Accounting Discretion and Stability: Insurer Ownership, Bond Volatility, and Firm Investment in Crises

John Barrios* Andreas Neuhierl† Linda Schilling‡

Abstract

This paper explores the real effects of accounting discretion by investigating how the exemption of insurance companies from mark-to-market (MTM) accounting during crises influences the performance of their bond holdings. Using a comprehensive dataset of corporate bonds held by insurers and mutual funds, we show that bonds owned by insurers, who employ held-to-maturity (HTM) accounting, experience significantly smaller drawdowns during financial crises compared to those held by mutual funds, which are subject to MTM rules. To address potential endogeneity, we apply a shift-share instrumental variable approach, leveraging the quasi-random allocation of bonds to insurers at issuance. Our findings demonstrate that the accounting treatment of bonds by insurers plays a critical stabilizing role, mitigating bond price declines in downturns. Additionally, we find that firms with a higher share of bonds held by insurers benefit from lower debt costs, which translates into increased capital expenditures and acquisitions post-crisis. These results highlight the broader implications of accounting rules in shaping financial stability and firm investment decisions, emphasizing the critical role of accounting discretion during periods of economic distress.

*School of Management, Yale University & NBER
†Olin Business School, Washington University in St. Louis
‡Olin Business School, Washington University in St. Louis, CEPR, FTG

1 Introduction

The role of accounting in financial stability has been a subject of extensive debate, particularly in the context of financial crises (Laux and Leuz (2009); Bischof et al. (2020)). One crucial aspect of this debate is the impact of mark-to-market accounting on the stability and performance of financial institutions (Laux and Leuz (2010); Bischof et al. (2021)). Mark-to-market, or fair value accounting, requires firms to value their assets at current market prices, reflecting real-time changes in market conditions. While this practice enhances transparency, it can also introduce volatility into financial statements, especially during periods of market stress.

Insurance companies, unlike mutual funds and other investors follow a regulatory framework that exempts them from mark-to-market accounting for their bond holdings. Instead, they are allowed to hold these bonds at amortized cost, thus avoiding the recognition of unrealized losses that would otherwise appear on their balance sheets during periods of financial instability (Ellul et al., 2015). This paper explores the real effects of this accounting exemption by examining the performance of corporate bonds held by insurance companies during financial downturns. Moreover, we examine the real effects of this difference for firms whose bonds are held by these insurance companies during a crisis.

The differential accounting treatment between insurance companies and mutual funds creates a distinct natural experiment to investigate how accounting rules influence investment behavior and financial stability. Mutual funds, governed by mark-to-market accounting and subject to daily pricing, often experience redemption pressures during market downturns. When investors seek to withdraw funds, mutual fund managers are compelled to liquidate assets to meet redemptions, even if those assets are trading at depressed prices. This forced selling amplifies market declines, as funds contribute to downward pressure on asset prices, a phenomenon well-documented in the literature (Chen et al., 2010; Coval and Stafford, 2007; Goldstein et al., 2017; Ferreira et al., 2012).

These "fire sales" create a feedback loop, where declining asset prices trigger further redemptions, leading to additional sales and further price declines (Shleifer and Vishny, 2011).

In contrast, insurance companies operate under different incentives and accounting rules. Insurers, particularly those governed by held-to-maturity accounting, are not required to mark their bond holdings to market. This allows them to hold onto assets through market downturns, avoiding the need to sell into declining markets. By being insulated from the daily pricing and liquidity demands that mutual funds face, insurers can act as stabilizing forces in financial markets, particularly during periods of high volatility (Chen and Fixler, nd; Santomero and Eckles, 2000; Zhong et al., 2021). The absence of immediate redemption pressures enables insurance companies to maintain more stable portfolios, reducing the likelihood of contributing to market instability. This distinction between the two types of institutions aligns with models of liquidity provision and financial stability, where investors with longer horizons (like insurers) can absorb temporary market shocks without resorting to asset sales, in contrast to liquidity-constrained institutions like mutual funds. This difference provides a critical mechanism through which accounting rules influence not only institutional behavior but also broader market dynamics.

To study this dynamic, we employ a comprehensive dataset that combines several sources: U.S. insurers' holdings from the Schedule D regulatory filings submitted quarterly to the National Association of Insurance Commissioners (NAIC), mutual fund holdings data from Morningstar, bond transaction-level data from the Enhanced Trade Reporting and Compliance Engine (TRACE), and bond characteristics from the Mergent Fixed Income Securities Database. This rich dataset enables us to analyze the weekly returns and characteristics of corporate bonds, allowing use to examine the bond performance during crisis periods. We focus on four significant bond market downturns: the Great Recession of 2008-09, the 2011 U.S. sovereign debt downgrade, the 2014-2016 commodity price collapse, and the onset of the COVID-19 crisis in 2020 as documented by Gilchrist and

Zakrajšek (2012) .

We begin our analysis by conducting a regression analysis that examines how bond downturns during crisis events vary based on the insurer share of ownership. We find that during crises, bonds held predominantly by insurance companies fall in value less than bonds held largely by mutual funds. Specifically, all else equal, increasing insurance holdings in a bond by 10 percentage points leads to price declines during downturns that are approximately 5 percent lower. Thus, firms whose bonds are held mainly by insurers experience less severe drawdowns in the value of their existing debt.

In contrast, bonds held predominantly by mutual funds experience a significant decrease in value during crisis periods. Increasing mutual fund holdings in a bond by 10 percentage points results in price declines that are approximately 7 percent higher. This stark difference highlights the stabilizing effect of insurance company ownership on bond prices during financial downturns. Mutual funds, which face redemption pressures, are more likely to sell bonds at depressed prices, exacerbating market declines.

The key empirical challenge is that the assignment of bonds to insurers or mutual funds might not be random but rather endogenous to the bonds' inherent safety. Insurers might, for instance, disproportionately hold bonds that are issued by firms whose revenues are more resilient and that will therefore do better in a crisis. To address this challenge, we introduce issuer-level fixed effects interacted with fixed effects for bond characteristics (such as credit rating, duration, issue size, debt seniority, and so forth) in each of our specifications. This approach fully absorbs any confounding variation that is fixed at the issuer level or explained by observable bond characteristics. Intuitively, the resulting estimates in our main specifications only compare bonds issued by the same firms, with the same credit rating, of very similar duration and size, one of which is held relatively more by insurers and the other by mutual funds.

Despite the strict empirical specification in our main test, we next turn to a shift-share instrumental variable (IV) approach to further strengthen the causal nature of our

findings. Our shift-share IV leverages the idiosyncratic nature of bond allocations to insurance companies at issuance. Insurers hold certain bonds more than others, even conditionally on being issued by the same firms and having the same characteristics, due to three institutional features of the market. First, large insurers mostly buy bonds when they are initially issued (on the primary bond market) and hold them for a long time — unlike mutual funds, which generally trade more actively. Second, even the very largest insurers are each only allocated a small subset of bonds at issuance through the primary-market distribution process; each insurer therefore ends up holding relatively few of the bonds available at any given time. These allocations at issuance in one particular bond versus a nearly identical one are driven by each insurer's idiosyncratic liquidity needs, relationships with underwriters, and purchase timing, making them plausibly exogenous. Third, these idiosyncratic allocations do not cancel out in the aggregate but rather affect the overall holdings of the insurance sector because of the heavily fat-tailed nature of the size distribution of insurers as shown in Coppola (2022).

These features motivate the use of a shift-share instrument that focuses on the extensive margin of primary market allocations: specifically, whether each insurer is allocated a particular bond at issuance. This approach removes potentially endogenous variation due to trading after a bond is first issued, as well as variation stemming from fluctuations over time in the total amount of capital available for new bond purchases by the insurance sector. Formally, the first stage regresses the insurance sector's aggregate holdings of a bond on binary indicators for whether each insurer purchased that bond at issuance, combined linearly according to insurer sizes. The instrument thus captures the overall size of the set of insurers that buy a bond at issuance, taking a high value if a bond is allocated to large rather than small insurers. The identifying assumption is that this matching between individual insurers and particular bonds on the primary market is uncorrelated with unobserved determinants of price dynamics during crises, which are not explained by issuer effects and the observed bond characteristics we control for.

Using the instrumented insurer shares, we continue to find a strong and negative effect of insurer share on drawdowns. Specifically, an increase in instrumented insurer shares by 10 percentage points leads to a reduction in bond price declines by approximately 1.12 to 1.16 percent during downturns. This result not only reinforces our earlier findings but also highlights the causal relationship between insurer ownership and bond performance during a crisis. This, in turn, affects the cost of debt for firms. By mitigating bond price declines, the held-to-maturity accounting reflected in the insurance ownership helps stabilize bond values, thereby reducing the effective interest rates and the overall cost of debt for firms during financial crises. This stabilization effect suggests that firms whose bonds are predominantly held by insurers would have lower debt costs and be better positioned to maintain operations, invest in growth opportunities, and weather economic downturns, which we examine further after our mechanism tests below.

Having established the causal relationship between insurer share holdings and bond drawdowns during crises, we next turn to examining the mechanism of accounting differences driving this relationship. We use the accounting treatments used in determining the required regulatory capital for holding speculative-grade assets differ significantly for life and property and casualty (P&C) insurers under the National Association of Insurance Commissioners's model law. Specifically, when an asset held by insurance companies is downgraded from investment to speculative grades, the Statutory Accounting Principles (SAP) state that P&C insurers must immediately recognize the asset value as the lower of the book value (based on historical cost accounting, HCA) or the market price (or model price, if no market price is available). In contrast, life insurers may continue to hold the downgraded asset under HCA, except in cases of significant impairment. This regulatory difference provides a natural experiment to isolate the impact of accounting practices on bond price stability within the insurance sector.

