the last decade shatters 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, Barbados, and the Cayman Islands) with more favorable capital regulation or tax laws. In contrast to traditional reinsurance with third-party reinsurers, there is no risk transfer in these transactions because the liabilities stay within the same holding company.

Using new data on all life and annuity reinsurance agreements for licensed companies in the U.S., we map out the financial plumbing of life insurer liabilities, paying particular attention to the shadow insurance sector. We find that the shadow insurance sector (i.e., liabilities ceded to shadow reinsurers) grew rapidly from $11 billion in 2002 to $363 billion in 2012. To put this figure into perspective, asset-backed commercial paper issued by the U.S. shadow banking sector was $650 billion in 2004, prior to its quick growth and spectacular collapse during the financial crisis (Acharya et al. 2013). Operating companies that are involved in shadow insurance are the largest in the industry that capture 50 percent of the market share for both life insurance and annuities. These companies ceded 28 cents of every dollar insured to shadow reinsurers in 2012, significantly up from only 2 cents in 2002.

We find that shadow insurance adds a tremendous amount of financial risk for the companies involved, which is not reflected in their current ratings. Our adjustment for shadow insurance reduces risk-based capital by 49 percentage points, or 3 rating notches, for the median company. Hence, actual impairment probabilities are likely to be higher than what may be inferred from reported ratings. Our adjustment for shadow insurance raises expected loss by at least $15.7 billion for the industry. Through the state guaranty funds, this cost is ultimately borne by state taxpayers and the companies that are not involved in shadow insurance.

Although shadow insurance clearly has these costs, its potential benefits are harder to measure. In theory, shadow insurance lowers the cost of financial frictions for these companies, which leads to lower marginal cost and a higher equilibrium supply in the retail

market. To estimate this potential benefit, we develop a model of an insurance holding company that consists of operating companies that sell policies and captives that assume reinsurance for the purposes of capital management. We use our structural model to estimate the impact of shadow insurance on the equilibrium supply in the retail market. Our counterfactual experiment is analogous to asking what would happen to loan markets if we were to eliminate shadow banking. We find that marginal cost would rise by 1.8 percent for the average company that is involved in shadow insurance. When aggregated across all these companies, annual insurance underwritten would fall by $1.4 billion (from its current level of $84.8 billion) at unit demand elasticity.

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 and 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 reinsurance with third-party reinsurers. All of the growth in life and annuity reinsurance over the last decade is affiliated reinsurance within the same holding company, which points to capital and tax management as the primary driver of this activity.

The remainder of the paper is organized as follows. Section 1 discusses relevant institutional background and presents a stylized example of captive reinsurance. Section 2 describes the data on life and annuity reinsurance. Section 3 documents developments in life and annuity reinsurance over the last decade, as a consequence of changes in life insurance regulation and captive laws. In Section 4, we measure the size of the shadow insurance sector and its impact on the financial risk of life insurers. In Section 5, we develop a model of optimal insurance pricing and affiliated reinsurance within a holding company. In Section 6, we use the structural model to estimate the impact of shadow insurance on the equilibrium supply in the retail market. Section 7 concludes with broader implications of our findings.

1. Institutional Background on Reinsurance

As discussed in Tiller and Tiller (2009, chapter 1), there are four basic motives for life and annuity reinsurance.

1. Risk transfer: To transfer mortality and morbidity risk, lapse and surrender risk, or investment risk.

2. Underwriting assistance: To gain access to expertise or experience of a reinsurer, especially in underwriting a new line of business.

3. Capital management: To increase statutory capital and surplus, to meet risk-based capital requirements, or to improve or maintain a credit rating.

4. Tax management: To change the timing of taxes to reduce overall tax liabilities.

Over the last decade, the third and fourth motives have become increasingly important relative to the first and second because of two related developments. On the one hand, changes in insurance regulation after 2000 forced life insurers to hold more capital against life insurance liabilities, straining their capital positions. On the other hand, new captive laws after 2002 allowed life insurers to set up special purpose vehicles, in states like South Carolina and Vermont, to circumvent the new capital requirements. In this section, we discuss these developments and related institutional background, to the extent that they are relevant for this paper.

1.1. 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 regulations forced life insurers to hold much higher statutory reserve on newly issued term life policies and universal life policies with secondary guarantees.

These changes in life insurance 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 freeing up "redundant reserves" that arise from these regulations. In practice, however, third-party reinsurance can be expensive because of the limited supply of capital for this purpose.

1.2. 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 freeing up redundant reserves. Captives are governed by state law that are different from the usual insurance regulation that applies to licensed companies. A captive

structure that has proven especially successful is the so-called 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.

Captives do not provide risk transfer at the holding-company level (by definition), so they exist solely for the purpose of capital and tax management. Captives usually have several advantages over traditional reinsurers (Captives and Special Purpose Vehicle Use Subgroup 2013). 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, and sometimes even to insurance regulators outside the state of domicile. Finally, they have a more flexible financial structure that allows them to finance redundant reserves through letters of credit or securitization.

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 a life insurer may be able to reduce its tax liabilities by ceding reinsurance to an offshore captive. Bermuda, Barbados, and the Cayman Islands are important captive domiciles for this purpose. An excise tax of one percent applies to life and annuity reinsurance premiums ceded to offshore captives. However, the investment returns accumulate free of U.S. tax once the capital is offshore.

1.3. A Stylized Example of Captive Reinsurance

The regulation that governs whether an operating company can take reserve credit on reinsurance ceded depends on whether the reinsurer is authorized (National Association of Insurance Commissioners 2011, Appendix A-785). An authorized reinsurer is licensed to sell insurance and, therefore, faces the same capital regulation as the ceding company. In this case, reserve credit on reinsurance ceded does not require special approval or collateral. An unauthorized reinsurer, such as a captive, is not subject to the same capital regulation as the ceding company. In this case, reserve credit on reinsurance ceded requires that the transaction be collateralized through a trust fund established in or an unconditional letter of credit from a qualified U.S. financial institution.

In Table 1, we illustrate the balance sheet mechanics of how an operating company can free up capital by ceding reinsurance to an unauthorized captive. Our example is for the case of coinsurance, which is the most common type of life and annuity reinsurance in the data. In Appendix A, we show that two other types, coinsurance with funds withheld and

modified coinsurance, can be structured to achieve the same economic outcomes. For further details, we refer to Loring and Higgins (1997) and Tiller and Tiller (2009, chapters 4–5).

The operating company initially 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 policies to retail customers for $100. The operating company must record statutory reserve of $110, which is higher than the GAAP reserve of $90 because of Regulation (A)XXX. As a consequence, its equity is reduced to $0.

In the second step, the operating company cedes all the policies to the captive, paying a reinsurance premium of $100. The captive establishes a trust fund with $90 in bonds and secures a letter of credit up to $20 to fund the difference between statutory and GAAP reserve. 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 GAAP reserve of only $90 because it is not subject to Regulation (A)XXX.[1]

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 extra $10 in cash that it can use for various purposes, including a commission to the operating company or a dividend to the parent company.

2. Data on Life and Annuity Reinsurance

2.1. 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 2003–2013b). These financial statements are annually reported to the NAIC according to statutory accounting principles, which are conveniently organized along with ratings information by the A.M. Best Company. The relevant parts of Schedule S for our study 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 reinsurer that is licensed to sell insurance in the U.S. In particular, they contain reinsurance ceded by a licensed company to an unlicensed reinsurer, such as a domestic captive or a foreign company. However, we do not observe reinsurance ceded by unlicensed companies that are not required to report to the NAIC.

[1] 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 statutory reserve of $110, so that its equity remains $10.

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.[2] 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 the 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.

