# Asset Insulators*


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**Abstract**

We propose that financial institutions can act as asset insulators, creating value by holding illiquid assets for the long run and insulating those assets from transitory fluctuations in market prices. We illustrate the empirical relevance of this theory for the balance sheet behavior of a large class of intermediaries, life insurance companies. The pass-through from assets to equity is an especially informative metric for distinguishing the asset insulator theory from Modigliani-Miller or other standard models. We estimate the pass-through using security-level data on insurers' holdings matched to corporate bond returns. Uniquely consistent with the insulator view, outside of the 2008-2009 crisis insurers lose as little as 10 cents in response to a dollar drop in asset values, while during the crisis the pass-through rises to roughly 1. The rise in pass-through highlights the fragility of insulation exactly when it is most valuable.



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# 1 Introduction

In the wake of the 2008-09 financial crisis, the role of financial institutions has come under scrutiny. How do they create or destroy value for their stakeholders and for the broader economy? We propose that some financial intermediaries act as *asset insulators*, creating value by holding illiquid assets for the long run and insulating those assets from transitory fluctuations in market prices. We illustrate the empirical relevance of this theory in the context of a large class of intermediaries, the life insurance sector.

We document a number of key aspects of insurers' balance sheets consistent with the view that asset insulation is an important component of their value creation. We then introduce the pass-through of a change in asset prices to equity value as an informative metric to distinguish the importance of asset insulation from alternative theories of the role of the life insurance sector. We design and implement an empirical strategy to identify the pass-through, taking advantage of detailed security-level data on insurers' holdings. Reflecting the insulation from market fluctuations, we estimate that equity value decreases by as little as 10 cents in response to a one dollar drop in asset values outside of the 2008-09 financial crisis. During the crisis, the pass-through rises to approximately 1. Our theory interprets the higher pass-through during the crisis as resulting from the deterioration in the financial health of insurers, which threatens their ability to act as long-lived investors. Thus, the asset insulation function of insurers is fragile exactly when it is most valuable.

We start by describing aggregate features of insurers' balance sheets which are consistent with the asset insulator approach and at odds with other views of life insurers. A commonly held view is that life insurance companies choose their assets to neutralize the interest rate risk of their liabilities (see, e.g., Briys and De Varenne, 1997). Such behavior can be justified as a way to avoid the costs of financial distress. Insurers do not come close to pursuing such a strategy. Treasuries and agency bonds constitute only about 13% of insurers' assets. Such a small position does not reflect supply constraints: jointly, insurers own no more than 14% of long-term Treasuries available. Moreover, the other assets on their balance sheet are not Treasury-like in their risk characteristics. The largest concentration of holdings is in corporate bonds, roughly 35% of their assets. Even before the crisis in 2006, the majority of these corporate bonds had a rating of BBB or below.

Instead, insurers' holdings concentrate in illiquid assets which they hold for long periods of time, on average 4 years. The structure of their liabilities complements this strategy. Life insurance and annuity policies have long contractual horizons. And, while policyholders may have the option to take an early surrender, the quantity of surrenders does not spike during periods of financial turmoil such as during the financial crisis. Thus, the long and predictable duration of liabilities makes insurers natural holders of illiquid assets.

The changes in value of the various components of publicly-traded insurers' balance sheets during the 2008-09 financial crisis provides further evidence consistent with the asset insulator view. During the year 2008, because of the sharp drop in interest rates, we estimate the value of policy liabilities to have increased by more than \$96 billion. At the same time, the risky assets held by these insurers lost at least \$30 billion. If the franchise value stayed constant, we would have observed a more than \$126bn loss in the value of the equity. In practice, insurers' equity dropped by "only" \$80 billion: franchise value increased. This result runs counter to the financial friction view that a deteriorating financial situation destroys firm value. In contrast, if the business of life insurers is to insulate assets from market dislocations, then the movement into a financial crisis would have represented a prime opportunity.

We use detailed security-level data on insurers' holdings to identify the pass-through of asset values to equity, providing direct evidence on fluctuations in the franchise value of insurers. Using regulatory filings, we construct daily cusip-level holdings of the assets on each publicly-traded insurer's balance sheet. We then construct daily asset price shocks that affect some insurers and not others, allowing us to identify the pass-through by comparing the responses of their equity prices. More precisely, we focus on corporate bonds experiencing large abnormal returns. We attribute the corresponding asset value change using the portfolio position of each insurer. We then regress the equity return on the asset value change in the cross-section of insurers. Focusing on tightly timed, large bond returns localized in a small subset of securities helps to ensure the asset value shocks are unrelated to other activities of affected insurers. Nonetheless, they are frequent and large enough to allow us to precisely estimate the pass-through. We further show that they are not driven only by high-frequency variation in prices.

Pass-through estimates differ markedly in and out of the crisis. Before or after the crisis, we find that a dollar lost on assets creates an approximately 10 cent loss to equity values, economically and statistically significantly much less than one. During the crisis, the point estimate of the pass-through rises and is not statistically distinguishable from 1. Moreover, the pass-through rises more for insurers with larger overall declines in their stock price, providing suggestive evidence of poor financial health during this period contributing to lower insulation from market movements.

We interpret these findings through the lens of a simple model of asset insulators. Our theory relies on two ingredients. First, the value of assets on traded markets is affected by shocks that do not affect value if held inside the firm. Previous literature has motivated this gap as coming from illiquidity costs (Cherkes, Sagi, and Stanton, 2009), fire sales in traded markets (Hanson, Shleifer, Stein, and Vishny, 2015), management skill (Berk and Stanton, 2007), or selection of investors in the insurer with different beliefs (Lee, Shleifer, and Thaler, 1991). Second, because of their leverage, we assume insurers must liquidate their assets on the open market if the value of their assets deteriorates beyond a certain threshold.

The theory provides a unifying narrative for the evidence we have described. Insurers create franchise value by targeting assets which may have a large wedge between their valuation on and off the market, namely illiquid assets. To capture the valuation difference, they hold those assets for a long time. In normal conditions, as asset prices fluctuate on the market, the value inside the firm is preserved and the pass-through is low. When the crisis occurs, asset prices on the market drop. This results in a larger comparative advantage to holding the assets on the balance sheet, so franchise value increases. However, this effect is mitigated by the deterioration in the financial health of insurers, putting them closer to liquidation. When liquidation becomes imminent, insurers lose the ability to insulate assets from market movements, resulting in a higher pass-through. Further, while high, the value creation from the asset insulator activity is precarious. Adverse price changes can precipitate liquidation, further increasing the pass-through. Both mechanisms apply more forcefully for more distressed insurers.

The behavior of the pass-through not only supports the asset insulator theory, but also rejects a number of alternative views. With frictionless financial markets, asset values are equalized inside and outside the firm and the pass-through is 1. In the presence of financial frictions such as costs of default, losing a dollar of assets deteriorates the financial health of the firm, further reducing firm value. Financial frictions can therefore only push the pass-through above 1. The presence of government guarantees can rationalize a pass-through lower than 1, as losing a dollar of assets increases the likelihood of receiving those guarantees, dampening the loss. However, the sensitivity of the value of guarantees to a dollar of assets rises closer to default, implying a lower pass-through during the crisis, at odds with our evidence.

While our empirical results are specific to life insurance companies, the asset insulation view might be useful in understanding the behavior of other related financial institutions. In particular, the balance sheets of commercial banks are also populated by risky illiquid assets and banks' stock prices experienced a similar evolution to that of insurers around the crisis. Indeed, our analysis of the complementarity between insurers' liabilities and asset choice closely relates to the theory of commercial banks proposed by Hanson et al. (2015). Long-term asset managers such as pension funds also match long and predictable liabilities with illiquid assets. More broadly, the asset insulation view suggests a stabilizing role for these institutions, rather than the amplifying role sometimes attributed to them.

The remainder of the paper proceeds as follows. The next section of the paper describes our data. In Section 3, we document aggregate facts about insurers' balance sheet and their evolution during the financial crisis. We provide a model of asset insulators in Section 4 and use it to generate predictions for the pass-through. In Section 5, we estimate the pass-through. Section 6 concludes.

# 2 Data

Our data on asset holdings come from mandatory statutory annual filings by all insurance companies to the National Association of Insurance Commissioners (NAIC). We use the version of these data provided by SNL Financial. Our main sample includes all publicly-traded U.S. life insurers that are substantively life insurers, and covers the period 2004-2014. Table 1 lists the names and ticker symbols of the 15 companies in our sample.[1]

Table 2 reports the total quantity of general account assets under management in the life insurance industry as a fraction of GDP. Life insurers segregate assets into general account assets which back fixed rate liabilities and death benefits, and separate account assets linked to variable rate products. As their name suggests, gains and losses on separate account assets flow directly to the policy holder and hence do not directly affect the equity in the insurance company, and we exclude them hereafter.[2] The first column uses data from the Financial Accounts of the United

[1] In particular, we exclude financial conglomerates or foreign insurers that have a small fraction of their assets in U.S. life insurance companies, and reinsurers. Many insurance companies have multiple subsidiaries. To maximize the comprehensiveness of our data, we include holdings of Property and Causalty (P&C) subsidiaries as well. SNL aggregates the data up to the parent company level and applies inter-company adjustments to present historical balance sheet data on an "As-is" data. We convert to an "As-was" basis by subtracting balance sheet holdings for companies acquired after the filing date. Similarly, for major mergers and acquisitions, we add in holdings of insurance companies that were divested by the parent company after the reporting date but before 2014.

[2] Separate account assets also do not qualify for state guaranty fund support in the event of insurer insolvency, and as a result do not trigger the same asset regulation as general account assets.

Table 1: Insurers Included in Sample

| Insurer | Ticker |
|---|---|
| Aflac Inc. | AFL |
| Allstate Corp. | ALL |
| American Equity Investment | AEL |
| American National Insurance | ANAT |
| Citizens Inc. | CIA |
| CNO Financial Group Inc. | CNO |
| Farm Bureau Financial Services | FFG |
| Independence Holding | IHG |
| Kansas City Life Insurance Co. | KCLI |
| Lincoln Financial Group | LNC |
| MetLife Inc. | MET |
| Phoenix Companies Inc. | PHX |
| Prudential Financial Inc. | PRU |
| Protective Life | PL |
| Torchmark Corp. | TMK |

States (FAUS, formerly known as the Flow of Funds). General account assets exceed 20% of GDP. For comparison, in 2014 assets of commercial banks equaled 77% of GDP, assets of property and casualty insurers 9% of GDP, and assets of closed-end funds 2% of GDP. The second column reports general account assets for the universe of insurers in the SNL database. The FAUS and SNL track each other extremely closely; in fact, SNL provides the source data for the FAUS. The third column reports assets at the 15 life insurers listed in table 1. This subset of insurers manages roughly one quarter of total insurer assets despite containing only 15 of the approximately 400 insurance companies in the SNL data.

NAIC Schedules BA and D require insurers to report a fair value per unit for all securities held on their balance sheet on December 31st of each year, regardless of whether valuation of the assets occurs at fair value or historical cost for accounting and regulatory purposes. These schedules also list the value of dividends received during the year, pre-payments, and purchases and sales. We use this information to construct for each asset a total dollar gain equal to the sum of mark-to-market capital gains and net dividends. Summing over assets then gives the total dollar value of investment gains and losses in a year. Insurers report the effective duration for each security they own. We construct matched-Treasury gains and losses by com-

About two-thirds of separate account assets are invested in corporate equities and back variable rate annuities.

Table 2: Assets Under Management

| | FAUS | SNL | Traded |
|---|---|---|---|
| | | (Percent of GDP) | |
| 2006 | 21.2 | 21.3 | 5.6 |
| 2010 | 21.9 | 22.0 | 5.8 |
| 2014 | 21.6 | 21.8 | 5.2 |

Notes: The table shows total general account assets under management at life insurance companies as reported in the Financial Accounts of the United States table L.116.g (FAUS), for all life insurance companies in the SNL database (SNL), and for the 15 life insurers listed in table 1 (Traded).

puting for each security the buy-and-hold return for a Treasury security of the same effective duration. When the holding changes due to purchases, sales, dividends, or pre-payments, we adjust the matched Treasury holding accordingly. We obtain information on derivatives holdings from Schedule DB. Like bonds, insurers must include a fair value of each derivative position in their filing, but depending on the hedging classification may not include unrealized gains and losses in their accounting totals. We use a string matching algorithm to match open derivatives positions across consecutive filing years and the fair value reported in each year to construct mark-to-market gains and losses on the derivatives portfolio.[3]

We measure changes in the value of insurance company assets at a higher than annual frequency using prices of corporate bonds from the FINRA TRACE data set. TRACE reports the date, time, and transaction price of all over-the-counter trades of corporate bonds in the U.S. We form a daily price series for each bond using the last trade on each date. We merge these data with the insurer holdings data from SNL. In order to have a current market value of each bond position, we require that the bond transact at least once on a date when an insurer reports the fair value price in a regulatory filing.

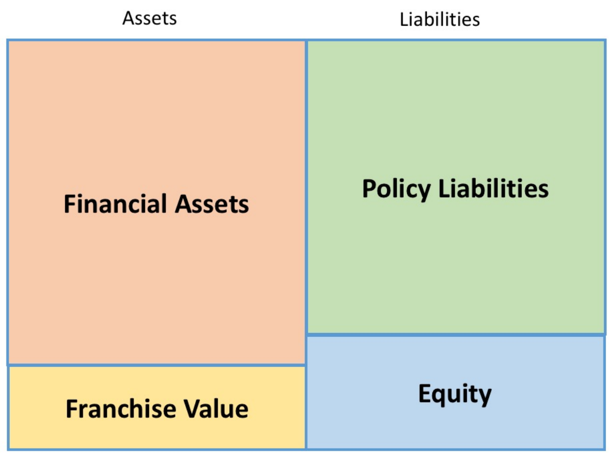
# 3 Assets of Life Insurers

Like all financial institutions, life insurers issue liabilities and invest in assets. Figure 1 illustrates the typical economic balance sheet of a life insurer.[4] The type of lia-

[3]The annual filings also contain detailed data on wholly owned mortgages (Schedule B) and directly held real estate (Schedule A), but value these assets only at historical cost. We exclude these assets in our calculations.

[4]For simplicity, we leave aside public debt issued by life insurers. We come back to it in our empirical analysis.

Figure 1: Economic Balance Sheet of a Life Insurance Company




bilities issued, primarily life insurance contracts and annuities, define what it means to be a life insurer for regulatory purposes. They also provide one possible source of the value creation of life insurers: profitably selling insurance products. However, this approach on its own does not provide guidance on how insurers choose which assets they hold nor on the consequences of these choices for franchise value. In this section, we discuss three standard answers to this question as well as introduce the asset insulation view. We then document key aspects of life insurers' balance sheets in light of these views.