Focusing on rating changes from investment grade to speculative for bonds bonds held by these insures, we find that bonds held by P&C insurers experience more negative

price changes following rating downgrades as compared to bonds held by life insurers. Specifically, a 10 percentage point increase in P&C insurer shares leads to an additional 1.17 percent decline in bond prices following a downgrade, while the effect for life insurers is small and not statistically significant. This difference suggest that the mark-to-market accounting requirements for P&C insurers amplify bond price declines during rating changes, whereas the held-to-maturity accounting for life insurers helps to mitigate these declines, underscoring the role of accounting practices in influencing bond price stability and, consequently, the cost of debt for firms.

We now transition from the bond market implications to examine the real effects of insurer bond holdings on firm behavior. Specifically, we investigate how the cost of debt, influenced by whether a firm's bonds are held by insurers, affects firms' capital expenditures and acquisition behavior around the financial crisis. Since this analysis is at the firm level, we cannot employ our prior identification strategy that relied on variation across securities issued by the same firm. Instead, we couple a difference-in-differences design with an aggregated version of the instrument.

We find that, consistent with a lower cost of debt for these firms, post-crisis firms with a higher share of bonds held by insurers exhibit significant increases in capital expenditures and acquisition activity. Specifically, an increase in insurer bond share by 10 percentage points is associated with a 0.18 percentage point increase in CAPEX. This effect remains robust across various specifications, including controls for firm size, leverage, and bond duration. Furthermore, when using the firm instrumented share to address potential endogeneity concerns, the effect of insurer share on investment activities becomes even more pronounced. A 10 percentage point increase in insurer bond share is associated with a 5.69 percentage point increase in CAPEX and an 11.35 percentage point increase in CAPEX plus acquisitions. These magnitudes are broadly consistent with findings in the bank lending literature; for example, Amiti and Weinstein (2018) find that a 20 percent contraction in bank lending supply leads to a decline of about 2 percentage points in firm

investment rates.

Overall, these results suggest that firms with a higher share of bonds held by insurers benefit from lower debt costs, enabling them to increase their capital expenditures and engage in more acquisition activities post-crisis. Consequently, these firms are better positioned to maintain operations, invest in growth opportunities, and navigate economic downturns, supporting the broader conclusion that accounting choices play a critical role in financial stability and firm performance during crises.

This paper makes several important contributions to the literature on accounting, disclosure and real effects behavior during crises.

First, we provide empirical evidence on the stabilizing effect of insurance company ownership on bond prices during financial downturns. Previous studies have highlighted the importance of investor composition in influencing bond price dynamics and capital allocation during crises. For example, Coppola (2024) demonstrates that the composition of bond investors significantly affects the resilience of bond markets during financial stress, with bonds held by insurers experiencing milder losses. However, our study extends this literature by examining the underlying mechanisms that drive these observations, specifically focusing on the differential accounting treatments of held-to-maturity (HTM) versus mark-to-market (MTM) accounting.

In the context of the bond market, several papers have underscored the influence of investor characteristics on equilibrium prices. Siani (2022) estimates a model of differentiated investors in segmented primary bond markets, while Ellul et al. (2011) highlight the role of regulatory constraints in shaping insurers' bond sales when bonds are downgraded to speculative grade. In their study, regulation-driven insurer behavior exacerbates fire sales in a localized sense. However, our findings show that insurer behavior can mitigate fire sales in a systemic context. Relatedly, Becker et al. (2022) demonstrate that regulatory incentives shape insurers' holdings of mortgage-backed securities. Our research complements these studies by showing how accounting discretion within the regulatory

framework can have stabilizing effects on the broader financial system during crises.

Additionally, our study contributes to the understanding of how accounting practices influence financial stability and firm real activity during economic downturns. we explore the real effects of these accounting practices on firm behavior. Our results reveal that firms with a higher share of bonds held by insurers benefit from lower debt costs, enabling them to increase capital expenditures and acquisition activities post-crisis. This evidence suggests that accounting discretion plays a critical role in enhancing financial stability and supporting firm-level investment and growth during periods of economic turmoil.

2 Institutional Setting

2.1 Held-to-Maturity vs. Mark-to-Market in Financial Institutions

The accounting treatment of financial instruments significantly influences the stability and performance of financial institutions. Two primary methods for valuing these instruments are Held-to-Maturity and Mark-to-Market accounting. HTM accounting allows financial institutions to record certain financial assets at their amortized cost, rather than their current market value. Under this method, assets classified as HTM are initially recorded at their purchase price, and any premiums or discounts are amortized over the life of the asset. This approach aligns with the long-term nature of certain liabilities, such as those of insurance companies, which hold these assets to maturity to meet future obligations. The key advantage of HTM accounting is that it provides financial stability by shielding the institution's balance sheet from short-term market volatility. Unrealized gains or losses are not recognized, which helps maintain a stable financial outlook.

In contrast, MTM accounting, also known as fair value accounting, requires financial institutions to value their financial assets at their current market prices at the end of each reporting period. This method ensures that the financial statements reflect the fair value of the assets, providing transparency and an accurate picture of the institution's

financial health. However, MTM accounting introduces significant volatility into financial statements, as the value of assets fluctuates with market conditions. This can lead to substantial swings in reported earnings and capital levels, particularly during periods of market stress.

The choice between HTM and MTM accounting has profound implications for financial institutions. HTM accounting provides stability by smoothing out the effects of market fluctuations, which is crucial for entities like insurance companies that have long-term liabilities. In contrast, MTM accounting enhances transparency but can exacerbate financial instability during market downturns, as institutions are forced to recognize unrealized losses, potentially triggering further sales and price declines.

2.2 Accounting Treatment by Insurance Companies for Fixed Income Securities

Insurance companies follow specific accounting standards for the treatment of fixed income securities, governed by the National Association of Insurance Commissioners (NAIC). These standards differ significantly from those applied to other financial institutions, such as mutual funds, particularly in the context of speculative-grade assets. Insurance companies in the United States adhere to Statutory Accounting Principles (SAP), which are designed to ensure solvency and provide a conservative measure of financial health. Under SAP, insurance companies can classify their bond holdings as HTM, allowing them to record these assets at amortized cost rather than market value. This classification is particularly prevalent among life insurers, who hold bonds to maturity to match their long-term liabilities.

For property and casualty (P&C) insurers, the accounting treatment is more stringent when it comes to speculative-grade assets. According to SAP, when a bond is downgraded from investment grade to speculative grade, P&C insurers must immediately recognize the asset at the lower of its book value or market price. This requirement introduces an element

of MTM accounting for downgraded assets, potentially increasing the volatility of financial statements during periods of economic stress. In contrast, life insurers may continue to hold downgraded bonds at amortized cost unless there is significant impairment. This leniency allows life insurers to avoid the immediate recognition of unrealized losses, thereby maintaining a more stable financial position. The ability to hold assets at amortized cost aligns with the long-term nature of their liabilities and investment strategies.

The differential accounting treatment between P&C and life insurers has important implications for financial stability. Life insurers benefit from reduced volatility in their financial statements, which can be critical during market downturns. In contrast, P&C insurers' requirement to mark down speculative-grade assets can exacerbate financial instability by forcing the recognition of losses during crises. Mutual funds, governed by Generally Accepted Accounting Principles (GAAP), must mark all their bond holdings to market. This requirement ensures that the net asset value (NAV) of the fund accurately reflects current market conditions but introduces significant volatility, particularly during financial crises. The transparency provided by MTM accounting comes at the cost of increased sensitivity to market fluctuations, which can lead to investor redemptions and forced sales, further driving down asset prices.

Understanding the accounting treatment of fixed income securities by insurance companies is crucial for comprehending their behavior and stability during financial crises. The choice between HTM and MTM accounting significantly affects the volatility and financial health of these institutions, with broader implications for market stability and firm performance. This institutional background sets the stage for our analysis of the real effects of accounting practices on bond performance and firm behavior during economic downturns.

2.3 Crises

Our analysis focuses on the impact of accounting choices by insurers during financial crises, specifically examining how bond downturns vary based on the insurer share of ownership during the four most significant bond market downturns in our sample period. We use the crisis events defined by Gilchrist and Zakrajšek (2012) (GZ), which identify these periods using the troughs and peaks of the GZ Index, a comprehensive measure of credit spreads on U.S. corporate bonds. The shaded areas in Figure 5 indicate the start and end dates of these crisis periods.

The first downturn event is the Great Recession of 2008-09, a period marked by severe financial instability and unprecedented market disruptions. During this event, the GZ index surged more than four-fold, rising from a trough of 1.7 percent in June 2007 to a peak of 7.9 percent in December 2008. This period saw widespread distress across financial markets, with significant implications for bondholders, particularly those holding assets marked-to-market.

The second event window spans from April 2011 to October 2011, coinciding with the downgrade of U.S. sovereign debt by Standard & Poor's. This downgrade triggered a cascade of global market turmoil, reflected in heightened credit spreads and increased volatility. During this period, the behavior of institutional investors, particularly insurers, was under scrutiny as they navigated the market turbulence.

The third window, from August 2014 to February 2016, captures a period of significant commodity price collapses. The sharp decline in commodity prices, especially oil, had far-reaching effects on credit markets, with the GZ index reflecting heightened credit risk. This period provides a contrasting scenario to the previous crises, offering insights into how different types of economic shocks influence bond markets and the role of insurers in these contexts.

Lastly, the fourth event window, from January 2020 to March 2020, corresponds to the onset of the global COVID-19 crisis. The pandemic induced severe market disruptions,

with widespread price dislocations for corporate bonds (Haddad et al., 2021; Ma et al., 2022). The GZ index during this period highlights the acute stress experienced in credit markets. The unprecedented nature of the COVID-19 crisis, combined with its global reach, provides a unique context to study the behavior of insurers and their impact on bond drawdowns.