We merge the Schedule S data with the annual NAIC financial statements of the ceding companies (A.M. Best Company 2003–2013c). The relevant parts for our study are Liabilities, Surplus and Other Funds; Exhibit 5 (Aggregate Reserve for Life Contracts); and Schedule S Part 6 (Restatement of Balance Sheet to Identify Net Credit for Ceded Reinsurance).

2.2. Description of the Sample

Table 2 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 in the sample, 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. Mean unaffiliated reinsurance ceded was \$36.9 million, which is much lower than \$1,198.9 million for affiliated reinsurance and \$2,003.3 million for shadow insurance. The average size of a shadow reinsurance agreement has generally increased over time from \$59.7 million in 2002 to \$512.9 million in 2012.

Table 3 describes the characteristics of the operating companies in our sample, by whether they are ceding reinsurance to shadow reinsurers. Although most of the companies are not involved in shadow insurance, the ones that are tend to be the largest in the industry, as measured by either market share or total assets. In 2012, 81 companies had reinsurance agreements with shadow reinsurers, while 347 companies did not. However, these 81 companies captured 50 percent of the market share for both life insurance and annuities, and their median assets were 324 percent higher.

[2]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.

In addition to being larger, companies that are involved in shadow insurance are more leveraged. Their median leverage ratio (i.e., total liabilities over total assets) was 93 percent in 2012, compared to 84 percent for those companies that are not involved in shadow insurance.

3. Recent Developments in Life and Annuity Reinsurance

In this section, we document developments in life and annuity reinsurance over the last decade, as a consequence of changes in life insurance regulation and captive laws that we discussed in Section 1. Since our data are unfamiliar to most readers, we start with a case study of the MetLife group, which is the largest insurance group in our sample 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.

3.1. A Case Study of the MetLife Group

Table 4 lists the U.S. operating companies of the MetLife group and their affiliated reinsurers in 2012. All the operating companies have an A.M. Best rating of A+ and cede reinsurance to the rest of the group. All the reinsurers are unrated and assume reinsurance from the rest of the group. All the reinsurers are also unauthorized, except for MetLife Reinsurance of Delaware and MetLife Reinsurance of Charleston since 2009. Overall, the liabilities disappear from the balance sheets of operating companies that sell policies to retail customers and end up in a less regulated and non-transparent part of the insurance industry.

Net reinsurance ceded by Metropolitan Life Insurance (the flagship operating company in New York) was $39.1 billion in 2012, 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 the companies in Table 4, which is total reinsurance ceded outside the MetLife group, was $5.5 billion. This shows that most of the reinsurance activity is within the MetLife group, rather than with unaffiliated reinsurers.

3.2. 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 $83 billion in 2002 to $547 billion 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 $30 billion in 2002 to $352 billion in 2012. The timing of this growth is consistent with changes in life insurance regulation and captive laws, as discussed in Section 1. In contrast, affiliated annuity reinsurance shows little growth prior to 2007. It then grew rapidly from $91 billion in 2007 to $195 billion in 2012. The timing of this growth 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).

3.3. 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 1, 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 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 20 percent in 2012. In contrast, the share of unaffiliated reinsurance ceded to these two states remains low throughout this period. Similarly, the share of affiliated reinsurance ceded to Bermuda, Barbados, and the Cayman Islands grew from 10 percent in 2002 to 48 percent in 2012. In contrast, the share of unaffiliated reinsurance ceded to these offshore domiciles shrank slightly during the same period.

3.4. Reinsurance with Unrated and Unauthorized Reinsurers

Figure 4 decomposes life and annuity reinsurance ceded by the 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 79 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 20 percent in 2002 to 69 percent in 2012. In contrast, the share of unaffiliated reinsurance ceded to unauthorized reinsurers has been relatively constant throughout this period.

4. Measuring the Financial Risk of Shadow Insurance

In this section, we estimate the size of the shadow insurance sector and its impact on the financial risk of life insurers.

4.1. Size of the Shadow Insurance Sector

Figure 6 reports total reinsurance ceded by U.S. life insurers to shadow reinsurers. The shadow insurance sector grew rapidly from $11 billion in 2002 to $363 billion in 2012. As a share of the capital and surplus of the ceding companies, it grew from 0.22 in 2002 to 2.52 in 2012. This is a tremendous amount of leverage in a less regulated and non-transparent part of the insurance industry.

Figure 7 provides an alternative measure of the size of the shadow insurance sector, from the perspective of retail customers that buy policies. As discussed in Section 2, operating companies that are involved in shadow insurance are the largest in the industry that capture 50 percent of the market share for both life insurance and annuities. These companies ceded 28 cents of every dollar insured to shadow reinsurers in 2012, significantly up from only 2 cents in 2002.

4.2. Measures of Financial Risk Adjusted for Shadow Insurance

We find that current ratings do not reflect differences in shadow insurance activity across operating companies. To show this, we first convert the A.M. Best rating to a numeric equivalent based on risk-based capital guidelines (A.M. Best Company 2011, p. 24). We then regress the rating on company characteristics, including the share of gross life and annuity reserves ceded to shadow reinsurers. Table 5 reports the standardized coefficients with standard errors in parentheses.

The conventional determinants of ratings, as discussed in A.M. Best Company (2011), have the expected signs and are statistically significant. For example, ratings increase by 0.10 standard deviations for every standard deviation increase in risk-based capital. Similarly, ratings increase in size, asset liquidity, and profitability and decrease in leverage. However, ratings are unrelated to shadow insurance activity after controlling for these other characteristics. The coefficient on shadow insurance is precisely estimated to be zero.

We estimate the impact of moving back on balance sheet both the assets and liabilities on reinsurance ceded to shadow reinsurers. Although capital and surplus would not change, risk-based capital would fall because the capital required to support the additional liabilities (i.e., the denominator of the ratio) would rise. We assume that the risk characteristics of reinsurance ceded are identical to existing life and annuity reserves on balance sheet, so

that required capital rises proportionally. We view this assumption as conservative because reinsurance ceded to shadow reinsurers is probably riskier than liabilities that remain on balance sheet.

Our assumption yields a simple adjustment to risk-based capital, based on the available data:

$$\text{Adjusted RBC} = \frac{\text{Reported RBC}}{1 + \text{Shadow insurance/Reported reserves}}. \tag{1}$$

Table 6 reports that our adjustment for shadow insurance reduces median risk-based capital by 49 percentage points in 2012. An analogous adjustment drops the median rating by 3 notches from A to B+.

Our adjustment for shadow insurance implies that actual impairment probabilities are likely to be higher than what may be inferred from reported ratings. For each operating company, we match its adjusted rating to the historical term structure of impairment probabilities by rating (A.M. Best Company 2013a). We also assume a 10 percent loss conditional on impairment, based on the historical experience (Gallanis 2009). We then calculate the present value of expected loss and aggregate across all the companies that are involved in shadow insurance. Table 6 reports that our adjustment for shadow insurance raises expected loss by $15.7 billion in 2012, significantly up from only $0.6 billion in 2002.

We view our estimate in Table 6 as a lower bound on the actual financial risk of shadow insurance. The historical impairment probabilities and loss ratios are mostly based on the idiosyncratic events of smaller life insurers. We expect the actual experience for larger life insurers that are involved in shadow insurance to be more systemic, leading to larger losses for the industry. In particular, about 30 percent of shadow insurance is funded by letters of credit, which are weaker collateral than trust funds or funds withheld. Based on regulatory information that is not publicly available, Lawsky (2013) reports that a large share of letters of credit involve parental guarantees, which are vulnerable to systemic shocks to the insurance sector. Even unconditional letters of credit are vulnerable to rollover risk that can arise from shocks to the banking sector.