## 3.1 Determinants of Asset Choice and Value Creation

**Irrelevance.** The simplest view of financial institutions is that they are irrelevant. Under the Modigliani-Miller theorem, a life insurer acts as a shell, raising capital — equity, debt, and policy liabilities — at market prices and investing it into securities at market prices as well. The insurer itself creates no value and asset choices are indeterminate. A variant of this view is that insurers are able to generate profits by selling policies at a price higher than their fair market value. One justification of this view is that households do not have direct access to competitive financial markets. Still, as long as insurers have access to frictionless capital markets, asset choices are indeterminate and have no consequences for the franchise value.

**Financial frictions.** A small cost of bankruptcy breaks this indeterminacy. This cost could involve the liquidation of financial assets, loss of expertise in pricing policies, or the destruction of reputation capital. Maximization of value therefore requires preserving the franchise value of the business by minimizing the risk of financial distress. Accordingly, the optimal investment policy involves choosing assets to completely hedge the risks from liabilities. Loosely speaking, insurers issue two types of liabilities against their general account assets: fixed rate (either annuities or life insurance contracts), and variable rate with minimum income guarantees.[5] Assuming diversified mortality risk, the only liability risk for fixed rate contracts comes from changes in interest rates. A portfolio of Treasury securities with duration equal to the duration of liabilities perfectly hedges this interest rate risk. More specifically, because most life insurer liabilities have long duration, this view predicts insurers will hold long-dated Treasuries. Similarly, insurers can hedge the risk of minimum income guarantees on variable rate annuities by buying put options on the underlying equity index. The liability-matching view has support within the life insurance industry itself (see, e.g., Briys and De Varenne, 1997). If insurers do not perfectly hedge the risk of their liabilities or take additional risk through investment in risky assets, poor asset performance can cause a deterioration in the financial health of the life insurer and reduce franchise value.

**Policy guarantees.** Insurance companies operate under state regulation and, like other financial institutions, may derive some private value from government guarantees of their liabilities. These guarantees include explicit backing of policy liabilities by state guaranty funds and possibly an implicit expectation of bailouts following large shocks. The presence of guarantees allows insurers to extract private value by investing in risky assets. In practice, many life insurers issue debt and such public debt is junior to policy liabilities, creating an additional buffer between asset losses and the use of guaranty funds. Moreover, most states have coverage caps of between \$100,000 and \$250,000, with policy claims in excess of these caps receiving a payout ratio equal to the value of total recovered assets divided by total policy claims. In actual insolvencies, we estimate a (dollar-weighted) average state guaranty share of roughly 80% of total policy claims, and a recovery rate on non-guaranteed claims of roughly \$0.75 on the dollar.[6]

[5] See Paulson, Rosen, McMenamin, and Mohey-Deen (2012) and McMillan (2013) for an overview of the different products life insurers offer consumers.

[6] These calculations correspond to multistate insolvencies over 1991-2009, and are based on the chart in National Organization of Life and Health Insurance Guaranty Associations (2011, p.11).

**Asset insulation.** The asset insulation view emphasizes directly the creation of value on the asset side of the balance sheet. In this view, insurers are a particular type of investment fund that issues equity claims and long-term liabilities. An insulator creates value by isolating assets from market fluctuations due for instance to illiquidity or fire sales. The empirical importance of this view is the main conclusion of this paper. We formalize this approach at length in Section 4.

## 3.2 Life Insurers Choose to Hold Risky Assets

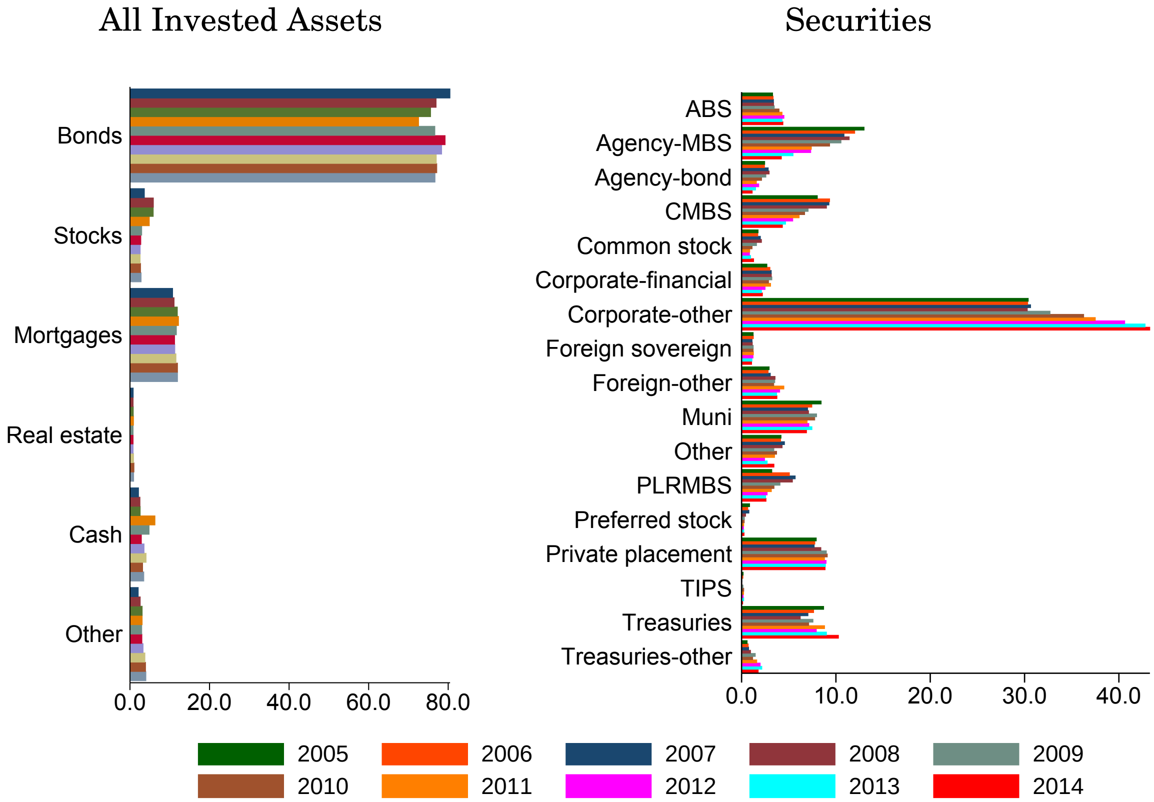
What assets do insurers invest in? Figure 2 summarizes the holdings of our sample of life insurance companies across years and asset classes. The left panel shows all invested assets by broad asset category. There is little variation across years. Bonds, including passthroughs, constitute 70-75% of insurers assets, equities approximately 5%, and wholly owned mortgages (overwhelmingly on commercial property) roughly 15%. The remaining 5-10% of insurers' assets are divided between directly owned commercial real estate, other private equity investments, and cash.

The right panel of figure 2 reports the breakdown within the securities category. Bonds of non-financial corporations constitute the largest single category at more than 30% of securities, and bonds of financial corporations comprise another 5%. There is an upward trend in the share of non-financial corporate bonds, rising from 30% in 2005 to more than 40% in 2014. The increasing share of non-financial corporate bonds comes largely from decreases in the shares of Agency (Government-Sponsored Entities (GSEs)) MBS, Commercial MBS (CMBS), and private-label residential MBS (PLRMBS). The share in agency MBS falls from approximately 15% of security holdings to less than 5% of security holdings in 2014. Similarly, the share of CMBS falls from about 10% to 5% and the share of PLRMBS falls from over 8% to less than 5%. Municipal bonds, including US state and public utility bonds, constitute 7-8% of securities. U.S. Treasuries constitute only about 10% of insurers' assets and Agency (GSE) bonds constitute another approximately 3% of holdings.

The low holdings of Treasuries poses a challenge to the view that liability matching is the main driver of asset choices of life insurers. We provide three additional types of evidence to confirm that insurers actively choose to hold risky assets.

First, the small concentration of insurers' assets in U.S. Treasuries does not reflect constrained supply. To rule out this possibility, we match the insurer-cusip holdings of all Treasury securities in the SNL data (including of non-publicly traded insurers) with the total amount outstanding of each cusip reported in the Treasury Monthly

Figure 2: Insurers' Asset Allocation by Year and Category

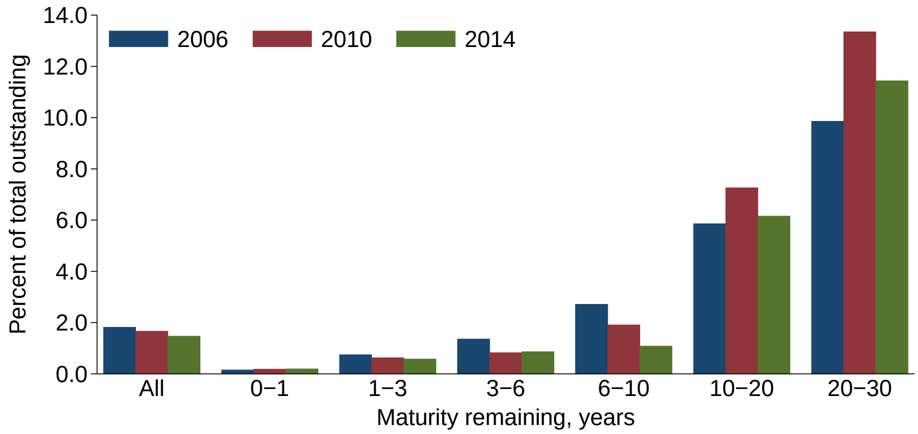



Notes: Agency-MBS refers to Mortgage-Backed Securities issued by the Government-Sponsored Entities (GSEs). Agency-bond refers to GSE bonds. CMBS refers to Commercial MBS. Muni refers to U.S. municipal, U.S. state, and U.S. public utility bonds. PLRMBS refers to private-label residential MBS. ABS represents Asset-Backed Securities not included in Agency-MBS, PLRMBS, or CMBS. Treasury-other comprises U.S. Treasury securities that do not have readily available pricing information (primarily STRIPs).

Statement of the Public Debt and the fraction held by the Federal Reserve reported in the weekly statement of the System Open Market Account Holdings.[7] Figure 3 shows the resulting share of Treasuries outstanding (excluding Federal Reserve holdings) held by life insurers, by maturity and calendar year. The life insurance sector holds less than 2% of all Treasuries outstanding. The fraction of Treasuries held by insurers increases with maturity, but even at the long end of 20 to 30 years remaining to maturity the share held by insurers does not exceed 14%. Notably, this share is less than the insurance sector share of the corporate bond market.

[7]The data on total Treasuries outstanding and SOMA holdings come from `https://www.treasurydirect.gov/govt/reports/pd/mspd/mspd.htm` and `http://nyapps.newyorkfed.org/markets/soma/sysopen_accholdings.html`, respectively.

Figure 3: Insurers' Share of U.S. Treasury Securities




Notes: Each bar shows the percent of outstanding Treasuries with the maturity remaining indicated held by the life insurance sector. The definition of Treasuries outstanding used here excludes holdings of the Federal Reserve system.

Second, the non-Treasury securities on insurers' balance sheets do not appear Treasury-like in their risk characteristics. Table 3 reports the value-weighted NAIC rating by asset class for the end of 2006. For example, the majority of insurers' corporate bond holdings are rated BBB or below. Similarly, even prior to the European sovereign crisis, insurers' holdings concentrated in riskier sovereign bonds.

Finally, insurers appear to choose risk even at the expense of duration-matching their liabilities. Table 4 provides one metric of this phenomenon by comparing the standard deviations of insurers' security portfolios with the standard deviations of insurers' security portfolios after subtracting off the duration-matched Treasury return for each asset. The last column shows the share of the cross-sectional variation in insurers' aggregate security returns that can be explained by differences in the durations of their portfolio. Across all years, the standard deviation is actually larger after we subtract off the duration matched Treasury. This result also emerges in strict cross-sections of the data for each year in 2004 through 2006 and 2008. In 2009 through 2014, the cross-sectional variation falls after we control for differences in duration across insurers, but the share of the cross-sectional variation we can explain with duration matching never exceeds 50%.

The small concentration of assets in riskless or low risk securities poses a challenge to the financial frictions/liability matching view of insurers, but is consistent with both the policy guarantee and asset insulator views.

Table 3: NAIC Risk Weights by Asset Category

| | Value-weighted share with NAIC designation: | | | | | | Value-weighted |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | mean |
| Agency-MBS | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| Agency-bond | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| Treasuries | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| Treasuries-other | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| TIPS | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| PLRMBS | 96.7 | 3.1 | 0.1 | 0.1 | 0.0 | 0.0 | 1.0 |
| Other | 92.7 | 6.2 | 0.5 | 0.2 | 0.0 | 0.3 | 1.1 |
| Corporate-financial | 91.4 | 7.2 | 1.4 | 0.0 | 0.0 | 0.0 | 1.1 |
| CMBS | 90.8 | 7.9 | 0.7 | 0.2 | 0.2 | 0.1 | 1.1 |
| Muni | 84.4 | 12.0 | 1.8 | 1.1 | 0.5 | 0.1 | 1.2 |
| ABS | 79.8 | 16.4 | 1.4 | 1.8 | 0.1 | 0.4 | 1.3 |
| Corporate-other | 42.9 | 44.9 | 7.6 | 4.1 | 0.3 | 0.1 | 1.7 |
| Foreign sovereign | 51.6 | 18.1 | 27.2 | 3.1 | 0.0 | 0.0 | 1.8 |
| Foreign-other | 28.2 | 61.0 | 8.6 | 1.4 | 0.7 | 0.2 | 1.9 |
| Private placement | 31.5 | 54.3 | 8.4 | 4.1 | 1.3 | 0.3 | 1.9 |

Notes: The table reports the dollar weighted percent of assets in each NAIC designation at the end of 2006 for the 15 insurers in our sample. The NAIC designations translate to bond ratings as: 1 = AAA/Aaa, AA/Aa, A/a ; 2 = BBB/Ba; 3 = BB/Ba; 4 = B/B; 5 = CCC/Caa; 6 = in or near default.

## 3.3 Insurers Hold Illiquid Assets, Have Low Turnover, and Issue Stable Liabilities

The portfolio strategies followed by insurers exhibit some important regularities.

Insurers invest in highly illiquid assets. This fact follows immediately from visual inspection of figure 2, which shows the largest concentrations of holdings in corporate bonds and in directly held mortgages. More formally, Hanson et al. (2015) assign liquidity weights to different asset classes and compare liquidity across several types of financial intermediaries. They conclude that commercial banks and life insurers have the most illiquid holdings. We extend their findings in Appendix A using our more granular data on insurer holdings and confirm their basic result.