3 Institutional Context and Theoretical Motivation

Our analysis builds on a robust theoretical foundation that explores how accounting practices influence financial stability and asset pricing, particularly during periods of economic stress. Existing studies, including Allen and Carletti (2008), Sapra (2008), Plantin et al. (2008), Heaton et al. (2010), Gigler et al. (2016), and Milbradt (2012), provide key insights into the interplay between accounting frameworks, institutional behavior, and market outcomes.

This section situates our analysis within this broader literature, detailing the institutional context of bond markets and the theoretical implications of different accounting practices. We focus on the roles of insurers, money market mutual funds (MMFs), and other investors, highlighting how their accounting choices shape their responses to economic shocks. In Section 4.1, we formalize these dynamics in a theoretical model that examines the interaction between accounting rules and investor composition, and how these factors influence bond prices and broader market stability.

3.1 Accounting Practices and Financial Stability

Accounting practices potentially play a pivotal role in shaping the behavior of financial institutions during crises, with significant repercussions for financial stability. A key distinction in accounting methods—mark-to-market versus held-to-maturity —can lead to very different outcomes for institutions holding the same underlying assets.

Mark-to-market accounting, which requires institutions to regularly adjust the value of their assets to reflect current market prices, can exacerbate financial instability during crises. As modeled by Allen and Carletti (2008) and Plantin et al. (2008), marking assets to market forces institutions to recognize unrealized losses when market prices decline, even if those price declines are temporary. This immediate recognition of losses can induce institutions to sell assets at depressed prices to maintain liquidity or meet regulatory capital requirements, initiating fire sales that further depress asset prices. This phenomenon contributes to a downward spiral, amplifying market volatility and worsening financial crises.

In contrast, HTM accounting allows institutions to avoid recognizing short-term losses by valuing assets at their amortized cost, as long as there is no permanent impairment. By decoupling reported asset values from fluctuating market prices, HTM accounting provides a degree of insulation from market volatility. Heaton et al. (2010) argue that this stability allows institutions to avoid unnecessary asset sales, manage liquidity more effectively, and weather short-term market fluctuations. As a result, HTM accounting can serve as a countercyclical buffer, reducing the procyclical pressures that exacerbate downturns under MTM rules.

3.2 Transparency, Information Asymmetry, and Market Discipline

While HTM accounting can stabilize balance sheets, it comes at the potential cost of reduced transparency. Mark-to-market accounting, by providing more frequent and accurate reflections of current market values, can improve transparency and mitigate information asymmetry. Sapra (2008) suggests that this transparency enables market participants to make more informed decisions, thereby enhancing market discipline and preventing institutions from hiding risks through opaque accounting practices. However, increased transparency may also have unintended consequences: Gigler et al. (2016) note that MTM accounting can lead to greater volatility, as market participants react to

short-term price movements, which may not reflect the long-term value of the assets.

In the context of financial crises, the tension between transparency and stability becomes particularly important. Institutions that provide more timely information through MTM accounting may face greater pressure to liquidate assets in response to perceived risks, even when the underlying fundamentals are sound. On the other hand, institutions using HTM accounting can maintain stable valuations, but at the cost of reduced market discipline and potentially less accurate information about their financial health. This trade-off between stability and transparency is central to our analysis of insurer behavior in the bond market during downturns.

3.3 Asset Liquidity and Price Dynamics

The liquidity of assets also plays a critical role in determining the impact of accounting practices on financial stability. Milbradt (2012) offers a theoretical model linking asset liquidity to market prices, showing that less liquid assets can experience larger price declines during financial crises. The model highlights that institutions holding illiquid assets may face steeper markdowns under MTM accounting, exacerbating financial distress. In contrast, HTM accounting allows institutions to avoid marking down these assets to their depressed market prices, thereby reducing the pressure to sell illiquid assets during crises.

This dynamic is particularly relevant in the bond market, where liquidity can vary significantly across different types of bonds. During a financial downturn, more liquid assets may recover more quickly, while less liquid assets—such as certain corporate bonds—may suffer prolonged price declines. Insurers, particularly those using HTM accounting, can hold these less liquid assets without being forced to sell at unfavorable prices, stabilizing both their own portfolios and the broader bond market.

4 Theory

Building on these theoretical insights, we introduce a formal model to analyze how accounting practices influence the behavior of institutional investors and bond market dynamics during financial downturns.

4.1 The Model

Our model is based on Plantin, Sapra, and Shin (2008) who also feature endogenous price impact, and an endogenous price stabilization mechanism since sales decisions can switch from being strategic complements to substitutes under mared-to market pricing. We further resemble Plantin, Sapra, and Shin (2008), since also here, prices are endo genous to the asset supply and vice versa. We differ from Plantin, Sapra, and Shin (2008) since here, the institutions do not decide whether or not to securitize a loan portfolio subject to repayment risk. Rather, we analyze bond sales in a secondary market. Further, in Plantin, Sapra, and Shin (2008) all institutions are small and each on its own has negligible price impact. In contrast, we have one large player, the insurer, versus many small players, the MMF investors. The large player's presence impacts the equilibrium price since abstaining might yield to higher profits. The fact that large players alter the equilibria in run games has been studied before in Corsetti, Dasgupta, Morris, and Shin (2004). Zeng (2017) also studies runs on MMFs, however, we differ from his model since we feature endogenous price impact, where redemptions must be optimal given expectations on future prices, and the extent of redemptions impact mutual fund share prices.

Bond investors and bond issuers In our model, there is a single bond issuer, three groups of bond investors, and investors of bond investors. There are three points in time, $t = 0$, $t = 1$, and $t = 2$. We assume a discount factor β.

The bond issuer issues zero coupon bonds of quantity S_0 (supply) to the market in

$t = 0$, which are to be repaid in $t = 2$. Let b_0 denote the market clearing bond price in $t = 0$, and denote by P the principal the bond is supposed to repay in $t = 2$. Denote by $\theta_0 > 1$ the solvency state of the bond issuer in $t = 0$, which is observable, and thus common knowledge to all market participants and let $p(\theta_0)$ the common prior at the issuance date that the bond repays principal P in $t = 2$, where $p(\theta)$ is a strictly increasing, continuous function, taking values in $[0,1]$. The initial market clearing bond price b_0 takes into account the solvency of the issuer θ_0 as well as other market conditions such as interest rates or discounting in $t = 0$.

The demand D_0 for the bonds is driven by three different investor groups, insurance companies, money market mutual funds (MMF), and "other investors." There are no other bond investors besides these three groups. Vice versa, we assume that the three bond investors hold only this particular bond, and do not invest in other bonds.[1] Insurers and MMFs have also investors, but of different types, see Figure 1.

Insurer's investors (households) The insurance company issues long-term insurance claims to households. The measure of insured households is given by a continuum of measure $A_I \geq 0$. In $t = 0$, the households invest in the insurance contracts, paying a premium d_I to the insurance company to establish their claim. The insurance company pools the premia, and invests them in bonds of the given issuer. We assume that insurance contracts are long-term from $t = 0$ to $t = 2$, and early cancellations in $t = 1$ come with high penalties such that households receive zero, meaning that we assume cancellations away. Denote the insurer's demand for bonds in $t = 0$ by

$$D_I = \frac{d_I A_I}{b_0} \tag{1}$$

MMF investors MMF investors are small, and are given by a continuum of measure

[1] The analysis effortlessly carries over to multiple bond issuers that issue similar bonds, since we can simply relable the group of bond issuers as one large issuer.

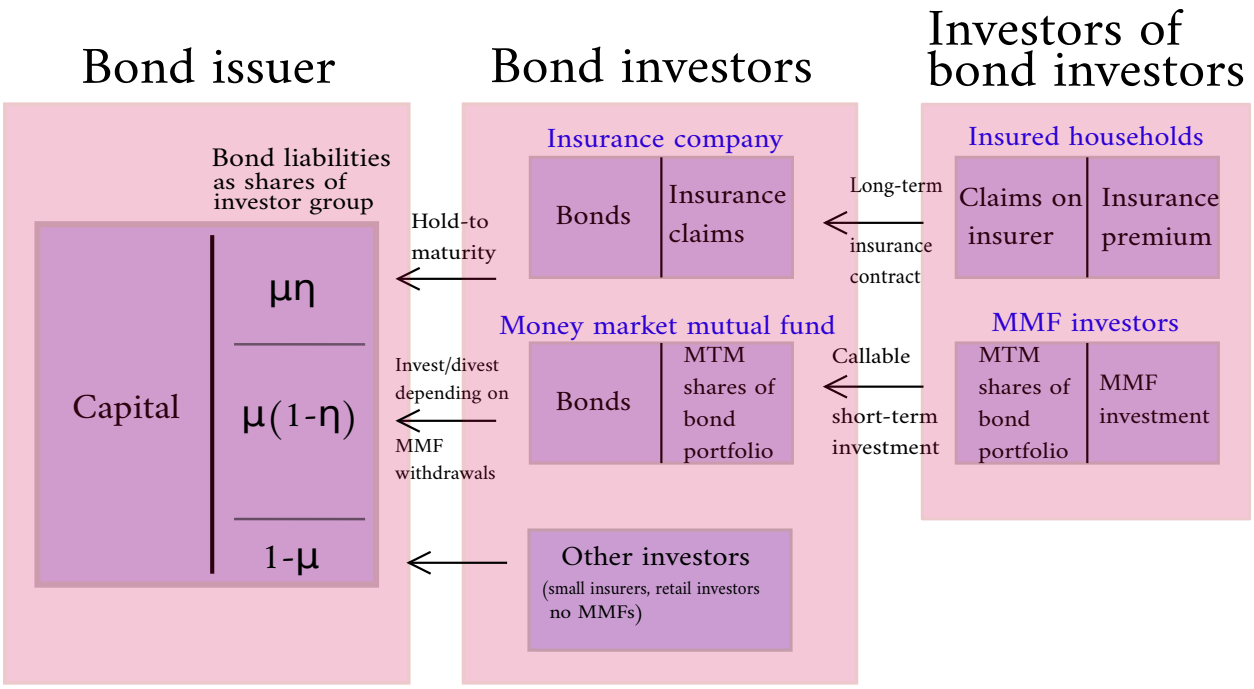


Figure 1: Bonds are held by different investor groups, insurers, MMFs and other investors. The bond investors, likewise, have investors such as insured households that pay insurance premia, respectively, MMF investors that have claims on MMF shares. The bonds thus back different types of claims with distinct maturities, long-term insurance claims and short-term callable MMF shares.