5. A Structural Model of Reinsurance

In this section, we develop a structural model of an insurance holding company that consists of affiliated companies in domiciles with different capital regulation. Affiliated reinsurance allows the holding company to reduce the cost of financial frictions, by efficiently moving capital between its affiliated companies. This lowers marginal cost for operating companies that sell policies, leading to a higher 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 measure. As discussed in Section 1, U.S. tax laws disallow reinsurance for the primary purpose of reducing tax liabilities.

5.1. An Insurance Holding Company's Maximization Problem

An insurance holding company consists of I affiliated companies, which we index as $i = 1, \ldots, I$. The affiliated companies may include an operating company whose primary function is to sell policies to retail customers, a reinsurer whose primary function is to sell reinsurance to unaffiliated companies, and captives whose primary function is to assume reinsurance from affiliated companies. The I affiliated companies are domiciled in different jurisdictions that may have different capital regulation.

Each operating company i faces demand $Q_{i,t}(P)$ at a given price P for its policies in period t. The demand curve is downward-sloping with elasticity

$$\epsilon_{i,t} = -\frac{P_{i,t}Q'_{i,t}}{Q_{i,t}} > 1. \tag{2}$$

For a captive j that only assumes reinsurance from affiliated companies, we follow the notational convention that $Q_{j,t} = 0$. We denote the actuarial value (i.e., frictionless marginal cost) of policies as V_t.

After the sale of policies, an operating company can cede reinsurance to an affiliated company within the holding company. Let $B_{ij,t} \geq 0$ denote the quantity of affiliated reinsurance ceded by company i and assumed by company j in period t. In addition, the operating company can cede reinsurance to unaffiliated reinsurers outside the holding company. Let $D_{i,t} \geq 0$ denote the quantity of unaffiliated reinsurance ceded at an exogenously given price $P_{D,t}$.

The holding company's total profit is

$$\Pi_t = \sum_{i=1}^{I} [(P_{i,t} - V_t)Q_{i,t} - (P_{D,t} - V_t)D_{i,t}]. \tag{3}$$

Total profit is equal to the profit from the sale of policies minus the cost of unaffiliated reinsurance, summed across all the affiliated companies. Note that the total profit does not depend on affiliated reinsurance.

We now describe how the sale of policies and reinsurance affect an affiliated company's balance sheet. Let $L_{i,t}$ be company i's reserves (i.e., liabilities) at the end of period t. For simplicity, we assume that the reserve value of policies is equal to actuarial value. The change in reserves in period t is

$$\begin{aligned}\Delta L_{i,t} =& L_{i,t} - L_{i,t-1} \\ =& V_t \left(Q_{i,t} - \sum_{j \neq i} (B_{ij,t} - B_{ji,t}) - D_{i,t} \right). \end{aligned} \tag{4}$$

Let $A_{i,t}$ be company i's assets at the end of period t. The change in assets in period t is

$$\begin{aligned}\Delta A_{i,t} =& A_{i,t} - A_{i,t-1} \\ =& \Delta L_{i,t} + (P_{i,t} - V_t) Q_{i,t} - (P_{D,t} - V_t) D_{i,t}. \\ =& P_{i,t} Q_{i,t} - \sum_{j \neq i} V_t (B_{ij,t} - B_{ji,t}) - P_{D,t} D_{i,t}. \end{aligned} \tag{5}$$

The change in assets is equal to the change in reserves, plus the profits from the sale of policies, minus the cost of unaffiliated reinsurance.

We define company i's statutory capital in period t as

$$K_{i,t} = A_{i,t} - (1 + \rho_i) L_{i,t}. \tag{6}$$

There are two ways to interpret our formulation of statutory capital, both which lead to equation (6). First, as discussed in Section 1, operating companies must hold higher reserve than reinsurers because of Regulation (A)XXX. Under this interpretation, ρ_i is the difference between statutory and GAAP reserve. Second, operating companies that are subject to risk-based capital regulation must hold extra capital to buffer shocks to the value of its liabilities. Under this interpretation, ρ_i is the risk charge on liabilities. Under both interpretations, higher ρ_i implies tighter capital regulation. Equations (4) and (5) imply that the change in statutory capital in period t is

$$\begin{aligned}\Delta K_{i,t} =& K_{i,t} - K_{i,t-1} \\ =& (P_{i,t} - (1 + \rho_i) V_t) Q_{i,t} + \sum_{j \neq i} \rho_i V_t (B_{ij,t} - B_{ji,t}) - (P_{D,t} - (1 + \rho_i) V_t) D_{i,t}. \end{aligned} \tag{7}$$

The holding company faces an adjustment cost on the statutory capital of its affiliated companies:

$$C_t = \sum_{i=1}^{I} \frac{\exp\{-\gamma \Delta K_{i,t}\}}{\gamma}, \tag{8}$$

where $\gamma > 0$ is a curvature parameter. This cost function is a simple way to model financial frictions, part of which arises from regulatory restrictions on the movement of capital between affiliated companies (National Association of Insurance Commissioners 2011, Appendix A-440). To simplify notation, we denote the marginal adjustment cost for company i in period t as

$$c_{i,t} = -\frac{\partial C_t}{\partial \Delta K_{i,t}} = \exp\{-\gamma \Delta K_{i,t}\}. \tag{9}$$

The holding company maximizes firm value, or the present value of profits minus capital adjustment costs:

$$J_t = \Pi_t - C_t + \mathbf{E}_t[M_{t+1} J_{t+1}], \tag{10}$$

where M_{t+1} is the stochastic discount factor. Its choice variables are the insurance price $P_{i,t}$ for each operating company, affiliated reinsurance $B_{ij,t}$ between all pairs of companies i and j, and unaffiliated reinsurance $D_{i,t}$ ceded by each company.

5.2. Optimal Pricing of Insurance

The first-order condition for the pricing of insurance by operating company i is

$$\begin{aligned} \frac{\partial J_t}{\partial P_{i,t}} =& \frac{\partial \Pi_t}{\partial P_{i,t}} + c_{i,t} \frac{\partial \Delta K_{i,t}}{\partial P_{i,t}} \\ =& Q_{i,t} + (P_{i,t} - V_t) Q'_{i,t} + c_{i,t}[Q_{i,t} + (P_{i,t} - (1+\rho_i) V_t) Q'_{i,t}] = 0. \end{aligned} \tag{11}$$

Rearranging this equation, the optimal insurance price is

$$P_{i,t} = V_t \left(1 - \frac{1}{\epsilon_{i,t}}\right)^{-1} \left(\frac{1 + (1+\rho_i) c_{i,t}}{1 + c_{i,t}}\right). \tag{12}$$

The first part of this equation is the standard Bertrand formula, and the second part is an additional cost that arises from financial frictions. The optimal insurance price rises with the capital adjustment cost and tighter capital regulation (i.e., higher ρ_i).

5.3. *Optimal Affiliated Reinsurance*

Assuming an internal optimum, the first-order condition for affiliated reinsurance ceded by company i to j is

$$\begin{aligned}\frac{\partial J_t}{\partial B_{ij,t}} =& c_{i,t}\frac{\partial \Delta K_{i,t}}{\partial B_{ij,t}} + c_{j,t}\frac{\partial \Delta K_{j,t}}{\partial B_{ij,t}} \\ =& c_{i,t}\rho_i V_t - c_{j,t}\rho_j V_t = 0.\end{aligned} \tag{13}$$

Rearranging this equation,

$$\rho_i c_{i,t} = \rho_j c_{j,t} \tag{14}$$

for a pair of companies i and j.

Equation (14) implies that a company subject to tighter capital regulation cedes reinsurance to an affiliated company subject to looser capital regulation. To illustrate this point, suppose that company i faces tighter capital regulation than company j (i.e., $\rho_i > \rho_j$). Then the first-order condition (14) requires that $c_{i,t} < c_{j,t}$, which implies that $\Delta K_{i,t} > \Delta K_{j,t}$. That is, company i's statutory capital must rise relative to company j's in order to reduce the overall capital adjustment cost for the holding company.