The regulatory environment faced by insurers poses a possible caveat to the conclusion that insurers desire illiquid assets. Since the 1990s, life insurance companies have operated under a risk-based capital regime, with different types of assets assigned different risk weights. For example, the capital charge for holding common

Table 4: Asset Risk and Duration Risk

| | N | $\sigma_R$ | $\sigma_{XR}$ | $\frac{\sigma_R - \sigma_{XR}}{\sigma_R}$ |
|---|---|---|---|---|
| All Years | 165 | 5.6 | 9.5 | -0.69 |
| Ex Outlier CUSIPs | 165 | 5.5 | 9.2 | -0.69 |
| 2004 | 15 | 1.7 | 1.9 | -0.10 |
| 2005 | 15 | 1.0 | 1.1 | -0.10 |
| 2006 | 15 | 0.6 | 0.9 | -0.33 |
| 2007 | 15 | 1.3 | 1.2 | 0.08 |
| 2008 | 15 | 3.4 | 4.0 | -0.15 |
| 2009 | 15 | 4.3 | 4.0 | 0.07 |
| 2010 | 15 | 2.5 | 1.5 | 0.38 |
| 2011 | 15 | 3.0 | 2.6 | 0.15 |
| 2012 | 15 | 2.0 | 1.7 | 0.16 |
| 2013 | 15 | 1.7 | 1.0 | 0.40 |
| 2014 | 15 | 3.0 | 1.6 | 0.46 |

Notes: $\sigma_R$ is the standard deviation of the return on the insurer's overall security portfolio (in %) aggregated from individual CUSIPs. $\sigma_{XR}$ is the standard deviation of the return on the insurer's Treasury-hedged security portfolio where the return on a duration matched US Treasury security for each security is substracted from the raw security return. Returns include income received during the year. "Ex Outlier CUSIPs" excludes cusips in the top and bottom 2% of each insurer-security class level before aggregating to the insurer level. The last column is the share of the standard deviation in security returns explained by differences in duration across insurers.

equity exceeds by a factor of 60 the charge for holding a highly rated fixed income security. Becker and Opp (2014) and Hanley and Nikolova (2014) discuss how these charges affect insurer portfolio decisions. Nonetheless, previous research has also found evidence of insurers selecting higher yield assets within risk weight categories (Becker and Ivashina, 2015), consistent with insurers' pursuing certain assets within the constraints of their regulatory environment.

Complementary to buying illiquid assets, insurers hold these assets for a long time. The left panel of table 5 reports the remaining years to maturity for the value-weighted security held by an insurer in our traded sample. The mean duration is about 14 years, and the 10th percentile exceeds 2 years. The right panel reports the time elapsed since purchase. The mean holding period is about 4 years, and the 90th percentile between 7 and 10 years.

These long holding periods echo the long and predictable duration of insurers' liabilities. The long duration follows from the long horizon of life insurance contracts and annuities. Offsetting this, policy holders can request early termination of a policy in the form of a policy surrender and withdrawal. Surrender claims typically trigger

Table 5: Insurers are Long-hold Investors

| | Years to maturity | | | Years since purchase | | |
|---|---|---|---|---|---|---|
| | 2006 | 2010 | 2014 | 2006 | 2010 | 2014 |
| Statistic: | | | | | | |
| Mean | 14.9 | 13.7 | 14.6 | 3.2 | 4.1 | 4.6 |
| SD | 10.4 | 10.0 | 9.8 | 3.0 | 3.5 | 3.9 |
| P(10) | 2.7 | 2.3 | 2.8 | 0.5 | 0.4 | 0.6 |
| P(50) | 11.6 | 9.9 | 13.1 | 2.4 | 3.4 | 3.8 |
| P(90) | 29.1 | 28.1 | 28.1 | 7.1 | 8.4 | 10.1 |
| Observations | 65,754 | 60,922 | 55,148 | 65,754 | 60,922 | 55,148 |

Notes: The sample includes Schedule D and BA holdings for the 15 publicly traded life insurers in our sample. Variables trimmed at 1st and 99th percentiles.

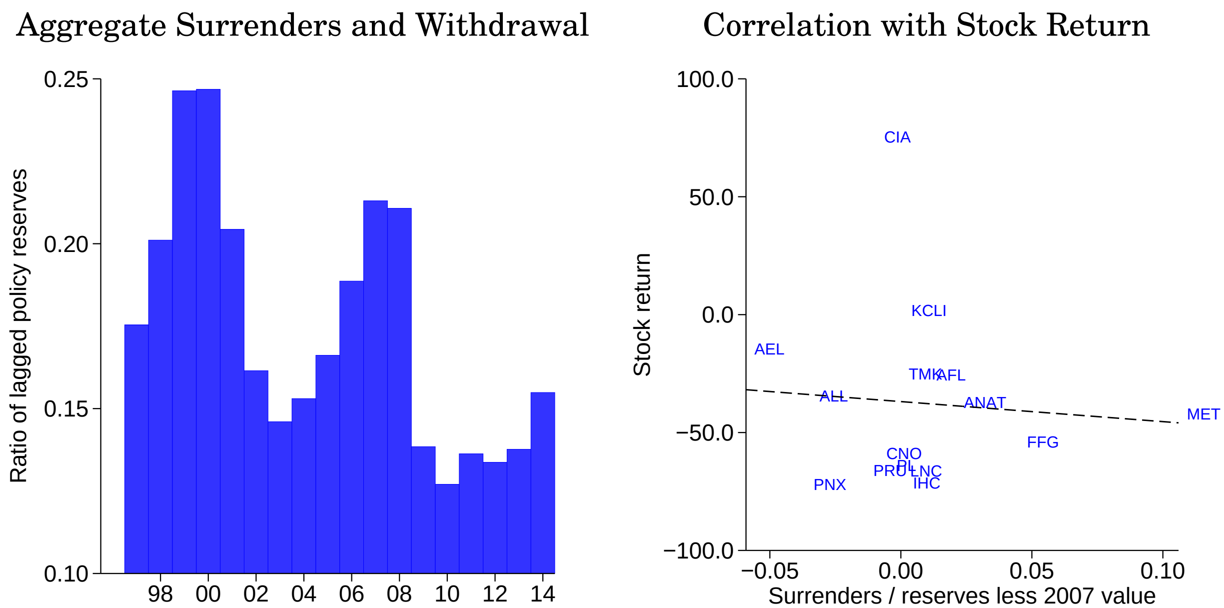
a penalty if exercised in the first few years of a contract, but the penalty decays over the life of a contract and may eventually disappear. Aggregate surrenders increase when interest rates rise, as policy holders "refinance" at the more favorable rates or move their savings into higher yield vehicles, and during business cycle downturns, since surrenders constitute a form of dis-saving and may help to smooth consumption during unemployment spells (Russell, Fier, Carson, and Dumm, 2013). In addition, individual insurers may experience run-like dynamics if policy holders become concerned about solvency (DeAngelo, DeAngelo, and Gilson, 1994, 1996).

We assess the importance of surrenders in the aggregate and at the insurer level. The left panel of figure 4 shows the evolution of policy surrenders and withdrawals for our 15 insurers over time. While policy surrenders rise in 2007 and 2008, the increase appears part of a longer term trend, and surrenders in 2008 are not high by historic standards. For example, policy surrenders are higher in 1999 and 2000 and at about the same level in 1998 and 2001. Surrenders then fall substantially in 2009. While the increase in unemployment may have pushed up surrenders for dis-saving purposes, the fall in interest rates likely reduced surrenders.[8]

The right panel of figure 4 shows a weak relation in the cross-section in 2008

[8]In addition to surrenders, policies may lapse because of nonpayment of premiums. Whenever possible, a policyholder is strictly better off taking the surrender value or selling the policy on the secondary market than allowing the policy to lapse because of nonpayment. Nonetheless, some policies do lapse, providing a windfall to the issuer (Gottlieb and Smetters, 2014). Ho and Muise (2011) report a small increase in combined lapses and surrenders in the 2007-09 period relative to previous years, almost entirely driven by lapses on newly issued policies.

Figure 4: Surrenders and Withdrawal

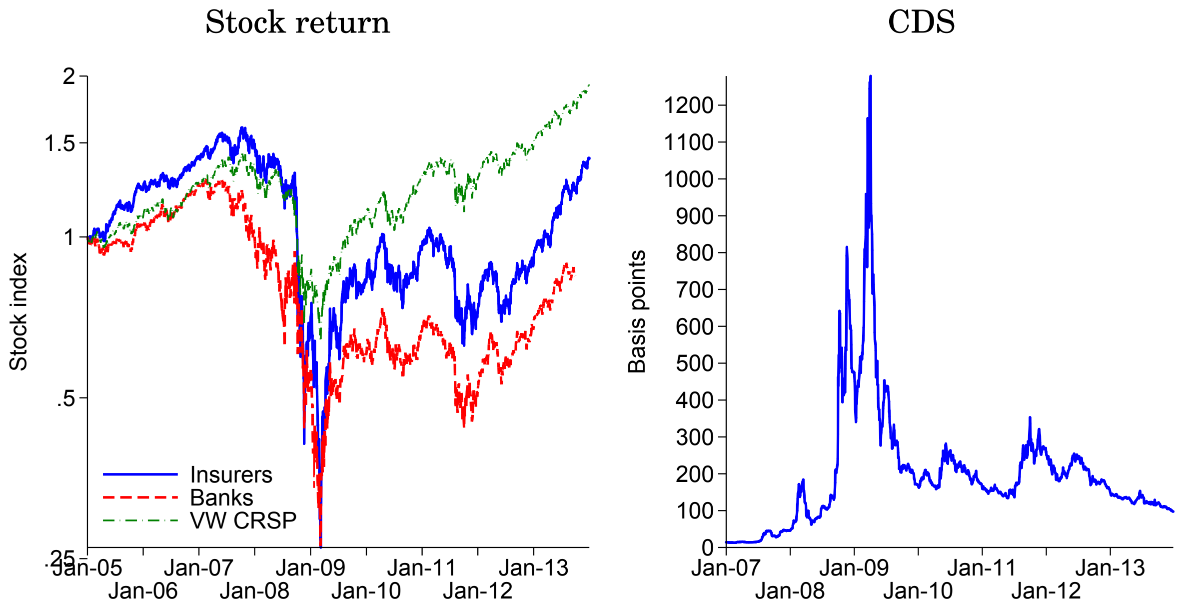



Notes: The left panel plots the ratio of surrenders and policy withdrawals to lagged policy reserves for the 15 insurers in our sample. The right panel shows a scatter plot of the change in surrenders in 2008 and the stock return.

between policy surrenders and stock returns. In particular, the insurers with the worst performance did not experience increases in surrenders. Insurers do not suffer large liability runs even during the market panic and insurance sector solvency crisis of 2008-09. Two features of the resolution process may explain the absence of runs. First, state laws allow regulators to intervene well before the event of default. Such interventions trigger automatically upon risk-based capital crossing certain thresholds and range from requiring an action plan to rebuild capital to taking operational control of the insurer through receivership. As such, policy holders may experience minimal operational disruption in the event of an insolvency. Second, as documented above, in the typical insurer insolvency policy holders absorb zero losses on the roughly 80% of claims under the guaranty cap. Thus, as with bank deposit insurance, the guaranty funds remove the incentive to run for most policy holders.

The asset insulator view of insurers can rationalize long-term holdings of illiquid assets as the counterpart of issuing long-term, predictable liabilities. The duration and predictability of liabilities allow insurers to hold illiquid assets without fearing sudden liquidation pressure. The duration of holdings insulates insurers from transitory fluctuations in bond prices, a point we return to at length below.

Figure 5: Insurer Distress During Crisis




Notes: The left panel plots the value-weighted total return index for publicly traded insurers, banks, and the entire CRSP value-weighted index. The right panel plots the equity value-weighted annual premium to insure $10,000 of debt for a period of 5 years for AFL, ALL, LNC, MET, PRU, and TMK.

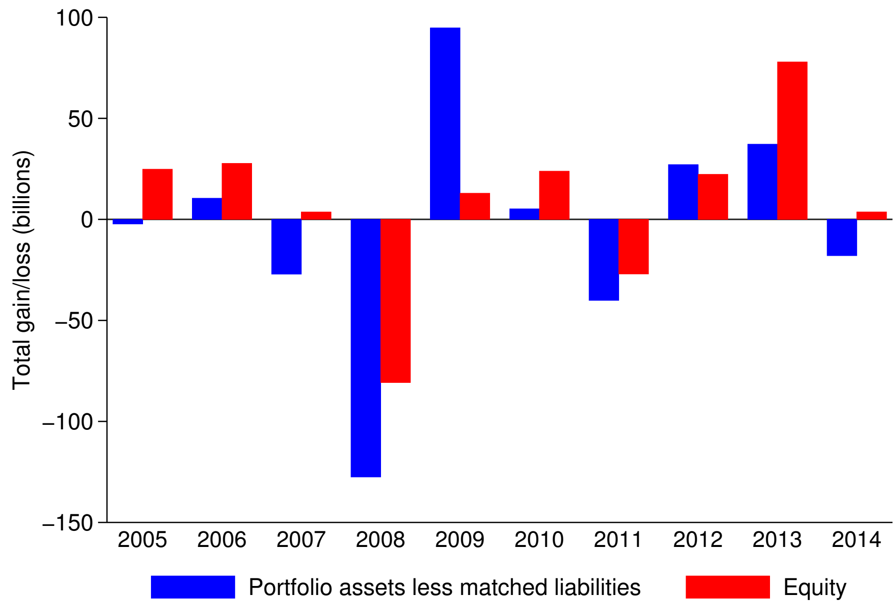
## 3.4 Franchise Value Rises During the Financial Crisis

We now turn to the relation between asset values and franchise value.

Figure 5 illustrates the financial distress of the life insurance sector during the financial crisis. The left panel shows the stock return index for publicly traded life insurers plotted against commercial banks and the value-weighted CRSP index for comparison. The insurance sector has the largest peak-to-trough decline of the three sectors. The right panel shows the equity value-weighted average CDS spread for the six insurers with liquid CDS throughout the period. From a low of essentially zero before the crisis, the spread rises beginning in 2008 and peaks above 1200 basis points in March 2009 before declining to a "new normal" range in the latter part of that year.