$A_M \geq 0$. In $t = 0$, the money market mutual fund offers shares to MMF investors for a unit investment. We assume that all MMF investors symmetrically invest one unit. The MMF pools the investments of its investors to purchase bonds. At an initial bond price b_0, the MMF's demand for bonds equals

$$D_M = \frac{A_M}{b_0} \tag{2}$$

MMF investment is short-term. The MMF investors can redeem shares at any point in time in $t = 1$, and $t = 2$ at an MMF share price which is marked to market, reflecting the value of the MMF's bond portfolio, see below.

Other investors' investors For completion, other bond investors collect funds A_o from their investors, and hence have a bond demand

$$D_o = \frac{A_o}{b_0} \tag{3}$$

Clearing in the bond market At $t = 0, 1$, the bond price b_t adjust such that the (secondary) bond market clears, equalizing supply and demand.

$$D_t(b_t) = S_t(b_t) \tag{4}$$

As the primary bond market clears in $t = 0$, the insurers, the MMFs and other investors hold asymmetric shares of the initial bond supply. Since we observe these different investor shares in the data, we take them as given. Generically, MMFs, insurers and other investors have different demand for the bond which gives rise to these different shares. Denote by $\mu \in [0, 1]$ the share of bonds held jointly by the insurer and the MMF, and call $1 - \mu$ the share of bonds held by other investors. Call $\mu\eta \in [0, 1]$ the share of bonds held by the insurer and call $\mu(1 - \eta)$ the share held by MMFs. We can decompose the bond issuance as

$$\underbrace{S_0}_{\substack{\text{total bond supply} \\ \text{(issuance)}}} = \underbrace{\mu\eta\, S_0}_{\substack{\text{bonds held by} \\ \text{insurers}}} + \underbrace{\mu(1-\eta)\, S_0}_{\substack{\text{bonds held} \\ \text{by MMFs}}} + \underbrace{(1-\mu)\, S_0}_{\substack{\text{bonds held by} \\ \text{other investors}}} \tag{5}$$

The main focal point of our analysis is on how a change in a bond's investor composition (η, μ) affects bond prices in times of crises. For this purpose, we consider how changes in μ, and in particular η drive bond prices. When holding the investments by other investors μ fixed, increasing η corresponds to the case where the insurer holds a larger initial share of the bond issuance relative to the MMF's bond share. In contrast, an increase in μ means that the insurer and the MMF jointly hold more bonds than other investors.

Bond allocation by investor group The size of the bond share of each of these bond investors corresponds to a particular group size and funds of their investors, $((A_I, d_I), A_M, A_o)$. Given the insurers' bond demand in (1), insurers hold the quantity $D_I = \mu\eta S_0$ of bonds, and the insurer share is pinned down by the insurer's investor groups size and premium,

$$\mu\eta = \frac{D_I}{S_0} = \frac{d_I A_I}{b_0 S_0} \tag{6}$$

Given the MMFs' bond demand in (2), the MMFs jointly hold the quantity $D_M = \mu(1-\eta)S_0$ of bonds, and the MMF's share in the bond must equal the MMF's bond demand as a share of the total bond supply,

$$\mu(1-\eta) = \frac{D_M}{S_0} = \frac{A_M}{b_0 S_0} \tag{7}$$

Given the demand (3) by other investors, the bond share other investors hold is determined by

$$(1-\mu) = \frac{D_o}{S_0} = \frac{A_o}{b_0 S_0} \tag{8}$$

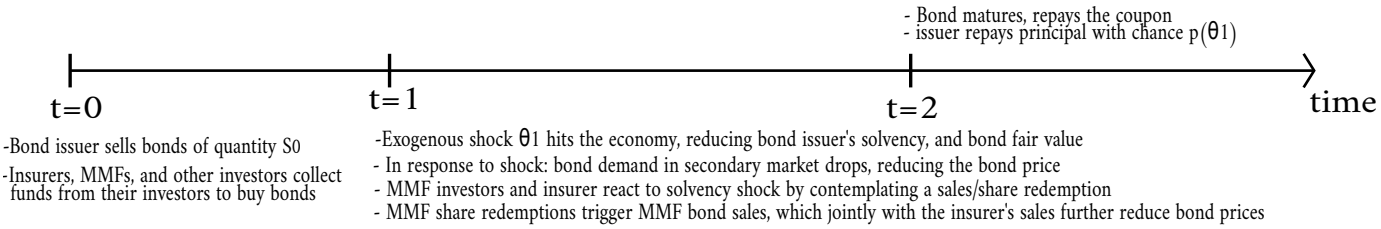


Figure 2: Unfolding of events

4.1.1 $t = 1$: Exogenous shocks, bond fire sales, and price responses

Exogenous systemic shock At the beginning of $t = 1$, an exogenous, random shock $\varepsilon \sim U[-1, 0]$ to the economy (systemic risk) realizes observably to all agents, lowering the bond issuer's solvency from θ_0 to $\theta_1 = \theta_0 + \varepsilon < \theta_0$. Due to the change in solvency, two things happen. First, the bond's repayment probability of principal P declines to $p(\theta_1)$, altering the bond's fair value to $b_2 = p(\theta_1)P$, equal to the expected principal to be repaid in

$t = 2$. Second, and relatedly, the solvency shock depresses the residual demand (after the clearing of the primary market in $t = 0$, $D_0 = S_0$ at price b_0) for the bond in the secondary market in $t = 1$,

$$D_1(b_1|\theta_1, b_2) = D_0(b_0|\theta_0) + \theta_1 < D_0(b_0|\theta_0), \quad \theta_1 \in [-1, 0] \tag{9}$$

We further assume, that the demand curve $D_1(b_1|\theta_1, b_2)$ is strictly decreasing, and continuous in the interim bond price b_1. The issuer's solvency shock and the bond demand shock both provoke a sales response from the bond's investors.

Insurer's actions, Held-to-maturity accounting (HTM), and Regulatory Capital Constraints First, since insurance contracts are long-term with high penalties for premature cancellation, insured households can generically not react in the same way as MMF investors can, and they will stick to their contracts. Insurers can, however, strategically liquidate bonds but are subject to regulation, and held-to-maturity accounting:

In response to the solvency shock, in $t = 1$ the insurer can strategically decide to sell bonds or wait until $t = 2$, unless the solvency shock θ_1 falls into an extreme, low range, $[0, \underline{\theta}]$. In the latter case, by **regulatory capital constraints**, the insurer is required to to liquidate all bonds. These capital requirements guide the insurers' investment and divestment decisions, but HTM accounting provides them with greater flexibility than MMFs that rely on MTM accounting. To capture HTM accounting discretion, we assume that insurers are required to liquidate their bonds only if the solvency shock is extreme, i.e. if the exogenous shock ε realizes low enough such that the updated issuer's solvency θ_1 falls in the interval $[0, \underline{\theta}]$, $\underline{\theta} \in (0, 1)$. One can think of the threshold $\underline{\theta}$ as the critical solvency threshold that would lead to a severe rating downgrade of the bond. If the shock falls in a less extreme range, the adjusted solvency θ_1 lies in the

$$\textbf{Accounting discretion range for insurers:} \qquad (\underline{\theta}, 1] \subset [0, 1], \tag{10}$$

and insurers have discretion as to whether they want to liquidated bonds or not. By not selling bonds, insurers can avoid recognizing unrealized losses immediately, and thus face less pressure to liquidate lower priced bonds. As we show below, this accounting discretion acts as a buffer against market price volatility, contrasting with the behavior of mutual funds and helping to explain the stabilizing effect we observe empirically.

While insurers may, hence, prevent incurring the lower bond sales price b_1, they remain subject to the risk that the bond does not repay principal with probability $1-p(\theta_1)$ in $t=2$. We assume that the insurer either liquidates all or no bonds. Let $a_I \in \{0,1\}$ the insurers action, where $a_I = 1$ means that the insurer sells all of its bonds.

MMF actions and MTM Accounting In response to the solvency shock, the MMF must respond to its investors. In $t=1$, each of the MMF investors strategically decide whether to redeem shares or rather to wait until $t=2$, where the redemptions prompt the MMF to sell bonds for financing redemptions. When making their decisions, the MMF investors take into account that MMF shares are **marked-to market**, meaning that the share price at which MMF investors redeem takes into account the current, market clearing price of the bond. Denote by $n_M \in [0,1]$ the share of MMF investors that redeem shares. In addition, we assume that among the other investors there is a measure $\bar{S}$ of investors that sell bonds in $t=1$ due to liquidity needs, unrelated to the price, so that only the insurer and the MMF act strategically in $t=1$.