By lowering the capital adjustment cost, affiliated reinsurance lowers the optimal insurance price and raises equilibrium supply in the retail market. To show this analytically, we assume that the demand elasticity is constant for tractability. We then apply the implicit function theorem to differentiate equation (12) with respect to $B_{ij,t}$:

$$\frac{\partial P_{i,t}}{\partial B_{ij,t}} = -\gamma\rho_i V_t \left[\frac{V_t(1-1/\epsilon_{i,t})^{-1}\rho_i c_{i,t}}{(P_{i,t}-V_t(1-1/\epsilon_{i,t})^{-1})^2} + \gamma Q_{i,t}\left(1+\epsilon_{i,t}\left(\frac{V_t(1+\rho_i)}{P_{i,t}}-1\right)\right)\right]^{-1} < 0. \tag{15}$$

5.4. *Optimal Unaffiliated Reinsurance*

The derivative of firm value with respect to unaffiliated reinsurance ceded by company i is

$$\begin{aligned}\frac{\partial J_t}{\partial D_{i,t}} =& \frac{\partial \Pi_t}{\partial D_{i,t}} + c_{i,t}\frac{\partial \Delta K_{i,t}}{\partial D_{i,t}} \\ =& -(P_{D,t}-V_t) - c_{i,t}(P_{D,t}-(1+\rho_i)V_t).\end{aligned} \tag{16}$$

This implies that company i will cede reinsurance to an unaffiliated reinsurer only if

$$\frac{\partial J_t(D_{i,t}=0)}{\partial D_{i,t}} > 0 \Longleftrightarrow P_{D,t} < V_t \left(\frac{1+(1+\rho_i)c_{i,t}}{1+c_{i,t}} \right). \tag{17}$$

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 may include risk transfer, underwriting assistance, or tax benefits.

6. Impact of Shadow Insurance on the Retail Market

In this section, we use the structural model to estimate the impact of shadow insurance on the equilibrium supply in the retail market.

6.1. Empirical Specification

Let o index an operating company that cedes reinsurance to a shadow reinsurer, which is indexed by s. The change in statutory capital for the shadow reinsurer simplifies to $\Delta K_{s,t} = -\rho_s \Delta L_{s,t}$ since its only function is to assume reinsurance from affiliated companies (i.e., $Q_{s,t} = D_{s,t} = 0$ in equation (7)). Similarly, we approximate the change in statutory capital for the operating company as $\Delta K_{o,t} \approx -\rho_o \Delta L_{o,t}$ (which is exact only if $P_{o,t} = P_{D,t} = V_t$). Then the first-order condition for affiliated reinsurance (14) and our parametrization of the capital adjustment cost (9) imply that

$$\Delta L_{o,t} = \frac{\rho_s}{\rho_o} \Delta L_{s,t} + \frac{\log(\rho_s/\rho_o)}{\gamma \rho_o}. \tag{18}$$

The equation delivers an intuitive prediction. If the operating company faces tighter capital regulation (i.e., $\rho_o > \rho_s$), its liabilities should move less than dollar-for-dollar with the shadow reinsurer's liabilities.

Equation (18) holds for a pair of affiliated companies within the same holding company in a given period of time. In the data, we observe various holding companies in different years. Therefore, we estimate

$$\Delta L_{o,n} = \frac{\rho_s}{\rho_o} \Delta L_{s,n} + \beta' \mathbf{x}_n + e_n, \tag{19}$$

where n indexes the observations that are pooled across holding companies and years. The vector $\mathbf{x}_n$ includes a full set of year and holding-company fixed effects as well as company

characteristics, and e_n is an error term with conditional mean zero. The key assumption in going from equation (18) to (19) is that the variation in γ across holding companies and years is well captured by these fixed effects and company characteristics.

6.2. Estimates of the Structural Model of Reinsurance

To construct our estimation sample, we first isolate pairs of operating companies and shadow reinsurers, where total reinsurance ceded is greater than $100 million. We then calculate the change in liabilities for both the operating company and the shadow reinsurer as annualized changes over the same time period, during which they have a reinsurance agreement in effect. We end up with a sample of 147 shadow insurance relationships between 2003 and 2012.

Table 7 reports our estimate of equation (19) by ordinary least squares. As predicted by the theory, the operating company's labilities move less than dollar-for-dollar with the shadow reinsurer's liabilities. The operating company's liabilities increase by $0.44 for every dollar increase in the shadow reinsurer's liabilities. The coefficients on log assets and return on equity are negative and significant, while the coefficient on leverage is positive and significant. This implies that smaller, less profitable, and more leveraged companies have more curvature (i.e., higher γ) in their capital adjustment cost.

6.3. Retail Market in the Absence of Shadow Insurance

Based on equation (12), we now estimate how shadow insurance lowers the capital adjustment cost, which leads to lower marginal cost and a higher equilibrium supply in the retail market. Our structural estimates in Table 7 and equation (18) imply an estimate of γ for each operating company. We calibrate the parameter ρ_o to 0.15, based on industry estimates of redundant life insurance reserves relative to total gross reserves (Stern et al. 2007).

Table 8 reports that marginal cost would rise by 1.8 percent for the average operating company in the absence of shadow insurance. The change in marginal cost varies significantly across companies that face different costs of capital, as captured by a standard deviation of 2.8 percent. When aggregated across all the operating companies in our sample, annual insurance underwritten would fall by $1.4 billion (from its current level of $84.8 billion) at unit demand elasticity.

We view our estimate in Table 8 as an upper bound on the actual impact of eliminating shadow insurance for two reasons. First, life insurers may find new ways to manage capital that substitute for shadow insurance. Second, only the largest companies that capture 50 percent of the market share are involved in shadow insurance. The smaller companies may be able to supply more insurance without a significant increase in marginal cost, thereby

offsetting the lower supply by the largest companies.

7. Conclusion

Activity in the shadow insurance sector has recently drawn the attention of some insurance regulators. In particular, New York has called for a national moratorium on further approval of shadow insurance until more information can be gathered about this activity (Lawsky 2013). However, such efforts are hindered by the fact that insurance is regulated at the state level, which makes national coordination difficult. Our analysis shows that there are both costs and benefits to shadow insurance. On the one hand, the current size of the shadow insurance sector implies an additional expected loss of at least $15.7 billion for the industry. On the other hand, marginal cost would rise by 1.8 percent in the absence of shadow insurance, which leads to a $1.4 billion reduction in annual insurance underwritten at unit demand elasticity.

The actual cost of shadow insurance may be higher than our lower-bound estimate for several reasons. First, the lack of public disclosure by shadow reinsurers prevents accurate assessment of their investment risk and the fragility of their funding arrangements. Second, $363 billion for the current size of the U.S. shadow insurance sector may just be the tip of an iceberg, if there is additional activity in the rest of the world. Third, the financial crisis has shown that even relatively small shocks can amplify due to the interconnectedness of financial institutions and the endogeneity of asset prices. Finally, problems in the insurance sector could spill over to real economic activity through the corporate bond market.

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Table 1: A Stylized Example of Captive Reinsurance

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 statutory reserve of $110, while the captive can hold GAAP reserve of $90.