Remarkably, the aggregate dollar change in insurers' assets net of liabilities during the crisis exceeds the substantial drop in equity. Figure 6 shows this result. The figure requires two caveats. First, we do not have mark-to-market data on the value of liabilities; instead, we assume liabilities have the same duration as assets and use the Treasury yield curve to construct the gain/loss. Since insurers tend to hold assets of shorter duration than their liabilities, this assumption leads us to for example un-

Figure 6: Aggregate Changes in Assets, Liabilities, and Market Equity




Notes: The blue bars show the fair value capital gain/loss on assets reported in NAIC schedule BA and D minus the gain/loss on a portfolio of Treasuries constructed by matching each cusip to a U.S. Treasury of the same duration. The red bars show the total change in market equity.

derestimate the increase in the value of liabilities due to the sharp drop in interest rates in 2008. Second, our calculation does not include balance sheet losses resulting from guaranteed income annuities, direct holdings of mortgages or real estate, or assets held outside of the insurance subsidiary. Omitting these factors results in a conservative estimate of the loss in portfolio assets net of liabilities in 2008.

Even with these conservative assumptions, we estimate the decline in the interest rate in 2008 to have increased the value of policy liabilities by at least $96 billion, while the assets held by insurers lost at least $30 billion. If the franchise value stayed constant, we would have observed more than a $126bn loss in the value of the equity in 2008. In fact, insurers' equity dropped by "only" $80 billion: franchise value increased. This result runs counter to the financial friction view that a deteriorating financial situation destroys firm value. In contrast, if the business of life insurers is to insulate assets from market dislocations, then the movement into a financial crisis would have represented a prime opportunity. At the aggregate level, there is not one-for-one pass-through from a change in insurers' net assets to their equity.

# 4 A Model of Asset Insulation

We now develop more formally the theory of insurers as asset insulators. The theory emphasizes the asset side of life insurers' balance sheets as an important source of value creation for them, rather than an afterthought in liability management. Indeed, to make the point as stark as possible we treat liabilities as a simple consol. We present a simple model inspired by Cherkes et al. (2009) to explain how insurers create value by insulating assets from market fluctuations. The theory provides us with additional predictions on how firm value responds to asset values. We test these predictions in Section 5.

## 4.1 Setup and Solution

**Assets inside and outside of the insurer.** The starting point of the the asset insulator approach is that the value of an asset can differ when held inside the firm rather than when traded freely in the market. We assume a portfolio of assets with a continuous payout rate of $c$. The value of the assets while held inside the firm is $A_t^{\text{in}}$. This value follows a risk-neutral law of motion:

$$\frac{dA_t^{\text{in}}}{A_t^{\text{in}}} = (r - c)dt + \sigma_A dZ_t^A. \tag{1}$$

Asset value including payouts grows at the risk-free rate $r$ and has volatility $\sigma_A$. The process $\{Z_t^A\}$ is a standard brownian motion.

The value of the assets when traded on the open market differs from the value inside the firm by a factor $\omega_t$, $A_t^{\text{out}} = \omega_t A_t^{\text{in}}$. The quantity $\omega_t$ follows a mean-reverting process:

$$d\omega_t = -\kappa_\omega(\omega_t - \bar{\omega})dt + \sigma_\omega \sqrt{\omega_t} dZ_t^\omega. \tag{2}$$

The parameters $0 < \bar{\omega} < 1$ and $\sigma_\omega$ control the mean and volatility of $\omega_t$, $\kappa_\omega$ is the speed of reversion to the mean.[9] For clarity of exposition, we assume the standard brownian motion $\{Z_t^\omega\}$ is orthogonal to $\{Z_t^A\}$.

The process $\omega_t$ characterizes the wedge between asset values inside and outside the insurer. Under the asset insulator view, assets typically have more value inside than outside the firm, $\omega_t < 1$. A lower value of $\omega_t$ corresponds to a more important gain

[9] We assume that $2\kappa_\omega\bar{\omega} > \sigma_\omega^2$ to ensure that $\omega$ is always strictly positive.

from holding the assets inside the firm. While novel in the insurance setting, the literature on banking and closed-end funds suggests three sources for such a comparative advantage.[10] First, Cherkes et al. (2009) argue that holding illiquid assets inside a closed-end fund insulates investors from costly transaction costs.[11] A closely related view from Hanson et al. (2015) proposes that institutions with long-lived sources of financing can avoid non-fundamental variation in prices, for instance related to fire sales. Second, Lee et al. (1991) argue that closed-end funds can select particular investors whose views of asset values differ from that prevalent on markets. The risk associated with these changing views prevents the wedge in valuation from being arbitraged away, along the lines of De Long, Shleifer, Summers, and Waldmann (1990). Third, Berk and Stanton (2007) posit that managers of closed-end funds might have a skill of choosing particular assets misvalued on markets. Hereafter, we focus on the first source of comparative advantage as it is particularly relevant for our empirical setting. Indeed, life insurers hold illiquid assets and many observers have argued that market prices during the crisis were affected by illiquidity concerns.

A necessary — but not sufficient — observable implication of the presence of the wedge $\omega_t$ is fluctuations in the prices of assets traded in the open market unrelated to changes in their expected payoffs. Changes in prices without any concommitant change in expected future cash flows in turn imply that asset returns must be predictable. There is substantial evidence of predictability for the main asset classes traded by life insurance companies. Gilchrist and Zakrajšek (2012) construct a component of aggregate corporate bond prices that does not predict future defaults. More broadly, Nozawa (2014) documents important variation in expected returns in the cross-section and time series of bonds. Mortgage-backed securities also exhibit substantial predictability. Breeden (1994), Gabaix, Krishnamurthy, and Vigneron (2007) and Boyarchenko, Fuster, and Lucca (2015) document a predictive relation between spreads and returns of MBS.[12]

**Insurer financing structure.** The assets of life insurers finance payments to three sets of agents: policyholders, asset managers, and equity shareholders. With diver-

[10]In addition to the work we discuss below, see Malkiel (1977); Weiss (1989); Barclay, Holderness, and Pontiff (1993); Pontiff (1996); Chay and Trzcinka (1999) and Bradley, Brav, Goldstein, and Jiang (2010).

[11]Following Cherkes et al. (2009), if transaction costs result in losses at a rate of $\rho$ at each instant, we obtain immediately $\omega_t = c/(c+\rho) < 1$. Larger transaction costs result in a lower $\omega$ and therefore more comparative advantage for the intermediary.

[12]More precisely, they focus on an option-adjusted spread (OAS) which adjusts for the possibility of prepayment and refinancing when rates drop.

sified mortality risk and abstracting from income guarantees, we can assume fixed and riskless policy liabilities which take the form of a perpetual console bond, with payments $\ell$ due continuously. Asset managers receive payments proportional to the amount of assets they manage, a flow $kA_t^{\text{in}}$ each period. These payments have a broader interpretation than the direct compensation of asset managers and represent any proportional costs linked with the management of the assets. Finally shareholders are the residual claimants.

Importantly, insurers are tightly regulated to ensure that policyholders do not suffer losses on their claims. In particular, if an insurer becomes financially distressed, it may have to liquidate its assets to reach a more sound financial situation. We model such forced liquidation by a threshold $A_0$ for the inside value of the assets at which liquidation occurs. In this situation, the proceeds $\omega_t A_0$ first pay policyholders in full, with equity claimants receiving the remaining value. We assume a liquidation threshold $A_0$ high enough that policyholders can be paid in full in almost all states of the world.[13]

This view of the liquidation process is of course stylized. In practice, insurers face a combination of capital requirements and accounting rules, as well as more direct regulatory pressure. Liquidation of the portfolio is likely to happen progressively rather than as a discrete event. For example, Ellul, Jotikasthira, and Lundblad (2011) provide evidence of capital-constrained insurers selling downgraded corporate bonds, Ellul, Jotikasthira, Lundblad, and Wang (2015) show how the interaction of accounting rules and asset downgrades led to early selling of assets, and Merrill, Nadauld, Stulz, and Sherlund (2014) document liquidations of mortgage-backed securities by capital-constrained insurers in distressed markets. The single threshold $A_0$ captures in a parsimonious way the increased prospect of liquidation into the open market when an insurer faces financial distress, as found in these studies.

**The value of equity.** The value of the equity is

$$E_t = \mathbb{E}_t \left[ \int_t^T e^{-r(\tau - t)} (c-k) A_\tau^{\text{in}} d\tau \quad + e^{-r(T-t)} \omega_T A_0 - \int_t^\infty e^{-r(\tau-t)} \ell d\tau \right], \tag{3}$$

where $T$ denotes the first time the asset value reaches $A_0$. The first integral gives the asset payouts net of management fees before liquidation. The second term is the

[13]Because $\omega_t$ is not bounded below, no threshold can ensure full payment to policyholders. However, we assume that $A_0$ is high enough that most of the distribution of $\omega_t$ lies above it, and neglect the potential losses for policyholders in our calculations.

liquidation value of the assets. The last term is the cost of policy liabilities.

In appendix B.1 we derive a closed-form expression for the value of equity as a function of the state variables $A_t^{\text{in}}$ and $\omega_t$:

$$E_t = A_t^{\text{in}} \frac{c-k}{c} - \frac{\ell}{r} + A_0 \left( \frac{A_t^{\text{in}}}{A_0} \right)^{-f(r)} \left( \bar{\omega} - \frac{c-k}{c} \right) + A_0 \left( \frac{A_t^{\text{in}}}{A_0} \right)^{-f(r+\kappa_\omega)} (\omega_t - \bar{\omega}), \tag{4}$$

with $f(\alpha) = \frac{r-c-\frac{1}{2}\sigma_A^2+\sqrt{\left(r-c-\frac{1}{2}\sigma_A^2\right)^2+2\sigma_A^2\alpha}}{\sigma_A^2}$. To understand this expression, it helps to first consider the two polar cases of $A_t^{\text{in}} \gg A_0$ (no default) and $A_t \to A_0$ (default boundary):

$$E_t \left( A_t^{\text{in}} \gg A_0, \omega_t \right) \approx A_t^{\text{in}} \frac{c-k}{c} - \frac{\ell}{r}, \tag{5}$$

$$E_t \left( A_t^{\text{in}} \to A_0, \omega_t \right) = \omega_t A_0 - \frac{\ell}{r}. \tag{6}$$

The first term of equation (5) gives the net-of-management-fees present value of assets inside the firm without default, and the second term subtracts the present value of policy liabilities. Notably, far from default the value of equity does not depend on the wedge $\omega_t$, as the insurer uses its advantage as a long-hold investor to fully insulate equity holders from market fluctuations in the value of $A_t$ which do not reflect future payouts. Conversely, at the default boundary the value of equity simply equals the liquidation value of the assets on the open market, $A_0^{\text{out}} = \omega_t A_0$, less the value of liabilities. In the intermediate case, the third and fourth terms of equation (4) describe the change in value in liquidation weighted by the time to liquidation. The first term comes from the average difference in value of assets outside and inside the firm. The second term reflects transitory deviations in the liquidation value of the assets.

## 4.2 Value Creation in the Asset Insulator View

The asset insulator view states that the asset side of an insurer's balance sheet is an important source of value creation. A useful benchmark is the firm value under Modgliani-Miller, $E_t^{\text{MM}}$, defined as the market value of the assets minus that of liabilities:

$$E_t^{\text{MM}} = \omega_t A_t^{\text{in}} - \frac{\ell}{r}. \tag{7}$$

The deviation of the value of the equity to this benchmark, $E_t - E_t^{\text{MM}}$, is the franchise value of the insurer. Our theory incorporates three determinants of franchise value. Most importantly, when $\omega_t < 1$, the value of assets inside the firm exceeds the value outside the insurer: $A_t^{\text{in}} > A_t^{\text{out}}$. This ability of the intermediary to protect asset valuation from the wedge $\omega_t$ provides the main source of value creation. The other two forces mitigate this ability to create value. First, in bad states of the world, insurers must liquidate their assets, only collecting the market value. This effects prevents the structure from obtaining the full difference $(1-\omega_t)A_t^{\text{in}}$. Second, not all the benefits from keeping assets inside the fund accrue to shareholders. The proportional cost $k$ captures the value paid to other stakeholders of the firm — asset managers and other employees — and the proportional operational costs of running the balance sheet. Depending on whether or not the present value of those costs exceeds the difference between asset valuations inside and outside the firm, the insurer will trade at a premium or discount relative to net asset value. In the special case of no default, the insurer trades at a premium if and only if $\omega_t < (c-k)/c$.[14]

**Balance sheet composition.** Our model does not feature an explicit asset choice but nonetheless provides guidance for the types of assets insurers should buy. Insurers should target assets where a wedge between holding assets inside the fund rather than on the market is large. As pointed out by Cherkes et al. (2009), a natural source of this wedge is the illiquidity present when assets trade on markets. Under this interpretation, fixed-income instruments like corporate bonds or mortgage-backed securities are a natural target. While having moderate risk, these assets trade in illiquid fashion.[15] Of course, unlike in the model, fixed income assets are not infinitely lived. Insurers must trade dynamically to renew their balance sheet. For the insulation from illiquid markets to be valuable, the portfolio must exhibit relatively low turnover for individual securities. Thus, the asset insulator view can rationalize why life insurers hold illiquid risky securities rather than engage in liability matching, and hold those assets for a long time, exactly as documented in Section 3.3.

**Response to illiquidity shocks.** The consequence of an increase in illiquidity in the markets provides another lens through which to view value creation in the asset

[14]Ross (2002) first put forward such an approach of why management costs can drive closed-end funds to trade at a discount. Management costs also play an important role in allowing funds to trade at a discount in Berk and Stanton (2007) and Cherkes et al. (2009).

[15]Additional costs of financial distress and liquidation might mitigate the optimal amount of risk held on the balance sheet. Such costs may include both fire sale prices on selling of assets and the sale of liabilities at discount to build regulatory capital (Koijen and Yogo, 2015). We extend the model in a straightforward way to accommodate additional liquidation costs in appendix B.3, and discuss the empirical relevance of this extension below.

insulator view. We can represent such a change by a drop in $\omega_t$. This variation lowers directly the value of the assets in the market: $\partial E_t^{\mathrm{MM}}/\partial\omega_t = A_t^{\mathrm{in}}$. In contrast, inside the intermediary, this change only has an impact through changing the liquidation value of the assets, $\partial E_t/\partial\omega_t = A_0\left(\frac{A_t^{\mathrm{in}}}{A_0}\right)^{-f(r+\kappa_\omega)}$. The term $A_0$ is the inside value at liquidation, lower than the current inside value. The second term is a form of cumulative liquidation probability, lower than $1$. Hence the drop in firm value in response to an increase in illiquidity is lower than that implied by the Modigliani-Miller benchmark, $\partial E_t^{\mathrm{MM}}/\partial\omega_t > \partial E_t/\partial\omega_t$. In other words, value creation through the asset insulator function of the life insurer increases following a decrease in $\omega_t$.

The 2008 financial crisis provides an example where the market valuation of assets decreased tremendously. As shown in Section 3.4, during this period the market value of insurer equity dropped much less than implied by the change in the market value of assets minus liabilities. Symmetrically, in 2009, asset values recovered more than the equity value. The asset insulator view proposes a natural explanation for this phenomenon, attributing some of the drop in asset value to a decrease in the wedge $\omega_t$.