Denote by $S_1(\theta_1)$ the endogenous bond supply in the secondary market, resulting from the MMF's, the insurers' and other investors' bond sales in response to the solvency shock. Denote by $b_1(\theta_1)$ the endogenous, market-clearing bond price in the secondary market after the solvency shock at $t=1$, given as the solution to

$$D_1(\theta_1, b_1) = S_1(b_1, \theta_1) \tag{11}$$

As an important feature of our model, the bond price b_1 is endogenous to demand D_1 and supply S_1 since we require market clearing, however, the supply S_1 is also endogenous to the price b_1 versus the updated fair value of the bond $b_2 = E[p(\theta_1)P]$, and the shock θ_1 because investors sell or redeem bonds strategically. Overall, equation (11) defines a fixed point problem. The value $b_2(\theta_1)$ is independent of bond sales, supply and demand, and will serve as an anchor in our calculations.

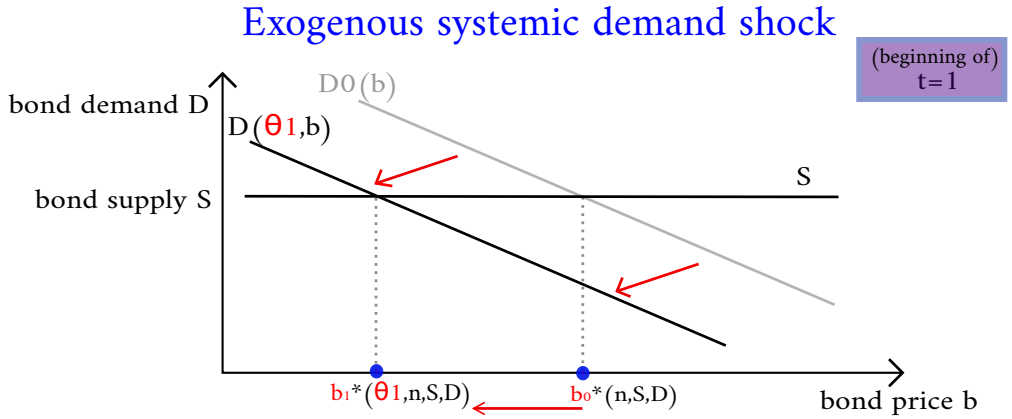


Figure 3: At the beginning of $t = 1$ (before the fire sales): An exogenous shock to the economy reduces the bond issuer's solvency, thus suppressing the bond's demand, and thus its price b_1 in the secondary market. In Figure 3, we depict how the initial shock shifts the demand for the bond down, from $D_0(b)$ to $D_1(\theta_1, b_1)$, suppressing the bond's market price, $b_1(\theta_1) < b_0$, before the fire sales begins.

Definition 4.1 (Equilibrium). *Given an initial bond supply S_0, bond principal P, an initial bond allocation $(\mu S_0, \eta(1-\mu)S_0), (1-\eta)(1-\mu)S_0)$ to the insurers, MMFs and other investors, an exogenous shock θ_1 to the economy, solvency indicator $p(\theta)$, and an exogenous demand curve $D_1(b_1, b_2, \theta_1)$, an equilibrium in the secondary bond market consists of bond prices (b_1, b_2), MMF share prices (p_1, p_2), MMF redemptions $n_M \in [0,1]$ in $t = 1$, the insurer's sales decision $a_I \in \{0,1\}$, and bond supply S_1 in the secondary market at $t = 1$, such that*

- *all investors update their fair value about the issuer's bond, given the shock θ_1, $b_2 = E[p_2(\theta_1)]P$*
- *The bond supply S_1 in $t = 1$ is optimal given prices: the redemption decisions n_M by MMF*

investors and the sales decision a_I by the insurer are optimal given prices (b_1, b_2), (p_1, p_2)

- *The bond prices clear the market: the supply in the secondary market, resulting from the redemption decisions by MMF investors and the sales decision by the insurer equals the demand*

$$S_1(b_1|b_2) = D_1(b_1|b_2, \theta_1)$$

- *The MMF share prices are marked-to market, given as functions of the market clearing bond prices*

$$\begin{aligned} p_1 &= b_1 \frac{D_M}{A_M} \\ p_2 &= b_2 \frac{D_M}{A_M} \end{aligned}$$

Importantly, as an MMF investor decides to redeem shares in $t = 1$, she does not know yet how many other MMF investors will redeem shares, and whether or not the insurer sells bonds. Therefore, the share price $p_2(\theta_1, n_M)$ is unknown as an MMF investor makes her redemption decision. However, in equilibrium, decisions need to be optimal. Thus, the overall bond sales S_1, composed of the insurer's sales, the MMF sales, and the sales of other investors has to imply market clearing bond prices at which supplying S_1 optimal.

4.2 Model Analysis

For a given investor base A_I, A_M, A_o, a bond issuance S_0, and market clearing bond price b_0, we can solve (8), (7), and (6) for μ and η, the MMF's and the insurer's bond shares can be expressed as

$$\begin{aligned} \mu &= 1 - \frac{A_o}{b_0 S} \\ \eta &= \frac{d_I A_I}{b_0 S - A_o} = 1 - \frac{A_M}{b_0 S - A_o} \end{aligned} \tag{12}$$

Optimal behavior by MMF investors The MMF investors hold claims on shares of the MMF's bond portfolio. In response to the shock in $t = 1$, MMF investors can redeem shares at the mark-to-market share price p_1 in $t = 1$, or wait until $t = 2$. The MMF observes the redemptions by its investors in $t = 1$, and finances redemptions by selling bonds in the secondary market. The MMF's bond sales affects the current market price of the bond (price impact). The MMF share value adjusts on an ongoing basis subject to the market conditions (marked-to-market), and directly depends on the value of the bond portfolio. Call p_1 the MMF share price in $t = 1$. Likewise, call p_2 the MMF share price in $t = 2$. Let $n_M \in [0, 1]$ denote the endogenous, random share of MMF investors that redeem shares in $t = 2$. Because a measure A_M of MMF investors have claims on the MMF, and the MMF holds a measure D_M of bonds, at a bond price b_1, the MMF share price must solve

$$b_1 \, D_M = p_1 \, A_M \tag{13}$$

where the left hand side equals the market value of the MMF's bond portfolio, and the right hand side yields the market value of the MMF's liabilities. This equation yields a mark-to-market MMF share price of

$$p_1 = \frac{D_M}{A_M} \, b_1 \tag{14}$$

Therefore, a single MMF share redemption at price p_1 requires the liquidation of D_M/A_M bonds at price b_1. An endogenous measure of $n_M A_M$ redemptions at price p_1 in $t = 1$, hence, require the MMF to sell $n_M A_M \times D_M/A_M = n_M D_M$ bonds at price b_1. The remaining bond portfolio is hence $(1 - n_M)D_M$, and the share price in $t = 2$ expected at $t = 1$ must equal

$$p_2(\theta_1) = b_2(\theta_1) \, \frac{(1 - n_M)D_M}{(1 - n_M)A_M} = E[p(\theta_1)]P \, \frac{D_M}{A_M} \tag{15}$$

After observing the updated solvency of the bond issuer, θ_1 in $t = 1$, the MMF investors

need to decide whether they want to redeem their shares or whether they wait until $t = 2$ when the bond matures. When making their decision, each MMF investor takes into account the lower probability that the issuer repays principal with probability $p(\theta_1)$, and the fact that other MMF redemptions and the insurer's possible bonds sales lower the MMF share price in $t = 1$.

Lemma 4.1 (Optimal MMF redemptions)**.** *An MMF investor optimally redeems shares in $t = 1$ if and only if the solvency shock θ_1, the secondary market supply of bonds S_1, and the market clearing bond prices b_1, b_2 are such that the MMF share prices satisfy $p_1(b_1, S_1) \geq \beta\ p_2(\theta_1)$ which holds if and only if*

$$b_1(S_1) \geq \beta\ b_2(\theta_1) \tag{16}$$

Lemma 4.2 (Optimal insurer bond sales)**.** *The insurer optimally sells bonds in $t = 1$ if and only if the solvency shock θ_1, the secondary market supply of bonds S_1 (including the insurer's and MMF's bond sales), and the resulting market clearing bond prices b_1, b_2 are such that $b_1 \geq \beta b_2$. The insurer is further required by regulation to sell bonds if $\theta_1 \in [0, \underline{\theta}]$.*

4.3 Maximum optimal bond supply in the secondary market

To understand the main economic mechanism in our paper, it is important to recall that sales decisions by the MMF and the insurer in $t = 1$ have an instantaneous price impact. Since MMF investors are small, a single redemption does not alter the bond, and thus MMF share price p_1. However, given the other investors' share redemptions n_M, and the insurer's sales decision a_I, redeeming in $t = 1$ is only optimal if the overall supply in the secondary market S_1 that results from joint sales decisions is small enough to guarantee a share price p_1 above $p_2\beta$, or, equivalently a bond price $b_1 \geq \beta b_2$. If supply S_1 is too large relative to $b_2(\theta_1)$, the joint price impact from the bond fire sales is too large, pushing the bond price b_1 below βb_2, implying that selling bonds, respectively redeeming shares is ex post no longer optimal.

(the actions to redeem shares become strategic substitutes once p_1 falls below βp_2). The MMF investors are aware of this, and redeem fewer shares, the secondary market supply declines since the MMF sells fewer bonds, and the bond price b_1 recovers back to a level βb_2.

Put differently, because MMF shares are marked-to market, and bond prices react to the market conditions, and in particular aggregate supply, bond sales and redemption decisions by the insurer and the MMF investors' are strategic complements only as long as supply S_1 is small enough, granting $p_1 > \beta p_2$. Sales and redemption decisions become strategic substitutes once the interim bond supply S_1 is too large. The price stabilization result via strategic substitutability is known in the literature, see Plantin, Sapra, and Shin (2008). Because of the switch of actions from strategic complements to substitutes, we can define a notion of a maximum rationalizable bond fire sales size, i.e. a maximum interim bond supply that is an optimal response to the shock θ_1, exogenous demand D_1, and beliefs about investor sales behavior.