Operating company
(in domicile with tighter capital regulation)

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

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

2. Cedes reinsurance.

Captive
(in domicile with looser capital regulation)

A		L			A		L	
				$\Longrightarrow$	Trust: Bonds	$90	Reserve	$90
					Letter of credit			
					Cash	$10		
		Equity	$0				Equity	$10

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

Table 2: Summary Statistics for Reinsurance Agreements

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

	Number of reinsurance agreements ceded to			Mean reinsurance ceded (million $)			Median reinsurance ceded (million $)		
Year	Unaffiliated	Affiliated	Shadow	Unaffiliated	Affiliated	Shadow	Unaffiliated	Affiliated	Shadow
2002	1,447	153	53	26.6	78.8	59.7	0.2	0.8	1.1
2003	960	119	70	25.9	116.4	59.3	0.1	2.4	1.5
2004	753	149	89	101.2	528.4	502.4	0.1	4.5	4.2
2005	824	182	110	28.3	210.8	162.9	0.0	2.3	4.9
2006	681	146	85	53.8	227.2	231.0	0.0	4.4	2.8
2007	599	114	65	38.9	344.8	450.9	0.1	9.2	8.6
2008	566	132	88	25.1	613.2	717.4	0.0	14.6	10.4
2009	456	120	67	36.9	1,198.9	2,003.3	0.1	11.1	12.3
2010	408	116	56	9.8	509.1	776.3	0.0	37.5	23.1
2011	277	100	49	60.8	684.5	640.4	0.0	36.9	131.8
2012	289	111	44	98.6	422.4	512.9	0.4	22.8	130.9

Table 3: Characteristics of Companies Ceding to Shadow Reinsurers

This table reports summary statistics for operating companies in 2012, by whether they are ceding reinsurance to shadow reinsurers. Shadow reinsurers are affiliated and unauthorized reinsurers without an A.M. Best rating. The market shares are based on gross reserves held for life insurance and annuities, respectively.

	Ceding to shadow reinsurers	
Statistic	No	Yes
Number of companies	347	81
Market share (percent):		
Life insurance	50	50
Annuities	50	50
Median:		
Risk-based capital (percent)	205	181
Log assets	0.00	3.24
Leverage (percent)	84	93
Current liquidity (percent)	84	66
Return on equity (percent)	7	14

Table 4: Affiliated Reinsurance within the MetLife Group

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 $100 million 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.

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		-5.8
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			5.5

Table 5: Relation between Shadow Insurance and Rating

The A.M. Best rating, converted to a numeric equivalent based on risk-based capital guidelines, is regressed on company characteristics. The key variable of interest is the share of gross life and annuity reserves ceded to shadow reinsurers. The sample consists of operating companies between 2002 and 2012. The coefficients are standardized, and the standard errors (reported in parentheses) are clustered by holding company. Year fixed effects are not reported for brevity.

Variable	Coefficient
Share ceded to	0.00
shadow reinsurers	(0.02)
Risk-based capital	0.10
	(0.03)
Log assets	0.79
	(0.04)
Leverage	-0.16
	(0.04)
Current liquidity	0.07
	(0.02)
Return on equity	0.04
	(0.02)
R^2	0.45
Observations	5,496

Table 6: Measures of Financial Risk Adjusted for Shadow Insurance

This table reports median risk-based capital and A.M. Best rating for operating companies that are ceding reinsurance to shadow reinsurers. 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 characteristics of reinsurance ceded are assumed to be identical to existing life and annuity reserves on balance sheet, so that required capital rises proportionally. The present value of expected loss assumes a 10 percent loss conditional on impairment, discounted by the Treasury yield curve.

	Median risk-based capital (percent)			Median rating		Present value of expected loss (billion $)		
Year	Reported	Adjusted	Difference	Reported	Adjusted	Reported	Adjusted	Difference
2002	132	122	-10	A+	A	1.2	1.8	0.6
2003	136	133	-3	A+	A	1.2	2.3	1.1
2004	145	129	-16	A+	A	1.4	4.6	3.2
2005	146	135	-11	A+	A-	1.6	4.9	3.3
2006	144	130	-14	A+	A	1.3	4.4	3.1
2007	182	140	-42	A+	A-	1.6	8.0	6.4
2008	161	133	-28	A	A-	2.5	12.1	9.6
2009	184	145	-39	A	B++	2.5	15.9	13.4
2010	202	161	-41	A	B++	2.5	16.6	14.2
2011	191	145	-45	A	B+	3.3	18.1	14.8
2012	193	144	-49	A	B+	3.5	19.1	15.7

Table 7: Estimates of the Structural Model of Reinsurance

The sample consists of pairs of operating companies and shadow reinsurers between 2003 and 2012, where total reinsurance ceded is greater than $100 million. Heteroskedasticity-robust standard errors are reported in parentheses. Year and holding-company fixed effects are not reported for brevity.

Variable	Coefficient
Change in shadow reinsurer's liabilities	0.44
	(0.14)
Log assets	-1.03
	(0.25)
Leverage	1.74
	(0.37)
Current liquidity	0.33
	(0.26)
Return on equity	-1.10
	(0.34)
Observations	174

Table 8: Retail Market in the Absence of Shadow Insurance

The structural model of reinsurance is used to estimate the counterfactual of eliminating shadow insurance. This table reports the change in marginal cost for operating companies that are ceding reinsurance to shadow reinsurers. It also reports the total dollar change in annual insurance underwritten, as measured by the change in gross life and annuity reserves.

Change in	Value
Marginal cost (percent):	
Mean	1.8
Standard deviation	2.8
Quantity (billion $)	-1.4

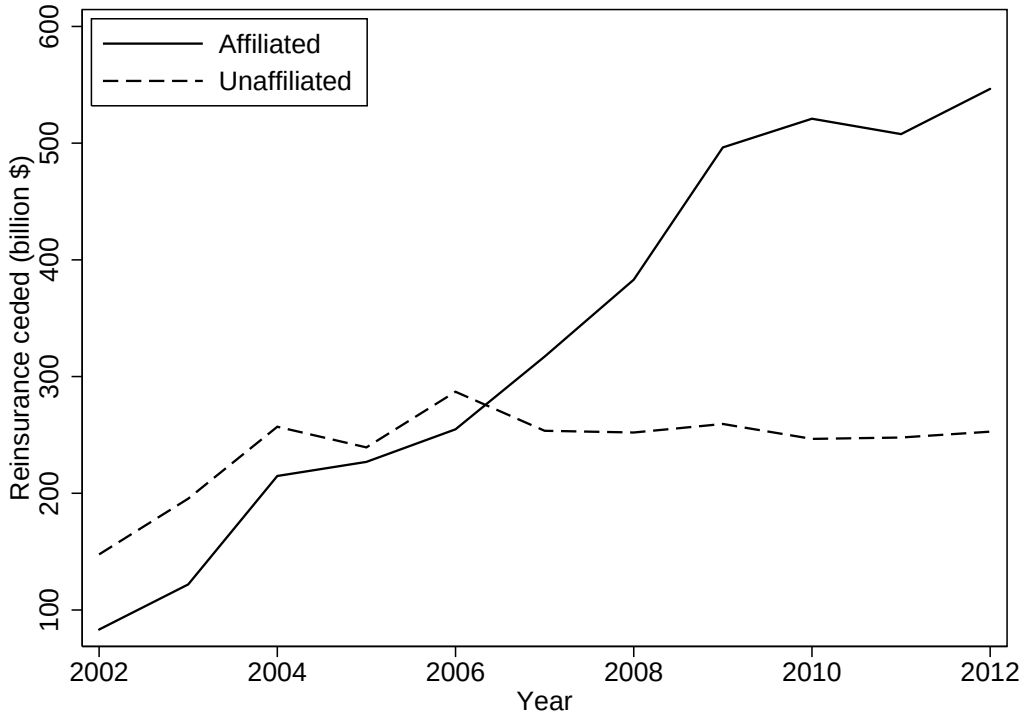

Figure 1: Reinsurance Ceded by U.S. Life Insurers

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.