During this episode, life insurers also became financially distressed. In the context of our model, this corresponds to a decrease in $A_t^{\mathrm{in}}$. As they approach default, insurers lose the ability to insulate assets from the market. Indeed, a large enough decrease in $A_t^{\mathrm{in}}$ could reverse the increase in value creation coming from the lower $\omega_t$; in the extreme case of $A_t \to A_0$, value creation from insulation ceases. Which of the two effects dominate is an empirical question, and the evidence suggests value creation increased in the crisis. The ability of the asset insulator view to justify the increase in value creation stands in opposition to explanations of the behavior of life insurers focusing entirely on costs of financial distress. Such approaches can only predict a decrease in value of the firm relative to the market value of the assets.

Overall the asset insulator view of value creation provides a consistent account of the behavior of the asset side of life insurer's balance sheets. To generate further predictions of this view, we now study more systematically how the firm valuation $E_t$ responds to changes in the market valuation of the assets $A_t^{\mathrm{out}}$ across various economic environments.

## 4.3 Pass-through

When the market value of assets drops by a dollar, how much does firm value decline? We define the asset pass-through $PT$ as the typical answer to this question. This corresponds to the coefficient of a regression of changes in firm value on changes in the value of the assets:

$$PT = \frac{\textbf{cov}\left(dE_t, dA_t^{\text{out}}\right)}{\textbf{var}\left(dA_t^{\text{out}}\right)}. \tag{8}$$

The Modigliani-Miller valuation provides a simple benchmark for the pass-through: $PT^{\text{MM}} = 1$. Any deviation from $1$ must come from changes in franchise value in response to changes in asset values.

Now consider our asset insulator model. Variations in the outside value of the assets, $dA_t^{\text{out}}$, come from changes in the inside value, $dA_t^{\text{in}}$, and changes in the wedge, $d\omega_t$. Let $V_A$ and $V_\omega$ denote the fraction of the variance var$(dA_t^{\text{out}})$ coming from each shock, so that $V_A + V_\omega = 1$. Using Ito's lemma on the expression for $E_t$, we derive the pass-through (see Appendix B.2):

$$\begin{aligned} PT = V_A &\left[\frac{\frac{c-k}{c}}{\omega_t} - \frac{f(r+\kappa_\omega)}{\omega_t A_t^{\text{in}}}\left(\frac{A_t^{\text{in}}}{A_0}\right)^{-f(r+\kappa_\omega)} A_0\left(\omega_t - \bar{\omega}\right) - \frac{f(r)}{\omega_t A_t^{\text{in}}}\left(\frac{A_t^{\text{in}}}{A_0}\right)^{-f(r)} A_0\left(\bar{\omega} - \frac{c-k}{c}\right)\right] \\ &+ V_\omega\left[\left(\frac{A_t^{\text{in}}}{A_0}\right)^{-f(r+\kappa_\omega)-1}\right]. \end{aligned} \tag{9}$$

The two bracketed terms characterize the response of firm value to changes in outside value coming from inside value $dA_t^{\text{in}}$ and the wedge $d\omega_t$. These conditional responses are weighted by the relative contribution of each shock to the variation in outside value of the assets. We next derive simple empirical predictions from extreme cases of financial health.

**Far from liquidation.** Consider first the case when the firm is in good financial health and far from liquidation: $A_t^{\text{in}} \gg A_0$. Then, we have approximately

$$PT_{\text{safe}} \equiv PT(A_t^{\text{in}} \gg A_0, \omega_t) \approx V_A \frac{\frac{c-k}{c}}{\omega_t}. \tag{10}$$

First, when the firm is in good financial health, it can completely fulfill its role of insulating the assets from the market. Therefore, shocks to the wedge $\omega_t$ do not impact firm value at all. This isolation reduces the unconditional pass-through. In the limiting case where $d\omega_t$ shocks account for all variation in market values, the pass-through converges to $0$.

Second the impact of shocks to inside value $dA_t^{\text{in}}$ on the firm relative to the outside value depends on whether the firm trades at a premium or at a discount, defined by the term $\frac{c-k}{c}/\omega_t$ which multiplies the variance share. Higher values of $\omega_t$ due to, for example, more liquid markets, push the fund towards trading at a discount, lowering the impact of valuation shocks on the firm value relative to market value.

Putting these two forces together, the asset insulator view can rationalize a low pass-through during episodes when insurers are in good financial health and markets are liquid. This result stands in contrast to standard models of financial frictions that can only push the pass-through above $1$.

**At liquidation.** Consider now the other extreme case when the firm is converging to liquidation, $A_t^{\text{in}} \to A_0$. In that case, we have

$$PT_{\text{liquidation}} \equiv PT(A_t^{\text{in}} \to A_0) = PT_{\text{safe}} - V_A \left[ \frac{f(r+\kappa_\omega)}{\omega_t A_t^{\text{in}}} (\omega_t - \bar{\omega}) + \frac{f(r)}{\omega_t A_t^{\text{in}}} \left( \bar{\omega} - \frac{c-k}{c} \right) \right] + V_\omega. \tag{11}$$

When the intermediary gets close to liquidation, two main differences arise. First, notice the last term $V_\omega$. With liquidation imminent, changes in the liquidation value of the assets affect directly the value of the firm. Hence shocks to the wedge $d\omega_t$ now transmit one-to-one to firm value.

Second, as the financial health of the firm deteriorates, the value of the assets converges from its inside value to its outside value. In particular, during episodes of low $\omega_t$, this corresponds to an additional decrease in firm value; the term in brackets is negative. In illiquid times, the pass-through is therefore larger because of the convergence of the firm towards liquidation in response to declines in asset values. In appendix B.3, we show that the presence of other liquidation costs reinforces this effect, generating even higher pass-through.

In contrast to good conditions, the combination of low financial health and illiquidity pushes the pass-through to higher values, potentially larger than $1$. This behavior illustrates the tension arising in periods of low asset valuation: while franchise value increases because of a low $\omega_t$, the losses due to a potential liquidation also increase, generating a higher pass-through.

**Intermediate situations.** Between these two extreme cases, the weights in equation (9) with the form $\left(\frac{A_t^{\text{in}}}{A_0}\right)^x$ play an important role. These weights are cumulative discounted default probabilities. Two ingredients enter these quantities. First, forecasted default intensities during future dates. Second, the role of the wedge $\omega_t$ depends on the persistence $\kappa_\omega$. More persistent shocks — lower $\kappa_\omega$ — are likely to still have an impact in future liquidations, and therefore have a larger impact on firm value. In contrast, extremely transitory shocks, for instance micro-structure noise, never impact firm value away from liquidation.

Putting these considerations together, we can summarize predictions on the behavior of the pass-through around the financial crisis of 2008-2009. To map various periods to the model, we consider insurers to be in good financial health ($A_t^{\text{in}} \gg A_0$) and assume a low wedge between the inside and outside value of assets ($\omega_t$ close to $1$) before and after the crisis. In contrast, the crisis is a period of low financial wealth ($A_t^{\text{in}}$ close to $A_0$) and a larger wedge (low $\omega_t$). We can thus compare the pass-through in and out of the crisis.

**Prediction 1.** *The pass-through out of the crisis is less than* $1$*, reflecting the ability to insulate assets from the market. The pass-through increases during the crisis. The pass-through during the crisis can be larger than* $1$*, reflecting the possibility of losing the ability to insulate assets from the market.*

We can also compare the pass-through across insurers with different levels of financial distress during the crisis.

**Prediction 2.** *The pass-through is larger for more distressed insurers during the crisis as they are more likely to have to liquidate their assets.*

In the following section, we develop an empirical strategy allowing us to measure the pass-through. We find that the behavior of life insurer valuations in and around the financial crisis accords with the predictions just described.

# 5 Empirical Pass-through

The pass-through of an additional dollar of assets into equity forms a key moment for distinguishing theories of life insurers. As we have just seen, the asset insulator view predicts a pass-through of less than one out of the crisis, a larger pass-through during the crisis, and a larger pass-through for more distressed insurers. In contrast, the financial friction view can only generate a pass-through above one, as losing a dollar of assets pushes the insurer closer to default and lowers franchise value. The policy guarantee view can generate a pass-through less than one, since the value of the guarantee rises as the insurer moves closer to default. However, this effect is stronger in periods of high financial distress, implying a smaller pass-through during the crisis and for more distressed insurers.

We use the rich data available on security-level holdings to estimate the pass-through in and out of the crisis. We generalize our previous notation in a straightforward way to accommodate multiple insurers and a more complicated liability structure. Let $E_{i,t}$ denote the market value of equity of insurer $i$ at date $t$, $A_{i,t}$ the open market gross asset value ($A^{\text{out}}$ in the notation of the previous section), and $L_{i,t}$ the present value of liabilities. We write the value of an insurer's equity as:

$$E_{i,t} = A_{i,t} - L_{i,t} + [\text{Franchise value}]_{i,t}\,. \tag{12}$$

Taking a total derivative of equation (12) and dividing through by lagged market equity,

$$R^E_{i,t} = \rho^A_t R^A_{i,t} - \rho^L_t R^L_{i,t} + R^{OB}_{i,t}, \tag{13}$$

where $R^E_{i,t}$ denotes the return on market equity, $R^m_{i,t}$ the scaled change in value of assets ($m = A$) or liabilities ($m = L$), $\rho^A_t = 1 + \frac{\partial[\text{Franchise value}]_{i,t}}{\partial A_{i,t}}$ the pass-through with respect to assets, $\rho^L_t = 1 + \frac{\partial[\text{Franchise value}]_{i,t}}{\partial L_{i,t}}$ the pass-through with respect to liabilities, and $R^{OB}_{i,t}$ the scaled return to franchise value with respect to other variables. We seek to consistently estimate $\rho^A_t$.

An identification challenge arises because the return on the assets we observe may be correlated with the return on liabilities and the value of future business. For example, a decrease in the risk free rate might raise the value of both assets and liabilities. We proceed in two directions. Our main set of results uses abnormal bond returns at a daily frequency to isolate a part of $R^A_{i,t}$ plausibly uncorrelated with the other determinants of equity. We complement this approach by using the fair value reporting requirements at the end of December of each year to confirm the basic patterns also hold at an annual frequency for a broader part of the balance sheet.

## 5.1 Daily Pass-through

We measure the pass-through of a dollar of assets on 2,600 trading days before, during, and after the financial crisis using our data set of insurer corporate bond holdings matched to the actual returns on bonds in the over-the-counter market.

Our econometric procedure focuses on corporate bonds with returns which deviate substantially from their benchmark index. We first partition $R^A_{i,t}$ into the part coming from corporate bonds for which we can construct a return, $R^A_{i,t}(T)$ ($T$ for "traded"), and the remaining assets for which we do not know the return, $R^A_{i,t}(NT)$. Let $R^{A,x}_{i,t}$ denote the rescaled excess return. We further partition $R^{A,x}_{i,t}(T)$ into the part coming from bonds with large excess (unscaled) returns $R^{A,x}_{i,t}(b)$, $b \subseteq T$ ($b$ for "big"), and the part coming from bonds with small excess returns $R^{A,x}_{i,t}(b^c)$, $b^c \subseteq T \setminus b$. Our main specification takes the form:

$$R^E_{i,t} = \rho^A_{\text{crisis}} \mathbf{I}\{t \subseteq \text{crisis}\} R^{A,x}_{i,t}(b) + \rho^A_{\text{noncrisis}} \mathbf{I}\{t \nsubseteq \text{crisis}\} R^{A,x}_{i,t}(b) + \alpha_t + \gamma_i' X_t + \epsilon_{i,t}, \quad (14)$$

where crisis denotes the period from January 2008 to December 2009.

In writing equation (14), we have replaced the non-idiosyncratic part of asset returns, the returns on non-traded assets, the return on liabilities, and the return on other business with the fixed effect $\alpha_t$, the loading $\gamma_i' X_t$, and the regression residual $\epsilon_{i,t}$. The fixed effect $\alpha_t$ absorbs aggregate shocks to the value of the insurance business which affect all insurers equally. In our baseline specification, we include the return on the 10 year Treasury bond in $X_t$ to control for differences in duration mismatch across insurers, and in robustness we also include the Fama-French factors. Thus, our identifying assumption to estimate pass-through is that $R^{A,x}_{i,t}(b)$ is uncorrelated with the returns on other parts of the insurer's balance sheet and with changes in the value of other business not captured by time fixed effects or the insurer-specific loadings. Intuitively, if large excess returns reflect idiosyncratic news about the particularly bond rather than systematic characteristics targeted by the insurer for its portfolio, then they will likely be uncorrelated with other parts of the balance sheet or aspects of its business.

We construct $R^{A,x}_{i,t}(b)$ as follows. On each date, we start with the universe of corporate bonds held by at least one insurer on that date and reported in the FINRA TRACE data set with at least one transaction on each of the current and previous trading day. Let $P_{j,t}$ denote the price of bond $j$ and $\tilde{R}^A_{j,t} = \frac{P_{j,t} - P_{j,t-1}}{P_{j,t-1}}$ the raw unscaled return. Using the NAIC ratings reported in the insurance regulatory filings, we match each bond to the BAML index of the same rating and compute the excess return as the residual in a pooled regression of the bond returns $\tilde{R}^A_{j,t}$ on the index return. A bond belongs to the large excess return set $b$ if the excess return exceeds 6 percentage points in absolute value. We then aggregate the large excess returns for each insurer to generate an insurer-level excess return on its corporate bond portfolio: $R^{A,x}_{i,t}(b) = \sum_{j \in b} \frac{Q_{i,j,t-1}(P_{j,t} - P_{j,t-1})}{V_{i,t-1}}$, where $Q_{i,j,t-1}$ denotes the quantity of bond $j$ held by insurer $i$.