Definition 4.2 (Residual supply)**.** *Fix the solvency shock θ_1, an exogenous demand curve $D_1(b_1|b_2,\theta_1)$ with according fair bond price $b_2(\theta_1)$ in $t=2$. Define the residual bond supply as the supply beyond $\underline{S}_1$ required to equalize the interim price with its fair value,*

$$S^{res} \equiv D_1(\beta b_2\,|b_2,\theta_1) - \underline{S}_1 \tag{17}$$

where $D_1(\beta b_2\,|b_2,\theta_1)$ is the bond demand in the secondary market conditional on $b_1 = b_2\beta$, i .e. if the bond price in $t=1$ equals the fair discounted value in $t=2$, and $\underline{S}_1$ is the unstrategic bond sales in $t=1$ resulting from liquidity needs of other investors.

Observe that S^{res} is independent of the investor allocation, determined by (μ,η), and only depends on $\theta_1, b_2, D(b_1|b_2,\theta_1), \underline{S}$. See that we possibly have $S^{res}=0$ or $S^{res}=\infty$. We discuss these corner cases below.

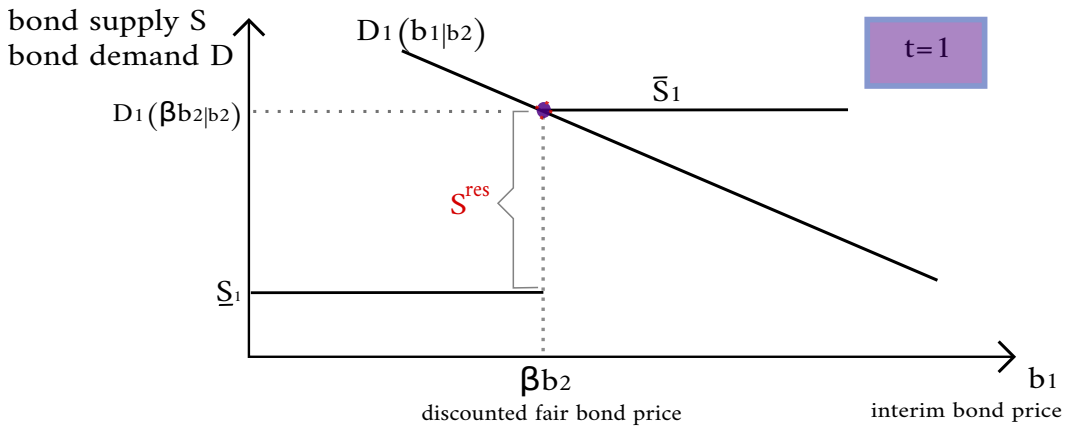


Figure 4: Residual bond supply required beyond $\underline{S}_1$ to equalize the interim price and discounted fair value

Proposition 4.1 (Maximum rationalizable bond fire sales). *If $S^{res} \in (0,,\infty)$ is strictly positive and finite, the maximum rationalizeable fire sales bond supply in the secondary market in $t = 1$, equals*

$$\bar{S}_1 = \underline{S} + S^{res} \tag{18}$$

and has the property that it is the unique supply that pushes the interim bond price down to its fair value,

$$b_1(\bar{S}_1, D_1(\theta_1)) = \beta\, b_2(\theta_1) \tag{19}$$

Why is it that $\bar{S}_1$ is the maximum rationalizable size of the bond fire sales? To prove Proposition 4.1, first, see that $\bar{S}_1$ satisfies equation (19) because for $S^{res} \in (0,,\infty)$,

$$S^{res} + \underline{S}_1 = \bar{S}_1 = D_1(\beta b_2 | b_2, \theta_1) \in (0, \infty) \tag{20}$$

That is, the supply $\bar{S}_1$ equals demand D_1 at price $b_1 = \beta b_2$, or put differently, the interim price $b_1 = \beta b_2$ is market clearing at supply $\bar{S}_1$. Because at supply $\bar{S}_1$, the market clearing bond price b_1 equals the discounted fair value b_2, both the insurer, and, since $b_1 = b_2\beta$ implies $p_1 = \beta p_2$, also MMF investors are indifferent between selling bonds, respectively, redeeming shares or not.

Next, to see that $\bar{S}_1$ is maximum rationalizable, we show that for any supply larger than $\bar{S}_1$, selling bonds is not optimal ex post. Assume $S_1 > \bar{S}_1$. We show that the interim price b_1 decreases in the interim supply S_1. Market clearing demands that the interim price b_1 changes with supply S_1 such that the market clears again, $S_1 = D_1(b_1|b_2, \theta_1)$. Because $S_1 > \bar{S}_1$, we know that $D_1(b_1|b_2, \theta_1) = S_1 > \bar{S}_1 = D_1(b_2\beta|b_2, \theta_1)$. Further, because the bond demand curve $D_1(b_1)$ is strictly decreasing in the the interim bond price, we can infer that the market clearing price has dropped to a level $b_1 < \beta b_2$. At these prices, the insurer is not willing to sell, i.e., if the overall supply including the insurer's bond sales equals $S_1 > \bar{S}_1$, selling is ex post suboptimal for the insurer. Now consider the MMF investors. Prices $b_1 < \beta b_2$ imply share prices $p_1 < \beta p_2$. Thus, also all MMF investors optimally abstain from redeeming shares whenever the overall bond supply exceeds $\bar{S}_1$.

Is $\bar{S}_1$ also the minimal rationalizable size of the bond fire sales, i.e. can we rule out an equilibrium bond supply $S_1 < \bar{S}_1$? If $S_1 < \bar{S}_1$ it follows $b_1(\bar{S}_1, D_1) > \beta\ b_2(\theta_1)$, and selling some additional small measure of bonds is optimal. However, generically we cannot infer that the equilibrium bond supply is always $\bar{S}_1$, because the insurer needs to mind its price impact when selling, as well as the size of its ownership share.

Overall, $\bar{S}_1$ is the turning point for the investors' strategies. If the fires sales is more extreem, and exceeds $\bar{S}_1$, $S_1 > \bar{S}_1$, then $b_1(\theta_1, \bar{S}_1) < \beta\ b_2(\theta_1)$, redeeming shares is no longer optimal. Thus, MMF investor actions become strategic substitutes. Likewise, insurers would not sell but rather wait until $t = 2$, unless they are required to sell by regulation.

Vice versa, however, if the sales is less extreme, and $S_1 < \bar{S}_1$, then $b_1(\theta_1, \bar{S}_1) > \beta\ b_2(\theta_1)$, and redeeming is optimal for MMF investors, meaning MMF fund investor actions are strategic complements.

Overall, because the solvency shock affects the fair bond value in $t = 2$, it causes MMF share investors and the insurer to overthink their optimal investments in the bond respectively the MMF in $t = 1$. However, their joint bond sales decisions affect the aggregate

supply in the secondary bond market, and thus the bond price today in $t = 1$. If the fire sales is too extreme, the bond price correction overshoots, $b_1(\theta_1, \bar{S}_1) < \beta\, b_2(\theta_1)$, and selling the bond is no longer optimal.

4.4 Solving for equilibria

The following Proposition summarizes equilibria by ownership structure, assuming that $S^{res} \in (0, \infty)$ is finite and interior. We discuss the boundary cases $S^{res} = \infty$ and $S^{res} = 0$ further below.

Fix the bond ownership share of the insurer, $D_I = \mu\eta S_0$, the MMF $D_M = \mu(1-\eta)S_0$, and other investors $D_o = (1-\mu)S_0$. Fix an exogenous demand curve $D_1(b_1|b_2, \theta_1)$ with according fair bond price $b_2(\theta_1)$ in $t = 2$. Let $\underline{S}$ the bond supply from other investors in the secondary market in $t = 1$, and let $S^{res} \equiv S^{res}(\theta_1, D_1, b_2)$ the residual supply in the secondary market to equalize the bond price in $t = 1$ with its fair value, $b_1 = b_2(\theta_1)$.

Proposition 4.2 (Equilibrium prices and supply by ownership)**.** *Fix a solvency shock $\theta_1 > \underline{\theta}$ so that the insurer is not required by regulation to sell but may decide to sell strategically. If $S^{res}(\theta_1) \in (0, \infty)$, the following types of equilibria can arise:*

A Assume $S^{res} < min(D_I, D_M)$. In the unique equilibrium, the insurer optimally abstains from selling bonds, $a_I^* = 0$, but there is a partial run on the MMF with an equilibrium share $n_M^* = \frac{S^{res}}{D_M} \in (0,1)$ of MMF investors redeeming shares, requiring the MMF to liquidate bonds of measure $n_M^* D_M = S^{res}$. The equilibrium bond supply in the secondary market equals $S_1^* = \underline{S} + S^{res}$, and the market clearing bond price in $t = 1$ equals $b_1^* = \beta b_2$.

B Assume $D_I < S^{res} < D_M$. There exist two types of equilibria:

(Bi) There is an equilibrium where the insurer optimally sells all bonds, $a_I^* = 1$, and there is a partial MMF run where an equilibrium share of $n_M^* = \frac{S^{res} - D_1}{D_M} \in (0,1)$ investors redeem shares, requiring the MMF to liquidate bonds of measure $n_M^* D_M = S^{res} - D_1$.