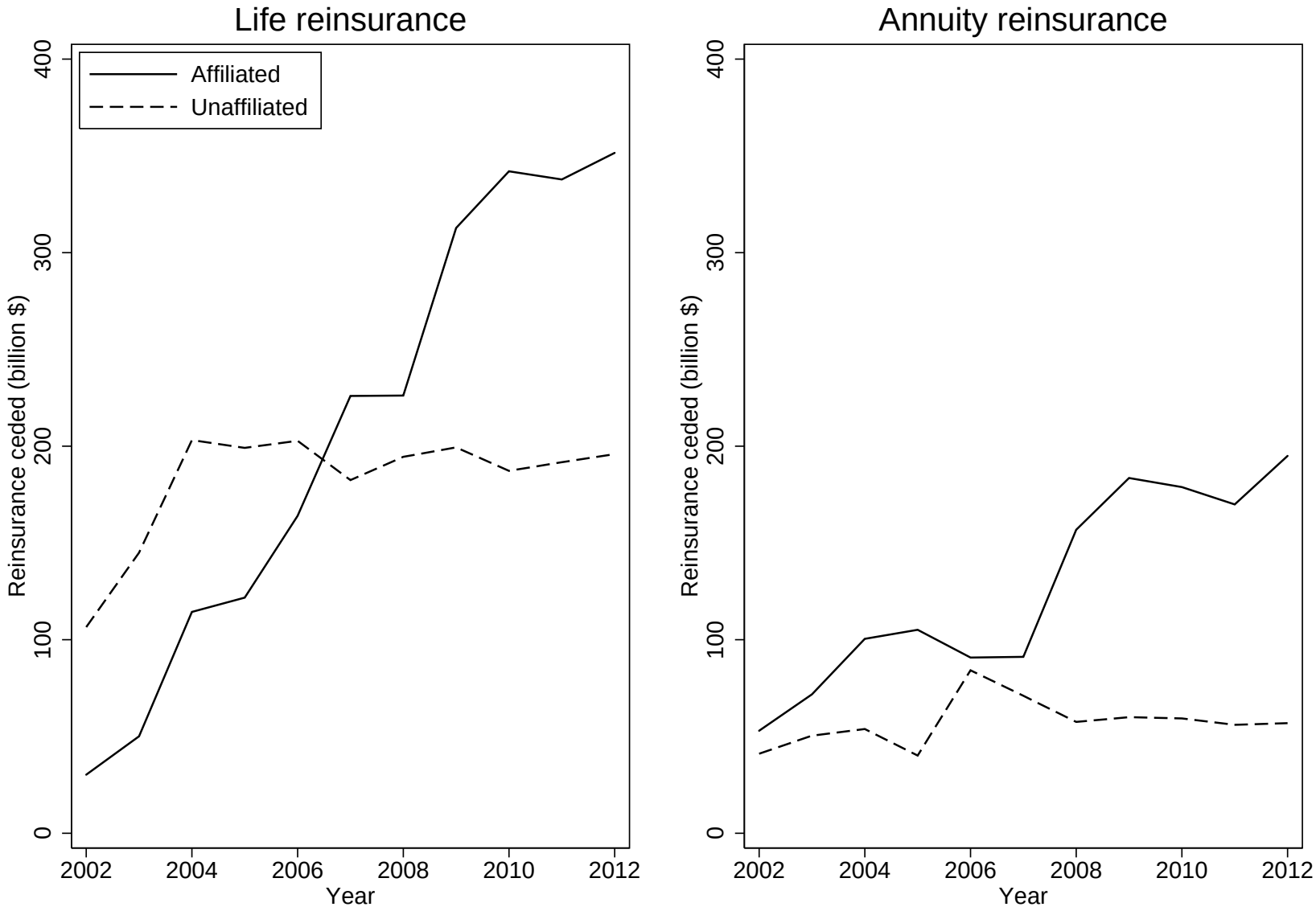

Figure 2: Life versus Annuity Reinsurance Ceded by U.S. Life Insurers

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.

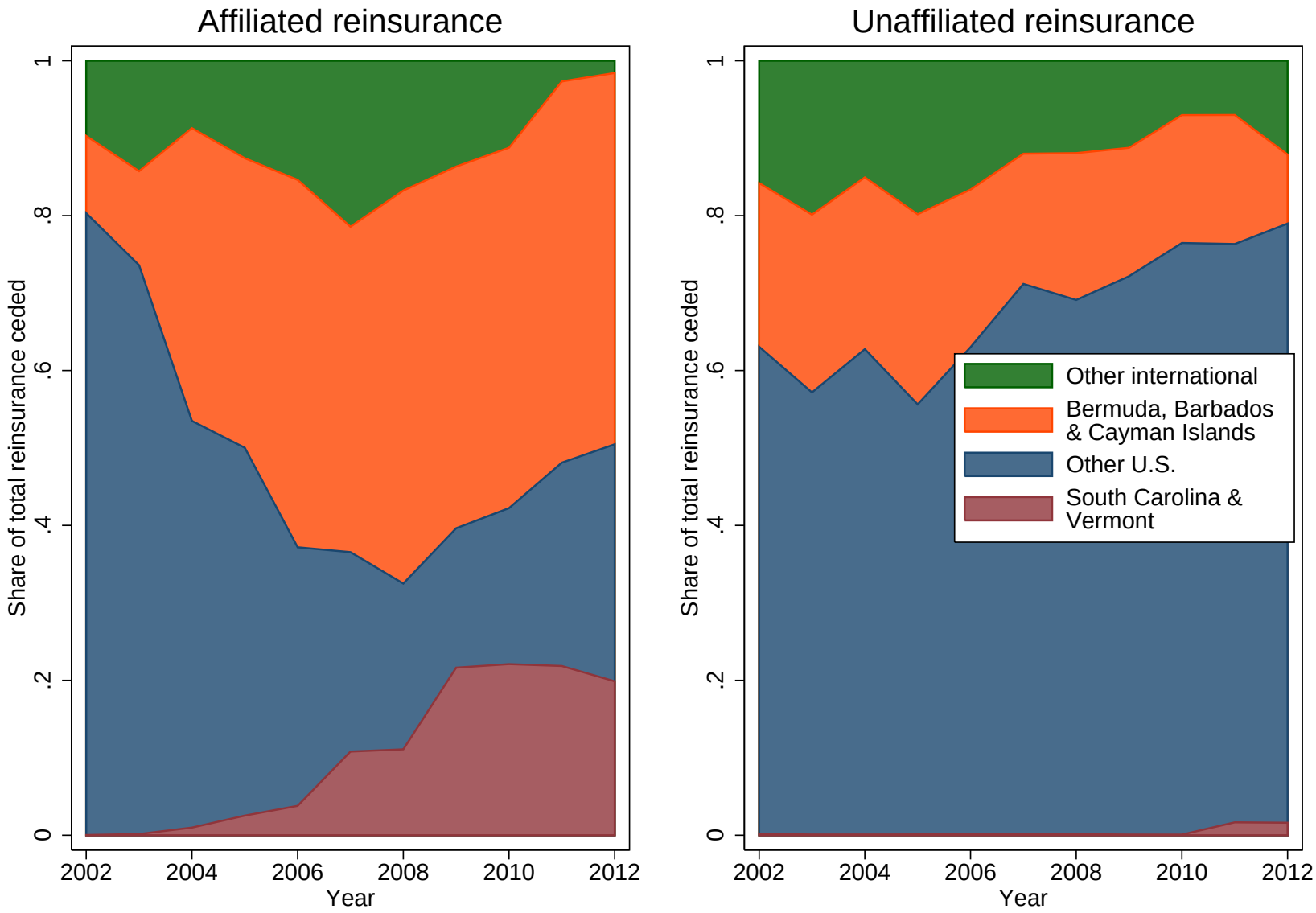

Figure 3: Reinsurance Ceded by Domicile of Reinsurer

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.