Table 6: High Frequency Portfolio Return Statistics

| | Dependent variable: | |
|---|---|---|
| | $\tilde{R}^{A,x}_{i,t}(b^c)$ | $R^{A,x}_{i,t}(T)$ |
| | (1) | (2) |
| Right hand side variable: | | |
| $\tilde{R}^{A,x}_{i,t}(b) \times$ Not crisis | 0.0036 | |
| | (0.0037) | |
| $\tilde{R}^{A,x}_{i,t}(b) \times$ Crisis | 0.0038 | |
| | (0.018) | |
| $R^{A,x}_{i,t}(b) \times$ Not crisis | | 1.23** |
| | | (0.071) |
| $R^{A,x}_{i,t}(b) \times$ Crisis | | 1.21** |
| | | (0.16) |
| Date FE | Yes | Yes |
| Treasury factor | Yes | Yes |
| Number small excess returns | 11,304,897 | 11,304,897 |
| Number large excess returns | 152,220 | 152,220 |
| Dollar share of large excess returns | 0.009 | 0.009 |
| $R^2$ | 0.25 | 0.65 |
| Observations | 36,810 | 36,810 |

Notes: In column 1, $\tilde{R}^{A,x}_{i,t}(b^c)$ is the unscaled excess return on corporate bonds with small excess returns and $\tilde{R}^{A,x}_{i,t}(b)$ is the unscaled excess return on corporate bonds with large excess returns. Both variables are demeaned on each date and normalized to have unit variance in and out of the crisis such that the reported coefficients are correlations. In column 2, $R^{A,x}_{i,t}(T)$ is the excess return on all traded bonds, and $R^{A,x}_{i,t}(b)$ is the excess return on bonds with large excess returns. Both variables are rescaled by the ratio of the holdings to market equity. The crisis is defined as January 2008-December 2009. Standard errors clustered by date in parentheses. ** denotes statistical significance at the 1% level. The data cover the period 2004 - 2014.

The data offer support for our identifying assumption. First, the bonds with large excess returns constitute only a small share of total bonds which transact on consecutive dates. Our sample contains more than 11 million insurer-date-cusip observations between 2004 and 2014 of a bond held by a particular insurer for which we can construct a return on a particular date; of these, less than 1.5% meet our threshold for a large excess return. The share by dollar value is less than 1%. The rarity of such large returns gives *a priori* plausibility to the assumption that they do not reflect systematic variation in insurers' holdings.

We assess the idiosyncrasy of the large excess returns more directly by comparing them to the rest of the transacted portfolio. Column 1 of table 6 performs this comparison by reporting the correlation coefficients of the (demeaned daily) unscaled returns $\tilde{R}^{A,x}_{i,t}(b)$ and $\tilde{R}^{A,x}_{i,t}(b^c)$ in and out of the crisis period. Both correlations are less than 0.005 in absolute value. Column 2 compares the total scaled excess return $R^{A,x}_{i,t}(T)$ to the part coming from the large excess returns $R^{A,x}_{i,t}(b)$. Here we find coefficients close to but slightly above one. The similarity of coefficients in and out of the crisis period suggests that differential correlation of large excess returns and the rest of the portfolio cannot explain a higher pass-through in the crisis.

Table 7 presents our main findings. Column 1 reports our baseline specification of the equity return on the scaled excess bond return $R^{A,x}_{i,t}(b)$ controlling only for the general movement in interest rates by including in $X_t$ the return on the 10-year Treasury and allowing the coefficient to vary across insurers. We obtain a pass-through of 0.10 out of the crisis and 1.13 during the crisis. The table reports standard errors clustered by date to allow for arbitrary correlation across insurers on each date. We can reject equality of the pass-through coefficients and equality of the pass-through out of the crisis and unity at the 1 percent level. We cannot reject equality of pass-through during the crisis and unity at any conventional confidence level. In words, an additional dollar of assets translates into an additional \$0.10 of equity out of the crisis, but slightly more than \$1 of equity during the crisis.

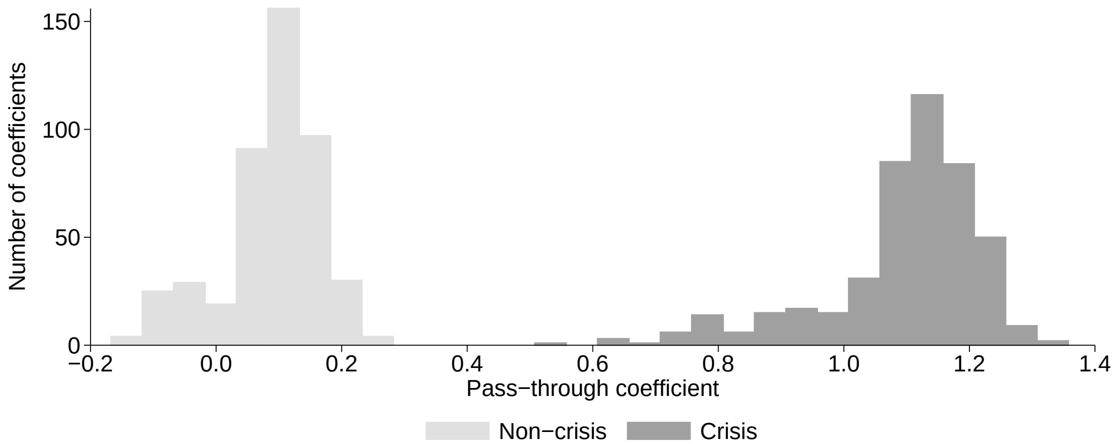
The remaining columns explore robustness. In column 2, we run the regression without controlling for the movement in Treasuries and find similar results to those from our benchmark specification. In column 3, we allow the non-crisis coefficient to differ before and after the crisis. We do not find evidence of a permanent structural break at the start of the crisis, but rather that pass-through is high during the crisis and low before and after. Column 4 reports the baseline regression without winsorizing the dependent variable; the few large equity returns cause the standard errors to rise, but the same pattern remains. Columns 5 and 6 explore sensitivity to the large declines in equity during the crisis for some insurers, in column 5 by scaling the changes in equity and bond holdings by the sample mean of market capitalization for each insurer rather than the $t-1$ market capitalization, and in column 6 by including the interaction of the inverse of market capitalization and a date fixed effect. In column 7, we define the crisis period more narrowly as the one year period from September 2008 to August 2009. In column 8, we include insurer-specific loadings on the three Fama-French factors. We consistently find results similar to the baseline specification. Finally, column 9 measures the pass-through to public debt for the

Table 7: High Frequency Portfolio Return Pass-through

| | Dependent variable: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Equity | | | | | | | | Debt |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Large excess bond returns interacted with: | | | | | | | | | |
| Not crisis | 0.10 | 0.10 | | 0.07 | 0.04 | −0.03 | 0.10 | 0.03 | −0.01 |
| | (0.20) | (0.21) | | (0.34) | (0.20) | (0.20) | (0.19) | (0.17) | (0.03) |
| Crisis | 1.13** | 1.06** | 1.13** | 1.69** | 0.86* | 1.08** | 1.14** | 1.02** | 0.32* |
| | (0.34) | (0.34) | (0.34) | (0.60) | (0.40) | (0.38) | (0.34) | (0.36) | (0.16) |
| Pre-crisis | | | 0.08 | | | | | | |
| | | | (0.48) | | | | | | |
| Post-crisis | | | 0.10 | | | | | | |
| | | | (0.22) | | | | | | |
| Date FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Dep. var. winsorized | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes |
| Crisis period | 2Y | 2Y | 2Y | 2Y | 2Y | 2Y | 1Y | 2Y | 2Y |
| Denom. | 1 | 1 | 1 | 1 | Mean | 1 | 1 | 1 | 1 |
| Size control | No | No | No | No | No | Yes | No | No | No |
| Treasury factor | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| FF factors | No | No | No | No | No | No | No | Yes | No |
| $R^2$ | 0.56 | 0.56 | 0.56 | 0.50 | 0.53 | 0.62 | 0.56 | 0.61 | 0.59 |
| p(Homog. effect) | 0.010 | 0.016 | 0.034 | 0.019 | 0.065 | 0.010 | 0.008 | 0.013 | 0.043 |
| Observations | 36,810 | 37,365 | 36,810 | 36,810 | 36,795 | 36,795 | 36,810 | 36,810 | 13,149 |

Notes: The estimating equation is: $R^E_{i,t} = \rho^A_{\text{crisis}}\mathbf{I}\{t \subseteq \text{crisis}\}R^{A,x}_{i,t}(b) + \rho^A_{\text{noncrisis}}\mathbf{I}\{t \nsubseteq \text{crisis}\}R^{A,x}_{i,t}(b) + \alpha_t + \gamma_i' X_t + \epsilon_{i,t}$, where $R^E_{i,t}$ denotes the equity return and $R^{A,x}_{i,t}(b)$ the market-capitalization scaled return on the insurer's holdings of corporate bonds with abnormal returns greater than 6 p.p. In all columns, the benchmark index is the BAML index of the same rating, and standard errors clustered by date are reported in parentheses. In columns 1 and 3-9, $X_t$ includes the return on the 10 year Treasury bond and we allow $\gamma_i$ to vary by calendar year. In column 2, $X_t$ is empty. In column 8, $X_t$ additionally includes the three Fama-French factors. In column 5, $R^E_{i,t}$ and $R^{A,x}_{i,t}(b)$ are rescaled by the ratio of one-day lagged market capitalization to the insurer's sample mean market capitalization. In column 6, we interact a date fixed effect with the inverse of insurer market capitalization. If indicated, the dependent variable is winsorized each month at the median ± 2.5 standard deviations. The 2Y crisis period is January 2008-December 2009. The 1Y crisis period is September 2008-August 2009. Standard errors clustered by date in parentheses. ** and * denote statistical at the 1 and 5% levels. The data cover the period 2004 - 2014.

Figure 7: Pass-through Coefficients Sample Robustness




Notes: The figure reports the histogram of coefficients of pass-through in and out of the crisis from the regression specification in column (1) of table 7 when we exclude three insurers at a time from the sample. The crisis period is January 2008-December 2009. The data cover the period 2004 - 2014.

subsample of insurers with liquid CDS on their outstanding public debt throughout our sample period.[16] We find some evidence of a higher crisis pass-through on public debt as well, but caution that equity pass-through is lower for this subgroup so that pass-through on the total value of the firm is not higher.

The evidence of differential pass-through in and out of the crisis does not depend on the asset price behavior of only one or two insurers. To make this point, we selectively drop three insurers at a time, or 20% of our sample, and re-estimate the baseline regression in column 1 of table 7. Figure 7 reports the histogram of coefficients from these $\frac{15!}{12!3!} = 455$ regressions. Most coefficients cluster around the level estimated in the baseline specification in the full sample, and the two distributions of coefficients in and out of the crisis do not overlap. The gap between the crisis and out of crisis coefficients estimated for each sample ranges between 0.5 and 1.4.

Table 8 explores the sensitivity of our results to the window over which we measure excess returns. We reproduce our benchmark specification, in which we measure returns over a 1-day horizon, in column 1. In column 2, we measure excess returns over a 3-day horizon, and in column 3 we measure returns over a 7-day horizion. Since the variance of returns may increase with horizon, we raise the threshold for inclusion in the idiosyncratic component $b$ to 8 p.p. for the 3-day horizon and to 10 p.p. for the 7-day horizon. The pass-through of the crisis remains low as the horizon increases, while the pass-through in the crisis remains above 1.

[16]The tickers of these insurers are: AFL, ALL, LNC, MET, PRU, TMK.

Table 8: High Frequency Portfolio Return Pass-through, Longer Horizons

| | Dependent variable: equity | | |
|---|---|---|---|
| | Return horizon: | | |
| | 1 day | 3 day | 7 day |
| | (1) | (2) | (3) |
| Large excess bond returns interacted with: | | | |
| Not crisis | 0.10 | 0.10 | 0.23 |
| | (0.20) | (0.35) | (0.43) |
| Crisis | 1.13** | 1.30** | 1.93** |
| | (0.34) | (0.33) | (0.74) |
| Date FE | Yes | Yes | Yes |
| Dep. var. winsorized | Yes | Yes | Yes |
| Treasury return | Yes | Yes | Yes |
| $R^2$ | 0.56 | 0.56 | 0.55 |
| p(Homog. effect) | 0.010 | 0.012 | 0.047 |
| Observations | 36,810 | 36,757 | 36,854 |

Notes: The estimating equation is: $R^E_{i,t} = \rho^A_{\text{crisis}} \mathbf{I}\{t \subseteq \text{crisis}\} R^{A,x}_{i,t}(b) + \rho^A_{\text{noncrisis}} \mathbf{I}\{t \nsubseteq \text{crisis}\} R^{A,x}_{i,t}(b) + \alpha_t + \gamma_i' X_t + \epsilon_{i,t}$. In column 1, $R^{A,x}_{i,t}(b)$ comprises daily returns which exceed their benchmark by 6 p.p., in column 2 3-day returns which exceed their benchmark by 8 p.p., and in column 3 7-day returns which exceed their benchmark by 10 p.p. The crisis period is January 2008-December 2009. Standard errors clustered by date in parentheses. ** denotes statistical significance at the 1% level. The data cover the period 2004 - 2014.

## 5.2 Annual Pass-through

A similar exercise based on regulatory data reported at the end of each calendar year complements the previous results. These data have the advantage of much fuller coverage of assets, but at the cost of limited power as we have only one observation per insurer-year. The annual data do allow us to exploit variation by insurer in broad asset class allocation as well as within asset class idiosyncratic returns. Indeed, as we document in figure A.1, insurers differ substantially in their broad asset class allocation with some heavily exposed to ABS and PLRMBS before the crisis and others with virtually no exposure.

We construct annual portfolio returns from the NAIC regulatory data. As described in section 2, we use fair value prices of all securities (bonds and stocks) as reported in Schedules D and BA along with transactions summaries to construct the total dollar portfolio gain or loss for each insurer over the course of a year. Our mea-

Table 9: Annual Portfolio Return Pass-through

| | Dependent variable: stock return | | | |
|---|---|---|---|---|
| | Portfolio capital gains measured as: | | | |
| | | Excess return w.r.t.: | | |
| | Actual | Asset-class year mean | 1 factor | Actual incl. derivatives |
| | (1) | (2) | (3) | (4) |
| Right hand side variables: scaled portfolio return in: | | | | |
| Not crisis | $-0.047$ | $-0.33^{**}$ | $-0.48^{**}$ | $-0.029$ |
| | (0.036) | (0.11) | (0.15) | (0.042) |
| 2008 | $0.72^{*}$ | $0.77^{*}$ | 0.71 | $0.87^{+}$ |
| | (0.29) | (0.33) | (0.50) | (0.51) |
| 2009 | 0.022 | 0.31 | 0.86 | 0.022 |
| | (0.052) | (0.42) | (0.93) | (0.050) |
| Year FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.55 | 0.55 | 0.56 | 0.54 |
| Observations | 150 | 150 | 150 | 150 |

Notes: The table presents the coefficients from regressions of the insurance company's total stock return on the change in the value of its asset holdings. The right hand side variable is the total return on the insurer's asset portfolio. In column (2), we adjust the portfolio capital gains by removing the asset-class mean in each year before aggregating to the individual insurer level. Our asset classes are defined as shown in the right hand panel of figure 2. In column (3), we control for differences across insurers in initial holdings by extracting the first principal component for each asset class before aggregating to the individual insurer level. In column (4), we include derivative positions in addition to the securities held. Heteroskedasticity-robust standard errors in parentheses. **, *, and + denote statistically significant at the 1, 5, and 10% levels. The data cover the period 2004 - 2014.

sure differs, sometimes substantially, from the investment gains and losses reported by insurers in their statutory filings because it attributes gains and losses to the period in which the underlying investments change value rather than the year in which they are recognized for accounting purposes.