(Bii) There is another equilibrium, equal to case A, where the insurer optimally abstains

from selling bonds, $a_I^* = 0$, and there is a partial MMF run where an equilibrium share of $n_M^* = \frac{S^{res}}{D_M} \in (0,1)$ investors redeem shares, requiring the MMF to liquidate bonds of measure $n_M^* D_M = S^{res}$. In either equilibrium, the equilibrium bond supply in the secondary market is given as $S_1^* = \underline{S} + S^{res}$, and the market clearing bond price in $t = 1$ equals $b_1^* = \beta b_2$.

C *Assume $D_M < S^{res} < D_I$. In the unique equilibrium, the insurer optimally abstains from selling, $a_I^* = 0$, but there is a full run on the MMF, $n_M^* = 1$. All investors redeem, causing the MMF to sell all of its bonds, D_M. The bond supply equals $S_1^* = \underline{S} + D_M < \underline{S} + S^{res}$. Since the MMF's bond ownership is small, the interim bond price stabilizes at a level $b_1^* > \beta b_2$.* ***[High insurer share prevents price draw-down]***

D *Assume* $\max(D_M, D_I) < S^{res}$.

(Di) If $D_M + D_I < S^{res}$, in the unique equilibrium, the insurer sells all bonds $a_I^* = 1$ and there is a full run by the MMF investors, $n_M^* = 1$, all of them redeeming their shares. The equilibrium bond supply equals $S_1^* = \underline{S} + D_M + D_I < \underline{S} + S^{res}$, which is why the market clearing interim bond price remains above the fair value, $b_1 > \beta b_2$.

(Dii) If $D_M + D_I > S^{res}$, there are two types of equilibria. In the first equilibrium, the insurer sells all bonds $a_I^* = 1$ and there is a partial run by the MMF investors, $n_M^* = (S^{res} - D_I)/D_M < 1$, requiring the MMF to sell $n^* D_M = S^{res} - D_I$ bonds. The equilibrium bond supply equals $S_1^* = \underline{S} + S^{res}$, and the market clearing interim bond price equals the fair value, $b_1^* = \beta b_2$.

In the other equilibrium, there is a full run on the MMF, $n_M^* = 1$, and the MMF sells all bonds D_M. The insurer abstains from selling, $a_I^* = 0$, the equilibrium bond supply equals $S_1^* = \underline{S} + D_M < \underline{S} + S^{res}$, and the market clearing interim bond price yields, $b_1^* > \beta b_2$.

How does the ownership share of the insurer versus the MMF matter for optimal bond sales, and thus market clearing prices? The MMF must respond to its small investors. A small MMF investor's redemption, and the required bond sales have negligible price

impact, however, large aggregate redemptions and according bond sales do move bond prices. The small MMF investors know of their negligible price impact, so that as long as $b_1 > b_2$ (i.e. $p_1 > p_2$) redeeming is optimal, forcing the MMF to sell bonds. However, because the MMF can sell small quantities of bonds to finance share redemptions, even a large ownership share by the MMF allows its investors to finetune their share redemptions, and thus its price impact in a way that the MMF appear to leave no money on the table, and $b_1 = b_2$ always obtains.

In contrast, the insurer has issued long-term contracts, and does not need to react to its investors. Whenever not required by regulation, the insurer either sells all or no bonds, and thus needs to take into account its own price impact when selling in addition to the price impact of other selling investors. If the ownership share of the insurer is large, the possible price impact may render selling ex post subopitmal, causing the insurer to abstain from selling, which causes interim bond prices that give the appearance as if the insurer would leave money on the table, holding bonds at value $b_2 < b_1$. This appearance is, however, not true since selling would have resulted in an even lower price realization, $p_1 < p_2$.

Our equilibria may give the impression that the stabilizing effect of the insurer vanishes, given it could liquidate bonds partially. This is not the case, because of the insurer's price impact. A partial sale would cause the bond supply in $t = 1$ to increase, which has a negative impact on the market clearing price at which the insurer finalizes the sales. Consider the particular case (C), where the ownership share of the insurer is large relative to the share of the MMF. Imagine the MMF investors do not redeem shares, $n_M = 0$, and the insurer sells bonds partially, supplying $S_1^I = S^{res}$. In that case, the insurer realizes a price $p_1 = p_2$, and the remaining bonds $D_I - S^{res}$ have an expected value of b_2. Thus, a partial sales yields the same expected profit to the insurer as no sales at all, making the insurer indifferent to not selling. When assuming that the insurer remains passive, and does not sell when indifferent, the same stabilizing price effect applies.

Given the different types of equilibria in Proposition 4.3, the question arises when these can occur. S^{res} is a constant that depends on the size of the shock θ_1, the price-elasticity of demand $D_1(b_1)$, and the unstrategic bond sales $\underline{S}_1$. Recall that S^{res} is independent of the ownership share.

Definition 4.3. *We say that S^{res} has full range, if there exist shocks θ_1, demand functions $D_1(b_1|\theta_1, b_2)$ and unstrategic supplies $\underline{S}_1$ such that the resulting residual demand S^{res} that would equalize $b_1 = \beta b_2$ can attain any value in $[0, \infty]$. S^{res} has restricted range if there are areas in $[0, \infty]$ that S^{res} cannot attain.*

Corollary 4.1. *Consider any range of S^{res}. The interim bond price stabilizes at a level above the fair discounted value $b_1 > \beta b_2$ more often if the ownership share by the insurer exceeds the ownership share of the MMF, $D_M < D_I$, rather than when $D_M > D_I$.*

The corollary is straightforward to see. There are only two case for which $b_1 > \beta b_2$, case C and case Di. Case C can only arise for $D_M < D_I$, whereas case Di is independent of whether $D_M < D_I$ or $D_M \geq D_I$, and thus occurs with equal likelihood. If S^{res} has sufficient range such that $D_M < S^{res} < D_I$ can occur, the ex ante (before the shock realization) expected price draw down when $D_M < D_I$ is strictly smaller than if the insurer share is small, $D_M > D_I$. If S^{res} has restricted range such that $D_M < S^{res} < D_I$ cannot arise, the expected price draw down for the case $D_M < D_I$ and $D_M > D_I$ are equal ex ante.

Proof. [Proposition 4.3] (A) Let $S^{res} < min(D_I, D_M)$. Recall that the insurer either sells all or no bonds. Let $S_{1,M} \in [0, D_M]$ the quantity of bonds the MMF sells in $t = 1$, which the insurer takes as given. If the insurer sells, $a_I = 1$, the bond supply in $t = 1$ equals $\underline{S} + S_M + D_I \geq \underline{S} + D_I > \underline{S} + S^{res}$. Thus, the market clearing bond price at which the insurer sells in $t = 1$ satisfies $b_1(\underline{S} + S_M + D_I) < b_2$. In contrast, if the insurer abstains from selling, it gets b_2. Thus, the insurer optimally does not sell, $a_I^* = 0$, independently of what the MMF and its investors do.

Given that the insurer does not sell, the MMF investors know that $p_1 \geq p_2$, i.e. $b_1 \geq b_2$ as long as $n_M D_M \leq S^{res}$. Thus, for $n_M < S^{res}/D_M$ some MMF investors still find it optimal to redeem shares (strategic complementarity) until $n_M = S^{res}/D_M$, and any aggregate redemption $n_M < S^{res}/D_M$ cannot be part of an equilibrium. For $n_M > S^{res}/D_M$, the interim bond price drops below its expected value, $b_1 < b_2$, and redeeming becomes ex post subopitmal, and redeeming shares become strategic complements for the MMF investors. Overall, any $n_M > S^{res}/D_M$, cannot be part of an equilibrium. Because $n_M^* = S^{res}/D_M$, the equilibrium bond supply is given as $S_1^* = \underline{S} + S^{res}$, and hence $p_1(S_1^*) = p_2$ by the definition of S^{res}.

(B) Assume $D_I < S^{res} < D_M$. There is an equilibrium where the insurer optimally sells all bonds, $a_I^* = 1$, because the insurer's price impact is small enough to not push the price b_1 below b_2. Thus, selling is optimal for the insurer, as long as the supply S_1 remains below $\underline{S} + S^{res}$. Now consider the perspective of the MMF investors. Imagine the MMF investors do not redeem shares. Then, $S_1 = \underline{S} + D_I < S^{res}$, and thus $b_1(S_1) > b_2$, implying $p_1 > p_2$. Thus, despite the insurer's sales, it is optimal for MMF investors to redeem shares as long as $p_1 \geq p_2$, which holds as long as the bond supply S_1, including the supply stemming from the MMFs bond sales to finance redemptions, is below $S^{res.}$ This holds for $n_M^* \leq \frac{S^{res} - D_1}{D_M} \in (0,1)$. MMF investors would, in the aggregate, not redeem more than n_M^* since this would push the supply S_1 above $\underline{S} + D_I < S^{res}$, and hence the market clearing bond price b_1 below b_2, implying $p_1 < p_2$. There exists an equilibrium where the insurer does not sell because the MMF has large ownership, and hence on its own may sell bonds that push the interim bond price b_1 below b_2, making not selling an optimal response by the insurer.

(C) Assume $D_M < S^{res} < D_I$. The insurer optimally abstains from selling because of its large ownership share. A sales would mean that the insurer realizes a bond price $b_1 < b_2$ whereas abstaining yields b_2. Because the insurer does not sell, the MMF investors

redeem shares as long as $p_1 > p_2$. Because the MMF holds only few bonds, even if all MMF investors redeem,$n_M^* = 1$, the bond supply is too small to push the price below b_2. Thus, $S_1^* = \underline{S} + D_M < \underline{S} + S^{res}$, and thus $b_1^*(S_1^*) > b_2$.

(D) Assume $\max(D_M, D_I) < S^{res}$.

If $D_M + D_I < S^{res}$, the joint price impact by the insurer and the MMF when selling all of their bonds is not sufficient to push the markt clearing bond price b_1 below b_2. Thus, selling/redeeming is optimal for both.