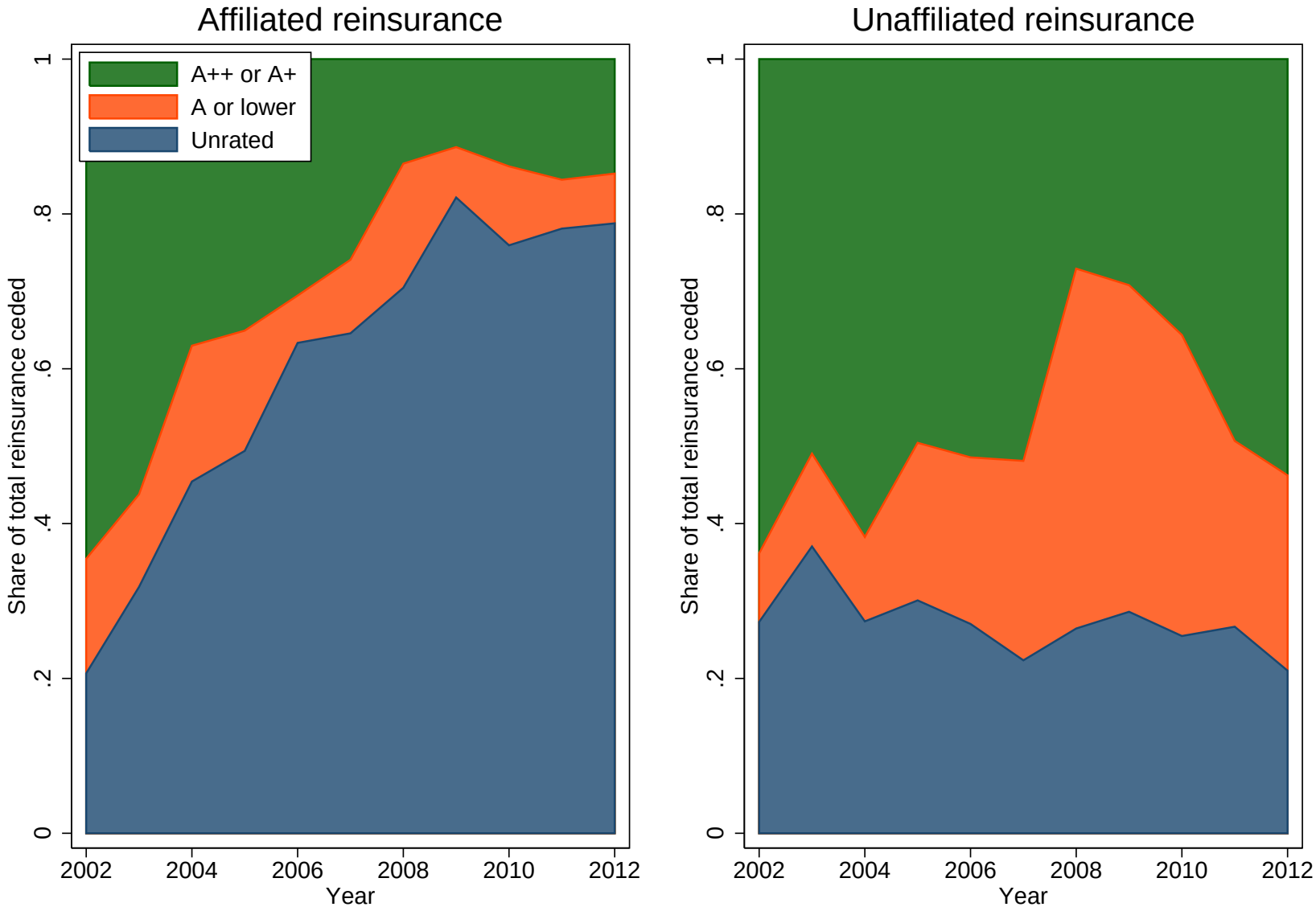

Figure 4: Reinsurance Ceded by Rating of Reinsurer

This figure decomposes life and annuity reinsurance ceded by the 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.

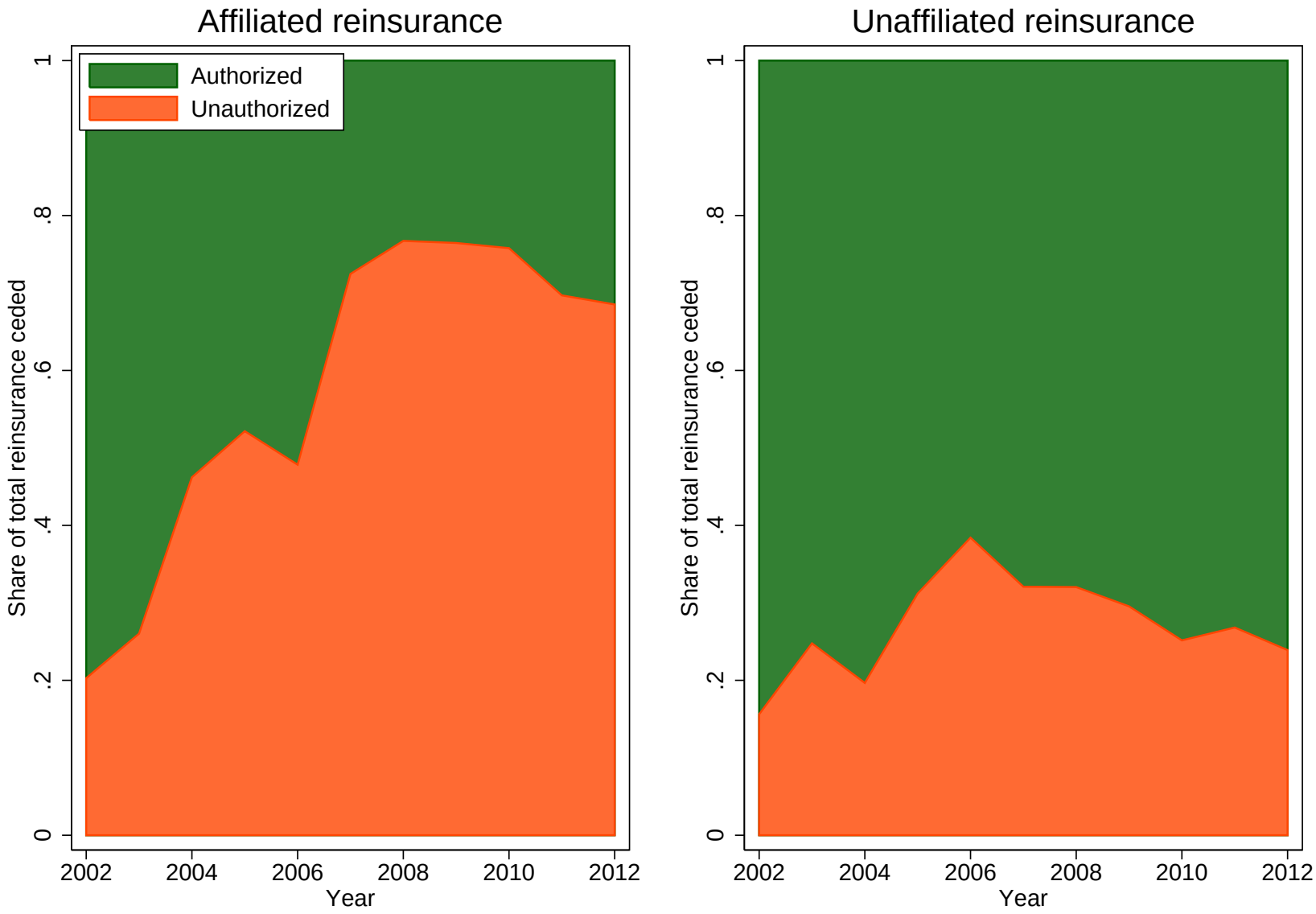

Figure 5: Reinsurance Ceded to Unauthorized Reinsurers

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.