Table 9 reports regressions of the same form as equation (14) but using the NAIC data at the annual frequency. The specification in column 1 includes no controls other than the year fixed effects and reports pass-through with respect to the untransformed scaled return on the portfolio assets. We obtain a coefficient of 0.72 for the year 2008 and of essentially zero for all other years. In columns 2 and 3 we construct excess portfolio returns by first demeaning each asset class return with respect to its yearly mean across all insurers (column 2) or as the residual after extracting one asset-class specific factor as chosen by the Bai (2009) interactive effects factor model (column 3). The 2008 pass-through changes little, while the non-crisis pass-through falls to be a bit negative.[17] The 2009 pass-through increases although it remains statistically indistinguishable from 0. In column 4 we augment the Schedule D and BA holdings with the mark-to-market capital gain/loss on each insurer's derivatives portfolio. The pass-through coefficients change little, in part because the gains and losses on the non-derivatives holdings dwarf those from the derivatives portfolio. In sum, while less powerful and well-identified than the results based on daily returns, annual data confirm the basic result of a low pass-through out of the crisis and a higher pass-through during the crisis.

### 5.3 Discussion

The finding of a pass-through coefficient significantly below one out of the crisis poses a challenge to a Modigliani and Miller (1958) theory of the firm and to the other standard views of insurance companies' asset management described in section 3.1. Before returning to our preferred interpretation of this result, we first consider and discard two possible concerns with interpreting these results as valid measures of the pass-through.

The first concern entails whether market participants could have calculated portfolio returns of insurers in real time. The NAIC end-of-year filings of security holdings become public about two months after the end of the calendar year, and quarterly filings of transactions a few months after the end of the quarter. If insurers engaged in frequent turnover of their portfolios, then equity analysts and traders might not know which insurers experienced large excess portfolio returns on a particular date. The finding of a daily pass-through close to 1 during the crisis and similar results in annual regressions belies this interpretation. Moreover, we can compute directly the fraction of large excess bond returns occurring in positions which insurers' had established before the previous regulatory filing. Both in and out of the crisis, this share exceeds 98%.

The valuation convention of equity analysts of insurance companies further confirms that a low pass-through reflects an active decision by market participants. According to Nissim (2013), most equity analysts value insurance companies using

[17] While much more complete than the set of corporate bonds which transact on consecutive days, the annual filings nonetheless lack mark-to-market prices of directly held mortgages, real estate, assets held outside the insurance company, and especially liabilities.

a price-book ratio which excludes accumulated other comprehensive income (AOCI) from the book valuation. We have verified this convention in our own conversations with market participants. The category AOCI includes all of the unrealized gains and losses from the asset portfolio. The rationale for excluding AOCI appears to have to do with the high volatility of investment gains and losses (Nissim, 2013, p. 326), consistent with the asset insulator view. In any case, the practice of ignoring AOCI when doing valuation comports well with an empirical pass-through of asset returns of close to zero in most periods.

The second concern involves the persistence of the underlying bond returns. The illiquidity of corporate bond markets constitutes a key reason why long-lived investors such as insurance companies create value by holding the assets on their balance sheets. However, if large excess returns reflect only very temporary price dislocations which quickily revert, the finding of a low pass-through might not seem surprising. We measure directly the persistence in excess returns in table 10. Using the set of cusip-dates with excess returns above 6 p.p., the table reports coefficients from regressions of the excess return over the subsequent 7 or 28 days on the excess return. Roughly one-third of the excess return has dissipated after 7 days, and this reversion is of similar magnitude in and out of the crisis. The amount of reversion after 28 days almost exactly equals the 7 day reversion, suggesting two-thirds of the excess returns persist over a longer period. Extremely temporary price dislocation may explain part of the large excess returns we use to estimate pass-through, but it cannot directly account for either the level of pass-through out of the crisis or the increase in pass-through during the crisis.

The asset insulator view of insurers can explain both the low pass-through out of the crisis and the increase in pass-through during the crisis. In normal conditions, as asset prices fluctuate on the market, the value inside the firm is preserved and the pass-through is low. When the crisis occurs, asset prices on the market drop. This results in a larger comparative advantage to holding the assets on the balance sheet, so franchise value increases. However, this effect is mitigated by the deterioration in the financial health of insurers, putting them closer to liquidation. Assets are less likely to be held for a long time, and therefore less well insulated from market movements, which results in a higher pass-through. Further, while high, the value creation from the asset insulation activity is precarious. Adverse price changes can precipitate liquidation, further increasing the pass-through.

We find additional evidence of the impact of the liquidation risk by splitting the sample according to the level of financial distress. Specifically, we form two sub-

Table 10: High Frequency Bond Return Serial Correlation

| | Dependent variable: excess return over next: | | | |
|---|---|---|---|---|
| | 7 days | | 28 days | |
| | (1) | (2) | (3) | (4) |
| Large excess bond returns interacted with: | | | | |
| Not crisis | $-0.29^{**}$ | $-0.35^{**}$ | $-0.30^{**}$ | $-0.34^{**}$ |
| | (0.03) | (0.03) | (0.03) | (0.03) |
| Crisis | $-0.29^{**}$ | $-0.34^{**}$ | $-0.27^{**}$ | $-0.31^{**}$ |
| | (0.02) | (0.02) | (0.03) | (0.02) |
| Date FE | Yes | Yes | Yes | Yes |
| Impute 0? | Yes | No | Yes | No |
| $R^2$ | 0.172 | 0.193 | 0.139 | 0.148 |
| Observations | 70,042 | 67,137 | 70,042 | 69,185 |

Notes: The table shows the extent of mean-reversion in excess bond returns in and out of the crisis. The sample includes one oberservation per cusip-date with an excess return above 6 p.p. Columns 1 and 3 impute a value of 0 for the subsequent 7 or 28 day return if the cusip does not transact again in that horizon, while columns 2 and 4 exclude such observations from the regression. The crisis period is January 2008-December 2009. Standard errors two-way clustered by date and cusip in parentheses. ** denotes statistical significance at the 1% level. The data cover the period 2004 - 2014.

groups of insurers based on each insurer's stock return during the period September 12, 2008 to October 10, 2008. This four-week period begins with the day of the Lehman bankruptcy and contains the most acute drop in the stock price index shown in figure 5. To avoid a mechanical correlation between stock price decline and crisis pass-through from sorting based on decline, we then drop this four-week period from the sample. Table 11 reports the results from estimating equation (14) separately for each subsample. The pass-through coefficient rises during the crisis in both groups, consistent with the increase in the comparative advantage of an asset on the balance sheet playing a role, as well as reflecting a heightened level of distress even among the healthier insurers. However, the pass-through coefficient for the healthier subgroup rises by only half as much as for the more distressed subgroup. The limited sample size generates too little power to formally reject equality of the crisis pass-through coefficients at conventional levels, but the difference of 0.6 is economically significant and consistent with liquidation risk substantially raising the pass-through.

In sum, the pass-through evidence in and out of the crisis, and the cross-sectional differences in pass-through during the crisis, accord well with the asset insulator view

Table 11: Pass-through by Insurer Distress

| | Dependent variable: equity return | |
|---|---|---|
| Sample: | Equity return 09/12/08-10/10/08 $<$ Median | Equity return 09/12/08-10/10/08 $>$ Median |
| | (1) | (2) |
| Large excess bond returns interacted with: | | |
| Not crisis | 0.15 | 0.15 |
| | (0.27) | (0.22) |
| Crisis | 1.13** | 0.51 |
| | (0.41) | (0.41) |
| Date FE | Yes | Yes |
| Drop 09/15/08-10/10/08 | Yes | Yes |
| Dep. var. winsorized | Yes | Yes |
| Treasury factor | Yes | Yes |
| P(Crisis pass-through equal) | 0.358 | 0.358 |
| $R^2$ | 0.62 | 0.59 |
| Observations | 17,161 | 19,346 |

Notes: The table shows the extent to which pass-through differs by how much the insurer's stock fell in the period September 12, 2008 - October 10, 2008. The crisis period is January 2008-December 2009. Standard errors clustered by date in parentheses. ** denotes statistical significance at the 1% level. The data cover the period 2004 - 2014 excluding the period September 12, 2008 - October 10, 2008.

of life insurers. In contrast, the financial friction view cannot explain the low pass-through out of the crisis, while the policy guarantee view counterfactually predicts a smaller pass-through during the crisis and for more distressed insurers. We conclude that only the asset insulator view can fit the empirical moments.[18]

[18] We have discussed already the inconsistency of the liability matching view with insurers' portfolio choices. The pass-through evidence here also helps to reconcile the evidence in Chodorow-Reich (2014) that insurers' stock prices rose sharply during the crisis on dates when the Federal Reserve took actions to lower interest rates, a result at odds with the duration mismatch of insurers but consistent with the sharp rise in the value of portfolio holdings passing through into the equity at a high rate.

# 6 Conclusion

We have proposed a theory of life insurance companies as asset insulators. In this view, an important component of the value of an insurer to an equity holder is its ability to hold illiquid assets for a long period of time, insulating those assets from transitory price fluctuations in the open market. The long contractual horizon and low susceptibility to runs of insurers' liabilities make them natural holders of such assets. We document other key aspects of insurers' balance sheets consistent with this view, including an active decision not to concentrate their asset holdings in liquid, riskless assets such as U.S. Treasuries, and a sharp rise in francise value during the financial crisis.

Our theory of asset insulators also makes specific predictions for the behavior of the pass-through of asset value into equity in and out of the crisis. Using detailed security-level holdings data matched to trading data on corporate bonds, we estimate that equity value decreases by as little as 10 cents in response to a one dollar drop in asset values outside of the 2008-09 financial crisis. During the crisis, the pass-through rises to approximately 1. Our theory interprets the higher pass-through during the crisis as resulting from the deterioration in the financial health of insurers, which threatens their ability to act as long-lived investors. Other theories of insurers cannot match this pattern of pass-through.

The role of asset insulator may apply to many other types of financial intermediaries and touches on important aspects of financial regulation. On the one hand, the asset insulation view suggests a stabilizing role for these institutions, rather than the amplifying role sometimes attributed to them. On the other, the correlation between market illiquidity and the health of the financial sector makes the asset insulation function most fragile exactly when it is most valuable. Future research might further explore the implications of this tradeoff.

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# A Additional Data Information

We assess the accuracy of insurers' self-reported valuations of their assets in two ways. First, we collect prices for as many assets as possible from external sources such as TRACE, CRSP, and Bloomberg terminals. We are able to obtain external prices for approximately 38% of insurers' securities by value in any given year. The primary difficulty in obtaining external prices is that many of the assets they hold are highly illiquid.[19] Table A.1 summarizes the difference in prices from what the insurers themselves report and third-party prices. In general, there is very little variation in asset prices reported in NAICs and external quotes. When we include outliers, insurers appear to slightly underreport the values of some securities as the mean raw price difference is -1.2%. However, after excluding outliers, the mean raw price difference is 0.2%. The absolute price differences with and without outliers are 3.6% and 1.8%. We thus feel confident using that insurers are reporting their asset values without significant bias to NAICs.

Table A.1: Differences Between Insurer-Reported and Third-Party Log Prices

| | All Cusips | Excluding Outliers |
|---|---|---|
| N | 328,230 | 326,684 |
| Mean Absolute | 0.036 | 0.018 |
| Median Absolute | 0.006 | 0.006 |
| Mean Raw | -0.012 | 0.002 |
| Median Raw | 0.000 | 0.000 |
| Mean Squared | 0.082 | 0.002 |
| Standard Deviation | 0.286 | 0.050 |
| P75 Absolute | 0.018 | 0.017 |
| P90 Absolute | 0.043 | 0.042 |
| P95 Absolute | 0.073 | 0.070 |
| P99 Absolute | 0.283 | 0.187 |
| Maximum Absolute | 13.816 | 0.999 |

Notes: All values as of Q4. Count (N) refers to number of CUSIPS for which external prices are available. Fair value per unit used for insurer-reported price. Raw difference calculated as log of insurer-reported less third-party value. Outliers are CUSIPS for which the insurer-reported value deviates by more than 100% from that reported by third-parties.

The second way we assess the accuracy of insurers' self-reported valuations is by comparing the prices reported by multiple insurers in our sample that hold the

[19] Edwards, Harris, and Piwowar (2007) report that about half of corporate bonds trade very infrequently. Bessembinder, Maxwell, and Venkataraman (2013) find that only 20% of structured finance securities trade at all in a 20-month period.

same asset. Approximately 55% of insurers' securities by value are held in securities that multiple insurers hold. Table A.2 details the deviations in prices reported across insurers. The mean and median standard deviations are 4.3% and 0.0%. After excluding outliers, these statistics fall to just 0.9% and 0.0%.

Table A.2: Cross-Insurer Standard Deviations for Insurer-Reported Log Prices by CUSIP

| | All CUSIPS | Excluding Outliers |
|---|---|---|
| N | 287,903 | 285,774 |
| Mean | 0.043 | 0.009 |
| Median | 0.000 | 0.000 |
| Standard Deviation | 0.277 | 0.036 |
| P75 | 0.004 | 0.004 |
| P90 | 0.017 | 0.016 |
| P95 | 0.043 | 0.035 |
| P99 | 1.687 | 0.190 |
| Maximum | 11.209 | 1.354 |

Notes: Q4 fair values used to calculate standard deviations. Count (N) refers to number of CUSIPS held by multiple insurers. Outliers are CUSIPS for which the differences in prices across insurers exceed 100%.

We next provide further detail on holdings by insurer and asset illiquidity. Figure A.1 reports the asset class allocation for each insurer for the years 2005, 2009, and 2013.