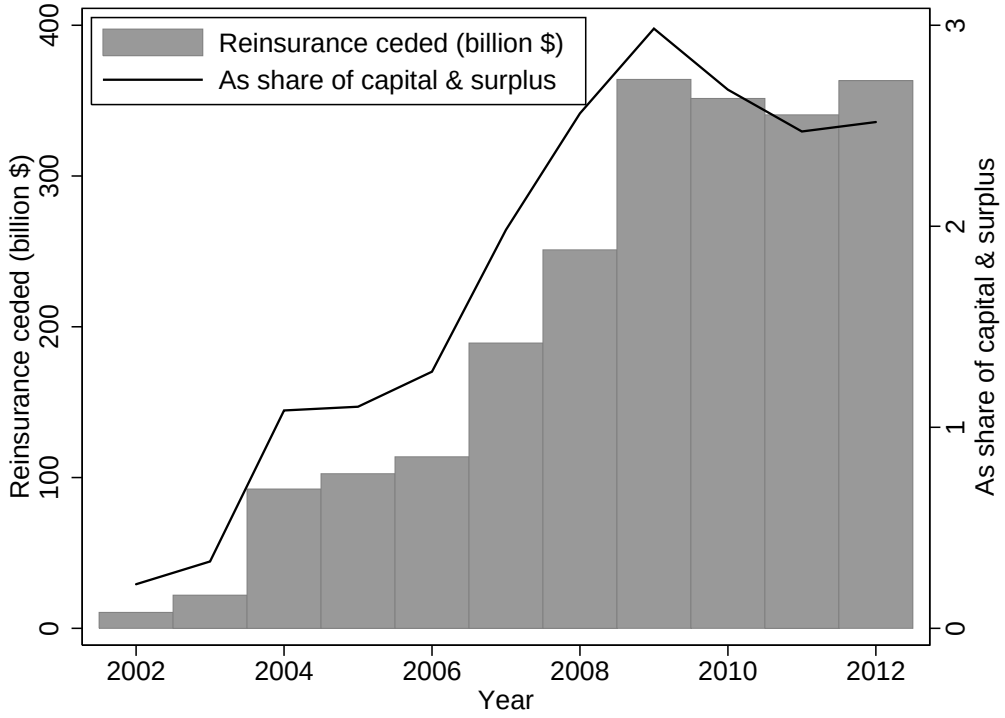

Figure 6: Reinsurance Ceded to Shadow Reinsurers

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. Shadow reinsurers are affiliated and unauthorized reinsurers without an A.M. Best rating. Reinsurance ceded is the sum of reserve credit taken and modified coinsurance reserve ceded.

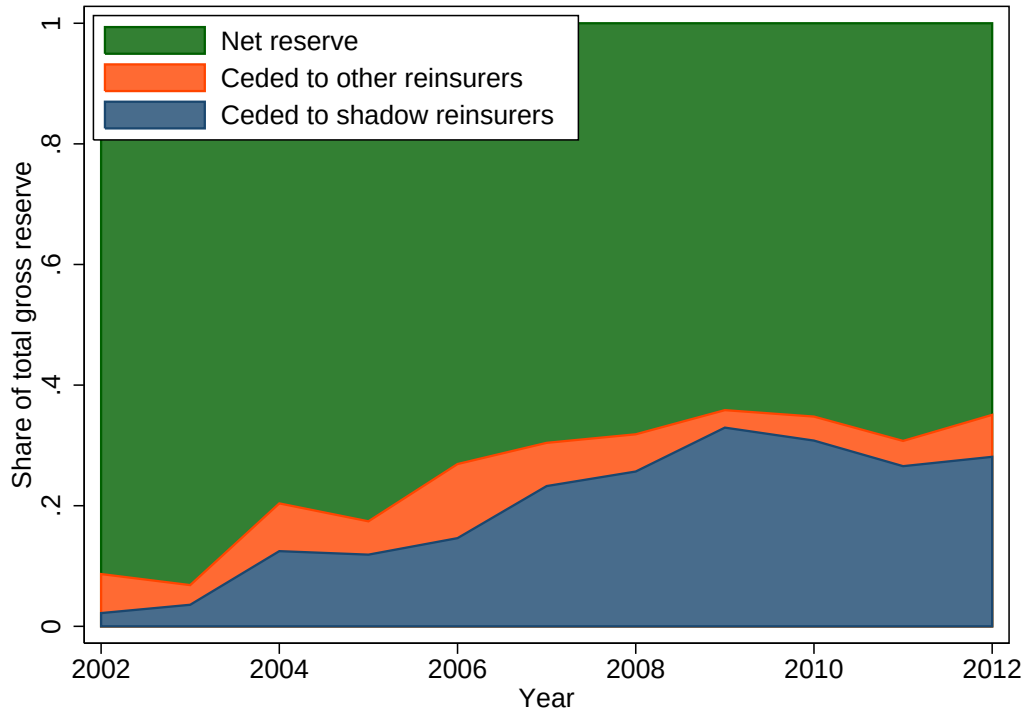

Figure 7: Decomposition of Gross Reserve for Companies Ceding to Shadow Reinsurers
This figure decomposes gross life and annuity reserves into reinsurance ceded versus net reserves held, for operating companies that are ceding reinsurance to shadow reinsurers. Shadow reinsurers are affiliated and unauthorized reinsurers without an A.M. Best rating.

Appendix

A. Additional Examples of Captive Reinsurance

In this appendix, we illustrate captive reinsurance when the transaction is structured as coinsurance with funds withheld or modified coinsurance. The main difference between these types of reinsurance and coinsurance is that the ceding company retains control of the assets. Therefore, the captive does not need to establish a trust fund.

A.1. Coinsurance with Funds Withheld

The first step in Table A1 is the same as in Table 1. In the second step, the operating company cedes all the policies 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 statutory and GAAP reserve. On the liability side, the captive records GAAP reserve of only $90 because it is not subject to Regulation (A)XXX.

A.2. Modified Coinsurance

The first step in Table A2 is the same as in Table 1. In the second step, the operating company cedes all the policies 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 statutory and GAAP reserve. On the liability side, the captive records GAAP reserve of only $90 because it is not subject to Regulation (A)XXX.

Table A1: 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 statutory reserve of $110, while the captive can hold GAAP reserve of $90.

Operating company
(in domicile with tighter capital regulation)

A		L	
Bonds	$10		
		Equity	$10

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

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

$\Longrightarrow$ *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)

A		L	
		Equity	$0

$\Longrightarrow$ *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 A2: 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 statutory reserve of $110, while the captive can hold GAAP reserve of $90.

Operating company
(in domicile with tighter capital regulation)

A		L			*1. Sells insurance for $100. (Statutory reserve of $110 and GAAP reserve of $90.)*	A		L			*2. Cedes reinsurance, paying $10 premium. Invests $90 in bonds.*	A		L	
Bonds	$10			$\Longrightarrow$		Bonds	$10			$\Longrightarrow$		Bonds	$100	Modco reserve	$90
						Premium	$100	Reserve	$110						
		Equity	$10					Equity	$0					Equity	$10

Captive
(in domicile with looser capital regulation)

A		L			*2. Assumes reinsurance. Secures letter of credit up to $20.*	A		L	
				$\Longrightarrow$		Modco deposit	$90	Reserve	$90
						Letter of credit			
						Cash	$10		
		Equity	$0					Equity	$10