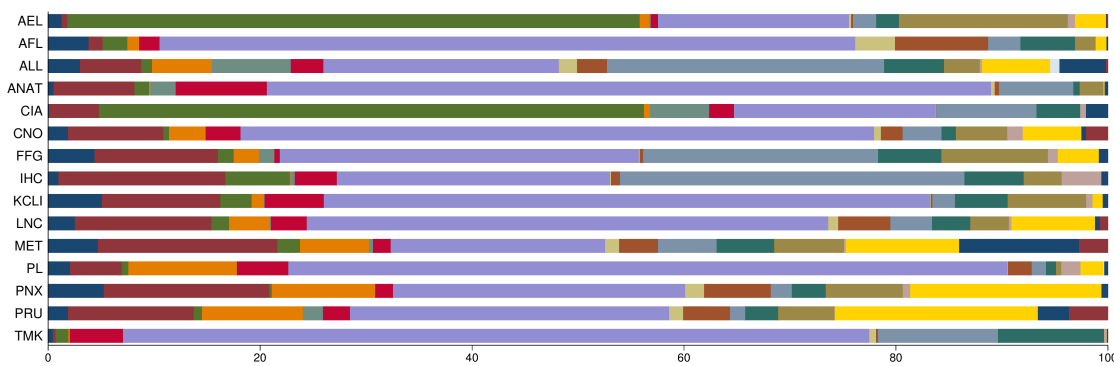
We use the Hanson et al. (2015, Appendix Table AII) liquidity weights summarized in table A.3 below to assign liquidity weights at the year-insurer-asset class level.[20] Table A.4 shows the illiquidity of our insurers by year. Despite our use of much more disaggregated data than Hanson et al., we obtain a very similar estimate of the illiquidity of our insurers of 60%. By comparison, Hanson et al. find that banks' assets have an illiquidity measure of slightly above 60%.

[20] Hanson et al. (2015) assign an illiquidity weight of 50% to corporate bonds under the assumption that the corporate bonds are rated A- or higher. We maintain this weighting scheme despite most corporate bonds held by insurers having a rating below AA (see Table 3). Because lower rated corporate bonds are generally less liquid (see, for example, Edwards et al. (2007)), this assumption likely biases our measure of the illiquidity of insurers' holdings downwards.

## Figure A.1: Portfolio Allocation by Insurer

### Panel A: 2005


### Panel B: 2009




### Panel C: 2013

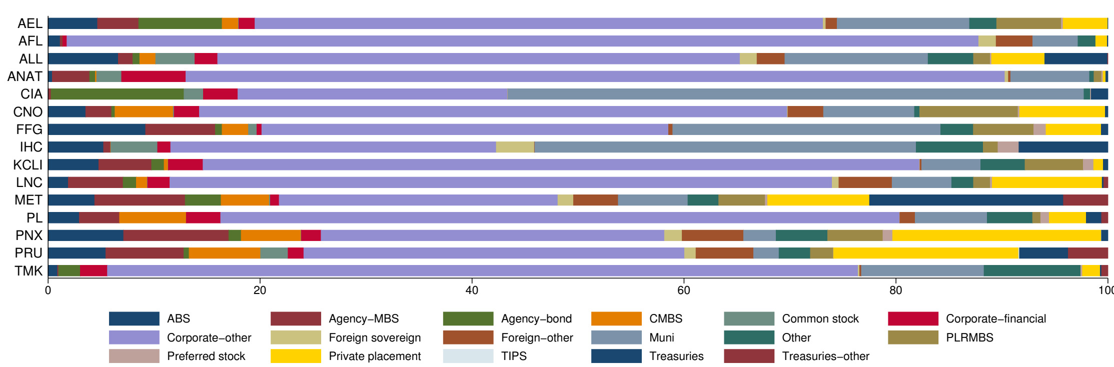


Table A.3: Illiquidity Weights by Asset Class

| Asset Class | Illiquidity Weight (%) |
|---|---|
| ABS | 100 |
| Agency-MBS | 15 |
| Agency-Bond | 15 |
| Cash | 0 |
| CMBS | 100 |
| Common Stock | 50 |
| Corporate-financial | 50 |
| Corporate-other | 50 |
| Foreign sovereign | 50 |
| Foreign-other | 50 |
| Mortgages | 100 |
| Muni | 50 |
| Other | 100 |
| PLRMBS | 100 |
| Preferred Stock | 50 |
| Private Placement | 100 |
| Real Estate | 100 |
| TIPS | 0 |
| Treasuries | 0 |
| Treasuries-other | 0 |

Notes: Weights based on Hanson et al. (2015). We assume a weight of 100% for mortgages because the overwhelming majority of insurers' mortgages are commercial rather than residential mortgages.

Table A.4: Illiquidity of Insurers' Total Portfolios by Year

| Year | Illiquidity Measure |
|---|---|
| 2005 | 58.3 |
| 2006 | 60.4 |
| 2007 | 61.2 |
| 2008 | 59.2 |
| 2009 | 60.0 |
| 2010 | 60.7 |
| 2011 | 60.5 |
| 2012 | 59.8 |
| 2013 | 60.1 |
| 2014 | 59.3 |
| Average | 60.0 |

Notes: See Table A.3 for weights assigned to individual asset classes. Summary is value-weighted by individual insurers' assets. 0=Completely liquid, 100=Completely illiquid.

# B Solving the Model

## B.1 Value of equity

The exogenous laws of motions are

$$\frac{dA_t^{\text{in}}}{A_t^{\text{in}}} = (r-c)dt + \sigma_A dZ_t^A, \tag{A.1}$$

$$d\omega_t = -\kappa_\omega(\omega_t - \bar{\omega})dt + \sigma_\omega\sqrt{\omega_t}dZ_t^\omega. \tag{A.2}$$

The liquidation stopping time $T$ is the hitting time of the threshold $A_0$.

The value of the equity is

$$E_t = \mathbb{E}_t\left[\int_t^T e^{-r(\tau-t)}(c-k)A_\tau^{\text{in}}d\tau + e^{-r(T-t)}\omega_T A_0 - \int_t^\infty e^{-r(\tau-t)}\ell d\tau\right]. \tag{A.3}$$

We drop the "in" superscript for simplicity and reorganize the equation:

$$E_t = \mathbb{E}_t\left[\int_t^T e^{-r(\tau-t)}(c-k)A_\tau d\tau + e^{-r(T-t)}\omega_T A_0 - \int_t^\infty e^{-r(\tau-t)}\ell d\tau\right] \tag{A.4}$$

$$= \underbrace{\mathbb{E}_t\left[\int_t^\infty e^{-r(\tau-t)}(c-k)A_\tau d\tau\right]}_{\text{no-liquidation asset value}} + \underbrace{\mathbb{E}_t\left[e^{-r(T-t)}\omega_T A_0 - \int_T^\infty e^{-r(\tau-t)}\left(c-k\right)A_\tau d\tau\right]}_{\text{liquidation adjustment}}$$

$$- \underbrace{\mathbb{E}_t\left[\int_t^\infty e^{-r(\tau-t)}\ell d\tau\right]}_{\text{liabilities}}. \tag{A.5}$$

The present value of liabilities is

$$\int_t^\infty e^{-r(\tau-t)}\ell d\tau = \frac{\ell}{r}. \tag{A.6}$$

Note that $\mathbb{E}_t\left[A_\tau|A_t\right] = A_t \exp\left(r-c\right)\left(\tau-t\right)$. Therefore,

$$\mathbb{E}_t\left[\int_t^\infty e^{-r(\tau-t)}(c-k)A_\tau d\tau\right] = A_t\int_t^\infty \left(c-k\right)\exp\left(-c\left(\tau-t\right)\right)d\tau \tag{A.7}$$

$$= A_t\frac{c-k}{c}, \tag{A.8}$$

and

$$\mathbb{E}_T\left[\int_T^{\infty} e^{-r(\tau-t)}\left(c-k\right)A_\tau d\tau\right] = \mathbb{E}_T\left[\int_T^{\infty} e^{-r(\tau-t)}\left(c-k\right)e^{(r-c)(\tau-T)}A_T d\tau\right] \tag{A.9}$$

$$= e^{-r(T-t)}\frac{c-k}{c}A_{T.} \tag{A.10}$$

We can also compute expectations of $\omega_\tau$ for various values of $\tau$. For this remember the conditional mean of a CIR process is

$$\mathbb{E}_t\left[\omega_\tau|\omega_t\right] = \omega_t e^{-\kappa_\omega(\tau-t)} + \bar{\omega}\left(1-e^{-\kappa_\omega(\tau-t)}\right). \tag{A.11}$$

Plugging these results in the liquidation adjustment, and using the fact that, by definition, $A_T = A_0$, we have

$$\mathbb{E}_t\left[e^{-r(T-t)}\omega_T A_0 - \int_T^{\infty} e^{-r(\tau-t)}\left(c-k\right)A_\tau d\tau\right] = A_0\mathbb{E}_t\left[e^{-r(T-t)}\left[\left(\omega_t-\bar{\omega}\right)e^{-\kappa_\omega(T-t)}+\bar{\omega}-\frac{c-k}{c}\right]\right] \tag{A.12}$$

We are left with computing $\mathbb{E}_t\left[e^{-r(T-t)}\right]$ and $\mathbb{E}_t\left[e^{-(r+\kappa_\omega)(T-t)}\right]$. The following lemma gives a general expression for this type of expectations.

**Lemma 1.** *For any* $\alpha \geq 0$ *, we have*

$$\mathbb{E}_t\left[e^{-\alpha(T-t)}\right] = \left(\frac{A_t}{A_0}\right)^{-f(\alpha)}, \tag{A.13}$$

*with*

$$f(\alpha) = \frac{r-c-\frac{1}{2}\sigma_A^2+\sqrt{\left(r-c-\frac{1}{2}\sigma_A^2\right)^2+2\sigma_A^2\alpha}}{\sigma_A^2}. \tag{A.14}$$

*The function* $f$ *is positive and increasing.*

*Proof.* Define $M_t = e^{-\alpha t}\left[\frac{A_t}{A_0}\right]^{-\tilde{\gamma}_1}$. Applying Ito's lemma gives

$$dM_t = M_t\left[-\alpha-\tilde{\gamma}_1(r-c)+\frac{1}{2}\sigma_A^2\tilde{\gamma}_1\left(1+\tilde{\gamma}_1\right)\right]dt - \tilde{\gamma}_1\sigma_A M_t dZ_t^A. \tag{A.15}$$

Hence $M_t$ is a martingale if $\tilde{\gamma}_1$ solves

$$0 = \left[\frac{1}{2}\sigma_A^2\right]\tilde{\gamma}_1^2 + \left[-(r-c) + \frac{1}{2}\sigma_A^2\right]\tilde{\gamma}_1 + [-\alpha] \tag{A.16}$$

$$\tilde{\gamma}_1 = \frac{(r-c) - \frac{1}{2}\sigma_A^2 \pm \sqrt{\left((r-c) - \frac{1}{2}\sigma_A^2\right)^2 + 2\sigma_A^2\alpha}}{\sigma_A^2}. \tag{A.17}$$

Let us consider the positive root, calling it $\gamma_1$. In this case $M_t$ is uniformly bounded before the stopping time $T$. Doob's optional stopping theorem applies: $M_t = E_t[M_T]$. Hence, substituting the definition of $M_t$,

$$e^{-\alpha t}\left[\frac{A_t}{A_0}\right]^{-\gamma_1} = E_t\left[e^{-\alpha T}\right], \tag{A.18}$$

$$E_t\left[e^{-\alpha(T-t)}\right] = \left[\frac{A_t}{A_0}\right]^{-\gamma_1}. \tag{A.19}$$

This last expression coincides with our lemma. ■

Using this lemma, we obtain the value of equity:

$$E_t = A_t\frac{c-k}{c} + A_0\left(\frac{A_t}{A_0}\right)^{-f(r+\kappa_\omega)}(\omega_t - \bar{\omega}) + A_0\left(\frac{A_t}{A_0}\right)^{-f(r)}\left(\bar{\omega} - \frac{c-k}{c}\right) - \frac{\ell}{r}. \tag{A.20}$$

## B.2 Pass-through

We can compute the laws of motion for $E_t$ and $A_t^{\text{out}}$ using Ito's lemma. We drop the $dt$ terms as they do not enter the pass-through calculation, and ignore the "in" superscript. For the equity value, we obtain:

$$dE_t = \left(\frac{c-k}{c} - \frac{f(r+\kappa_\omega)}{A_t}\left(\frac{A_t}{A_0}\right)^{-f(r+\kappa_\omega)}A_0(\omega_t - \bar{\omega}) - \frac{f(r)}{A_t}\left(\frac{A_t}{A_0}\right)^{-f(r)}A_0\left(\bar{\omega} - \frac{c-k}{c}\right)\right)dA_t + A_0\left(\frac{A_t}{A_0}\right)^{-f(r+\kappa_\omega)}d\omega_t \tag{A.21}$$

For the outside value of the assets, we obtain:

$$dA_t^{\text{out}} = \omega_t dA_t + A_t d\omega_t \tag{A.22}$$

We can then compute the pass-through, remembering that cov $(dA_t, d\omega_t) = 0$:

$$PT = \frac{< dE_t, dA_t^{\text{out}} >}{(dA_t^{\text{out}})^2} \tag{A.23}$$

$$= \frac{\omega_t^2 dA_t^2}{\omega_t^2 dA_t^2 + A_t^2 d\omega_t^2} \left[ \frac{\frac{c-k}{c}}{\omega_t} - \frac{f(r+\kappa_\omega)}{\omega_t A_t} \left(\frac{A_t}{A_0}\right)^{-f(r+\kappa_\omega)} A_0 \left(\omega_t - \bar{\omega}\right) - \frac{f(r)}{\omega_t A_t} \left(\frac{A_t}{A_0}\right)^{-f(r)} A_0 \left(\bar{\omega} - \frac{c-k}{c}\right) \right]$$

$$+ \frac{A_t^2 d\omega_t^2}{\omega_t^2 dA_t^2 + A_t^2 d\omega_t^2} \left[ \left(\frac{A_t}{A_0}\right)^{-f(r+\kappa_\omega)-1} \right]. \tag{A.24}$$

We define the fractions of variance of $dA_t^{\text{out}}$ coming from the two shocks

$$V_A = \frac{\omega_t^2 dA_t^2}{\omega_t^2 dA_t^2 + A_t^2 d\omega_t^2}, \tag{A.25}$$

$$V_\omega = \frac{A_t^2 d\omega_t^2}{\omega_t^2 dA_t^2 + A_t^2 d\omega_t^2}. \tag{A.26}$$

## B.3 Extension: costs of financial distress

Consider the same setup as before, except that an additional cost $K$ is paid at liquidation. This cost can for instance represent the lower sales of policies because consumers are worried about the continued existence of the insurer or the cost of operating under higher regulatory scrutiny if constraints are not respected. It could also be generated by the direct fire sale discount when liquidating large positions on short notice. Noting $E_t^K$ the value of the equity and still $E_t$ the value in our standard model, we have:

$$E_t^K = E_t - \mathbb{E}_t \left[e^{-rT} K\right] \tag{A.27}$$

$$= E_t - \left(\frac{A_t}{A_0}\right)^{-f(r)} K. \tag{A.28}$$

Default costs lower the value of the equity, more so when the firm is close to liquidation. Similarly, we can immediately obtain the pass-through:

$$PT^K = PT + V_A \frac{f(r)}{\omega_t A_t} \left(\frac{A_t}{A_0}\right)^{-f(r)} K. \tag{A.29}$$

The costs of financial distress increase the pass-through.