If $D_M + D_I > S^{res}$, the joint price impact of bond sales can push the price b_1 below b_2. Thus, the MMF and the insurer need to coordinate on who sells, and how much such that the overall bond supply in $t = 1$ equals but neither exceeds not falls short of $\underline{S} + S^{res}$ at which $b_1 = b_2$. If the insurer sells everything, the MMF run must be partial, yielding $b_1 = \beta b_2$. In the other equilibrium, there is a full run on the MMF, $n_M^* = 1$, and the MMF sells all bonds D_M. The insurer abstains from selling, $a_I^* = 0$, since selling would push the interim price below βb_2. The equilibrium bond supply equals $S_1^* = \underline{S} + D_M < \underline{S} + S^{res}$, and the market clearing interim bond price yields, $b_1^* > \beta b_2$. □

4.5 Extreme corner cases

If demand $D_1(b1|b_2, \theta_1)$ takes extreme forms, the boundary cases $S^{res} = \infty$ and $S^{res} = 0$ can arise.

By Definition (4.2), $S^{res} = \infty$ corresponds to the case where the demand for the bond at price $b_1 = \beta b_2$ is infinite, implying that for every finite bond supply S_1 the interim price of the bond, $b_1^* = \infty$, is infinitely high, and above βb_2. For such prices and infinite demand, selling bonds, respectively redeeming shares is always optimal for both the insurer and the MMF investors, yielding the equilibrium supply $S_1^* = \underline{S}_1 + D_1 + D_M$.

The case $S^{res} = 0$ corresponds to the case where the demand at price $b_1 = \beta b_2$ falls short of the unstrategic sales by other investors, $D_1(\beta b2|b_2, \theta_1) < \underline{S}_1$. Thus, even for

zero additional joint bond supply from the insurer and the MMF sales, $S_I + S_M = 0$, the bond demand at price $b_1 = \beta b_2$ exceeds its supply, and the market clearing price for any additional joint bond supply from the insurer and the MMF sales, $S_I + S_M \geq 0$, must yield prices $b_1^* < \beta b_2$. Thus, selling bonds respectively redeeming MMF shares is suboptimal, and the equilibrium supply equals $S_1^* = \underline{S}_1$.

4.6 What if the shock is severe such that the insurer must sell?

Proposition 4.3 (Equilibrium prices and supply by ownership)**.** *Fix a solvency shock $\theta_1 \in [0, \underline{\theta}]$ so that the insurer is obliged to sell by regulation. If $S^{res}(\theta_1) \in (0, \infty)$, the following types of equilibria can arise:*

A *Assume $S^{res} < min(D_I, D_M)$. The insurer must sell, $a_I^* = 1$. In the unique equilibrium, no MMF investor redeems, $n_M^* = 0$, so that the MMF sells zero shares. The equilibrium bond supply in the secondary market equals $S_1^* = \underline{S} + D_I > \underline{S} + S^{res}$, and the market clearing bond price in $t = 1$ yields $b_1^* < \beta b_2$, and is below the discounted fair value.*

B *Assume $D_I < S^{res} < D_M$. There exists only one equilibrium now: The insurer must sells all bonds, $a_I^* = 1$, and there is a partial MMF run where an equilibrium share of $n_M^* = \frac{S^{res} - D_1}{D_M} \in (0, 1)$ investors redeem shares, requiring the MMF to liquidate bonds of measure $n_M^* D_M = S^{res} - D_1$. The equilibrium bond supply in the secondary market is given as $S_1^* = \underline{S} + S^{res}$, and the market clearing bond price in $t = 1$ equals $b_1^* = \beta b_2$.*

C *Assume $D_M < S^{res} < D_I$. The insurer must sell, $a_I^* = 1$, and the MMF investors optimally respond by refraining from redeeming, $n_M^* = 0$. The bond supply equals $S_1^* = \underline{S} + D_I > \underline{S} + S^{res}$, and the interim bond price yields $b_1^* < \beta b_2$, and is below the discounted fair value.*

D *Assume* $\max(D_M, D_I) < S^{res}$.

(Di) Assume $D_M + D_I < S^{res}$. The insurer must sell all bonds $a_I^* = 1$, and in the unique equilibrium, there is a full run by the MMF investors, $n_M^* = 1$, all of them redeeming their

shares. The equilibrium bond supply equals $S_1^* = \underline{S} + D_M + D_I < \underline{S} + S^{res}$*, and the market clearing interim bond price remains above the fair value,* $b_1^* > \beta b_2$*.*

(Dii) Assume $D_M + D_I > S^{res}$*. The insurer must sell all bonds* $a_I^* = 1$*, and in the unique equilibrium, there is a partial run by the MMF investors,* $n_M^* = (S^{res} - D_I)/D_M < 1$*, requiring the MMF to sell* $n^* D_M = S^{res} - D_I$ *bonds. The equilibrium bond supply equals* $S_1^* = \underline{S} + S^{res}$*, and the market clearing interim bond price equals the fair value,* $b_1^* = \beta b_2$*.*

5 Data

5.1 Insurance and Mutual Fund Holdings Data

Institutional investors, including mutual funds, ETFs, and insurance companies, hold substantial shares of the corporate bond market. To analyze their bond holdings, we draw on data from multiple sources. For insurance companies, we utilize the quarterly "Schedule D" filings, submitted to the National Association of Insurance Commissioners (NAIC), and obtained via CapitalIQ. These filings provide detailed and standardized information on the bond holdings of U.S. insurers, allowing us to track their exposure and investment behavior over time.

Our dataset includes **5,621** distinct insurance companies, each with varying levels of bond holdings. The median dollar amount held by each insurer is approximately **$970 million** , highlighting their significant presence in corporate bond markets. This dataset is particularly valuable for our analysis, as it allows us to observe how insurers' ability to classify bonds as HTM contributes to the relative stability of bond prices during financial crises.

Bond holdings data for mutual funds and ETFs are obtained from Morningstar, which covers a wide array of funds operating under different regulatory frameworks. Our sample comprises a total of **16,474** mutual funds and ETFs, with a fund size of **$231 million**. Mutual funds and ETFs, which are subject to MTM accounting rules, tend to exhibit

more sensitivity to market fluctuations compared to insurers. By examining the holdings and behaviors of both types of investors, we aim to disentangle the impact of accounting treatments on bond price stability and firm-level outcomes during periods of financial stress. Summary statistics for our insurer and mutual fund holdings can be found in Table 1.

5.2 Bond Data

We obtain transaction level data for US corporate bonds from the Enhanced Trade Reporting And Compliance Engine (enhanced TRACE) database provided by FINRA. We then follow the cleaning procedure of Dick-Nielsen (2014) to filter out erroneous transactions. We then compute weekly bond returns as

$$R_{t+1} = \frac{P_{t+1}}{P_t} - 1,$$

where P_t and P_{t+1} denote the "clean" bond prices. We obtain bond characteristics (issuer cusip, offering date, offering amount, Moody's rating, S&P rating) from Mergent Fixed Income Security Database (FISD). To compute excess returns, we subtract the return of a month T-Bill obtained from Kenneth French research data. Our sample period is from July 2002 to March 2002. However, as most of our analysis is confined to the crisis periods, we do not use the full time series. We keep only actively traded bonds, with an offering amount of more than 25 million USD. We then compute the drawdowns over the crises periods outlined in Section 2.3. Over these periods, we have bond return observations for 4874 firms and 74,313 firm-bond pairs. Summary statistics for our drawdown measure can be found in Table 1.

5.3 Firm Outcomes

To analyze the real effects of insurer bond holdings on firm behavior, we examine firm-level outcomes using data from the Compustat database. Our sample includes firm-year observations from 2000 to 2020, focusing on firms with outstanding bonds as of the first quarter of 2007. The primary variables of interest are capital expenditures (CAPEX), acquisitions (AQC), total assets (AT), and total liabilities (LT). CAPEX represents investments in fixed assets and indicates a firm's growth and expansion activities. AQC captures merger and acquisition activities, reflecting strategic investments to expand operations or enter new markets. AT measures the firm's size and overall resource base, while LT indicates the firm's debt level and leverage. These measures allow us to investigate how the cost of debt, influenced by insurer-held bonds, affects firms' capital expenditures and acquisition behavior around financial crises. Summary statistics for these variables can be found in Table 1.

6 Empirical Analysis

6.1 Insurer Shares and Corporate Bond Returns during Crisis

We begin by examining how bond downturns differ based on the Insurer Share of ownership during the four most significant bond market downturns within the sample period. Utilizing the crisis events documented in Gilchrist and Zakrajšek (2012), we mark these period by the shaded areas in Figure 5, to indicate their start and end dates. These periods begin at the previous low points and end at the subsequent peaks in Gilchrist and Zakrajšek (2012) based on a broad measure of credit spreads on U.S. corporate bonds.

The first downturn event is the Great Recession of 2008-09, during which the GZ index increased more than four-fold from a trough of 1.7 percent in June 2007 to a peak of 7.9 percent in December 2008. The second event window spans from April 2011 to October

2011, coinciding with the downgrade of U.S. sovereign debt and subsequent global market turmoil. The third window, from August 2014 to February 2016, includes significant collapses in commodity prices. Lastly, the fourth event window, from January 2020 to March 2020, corresponds to the global COVID-19 crisis, which resulted in substantial price dislocations for corporate bonds (Haddad et al. (2021); Ma et al. (2022)).

We analyze Our baseline specification is a regression of the log drawdown ($\xi_{i,e}$) of bond i during event e on the ex ante insurer share $\phi_{i,t_{S_{e-1}}}$ and interacted fixed effects. The equation is:

$$\log(1+\xi_{i,e}) = \alpha + \beta\phi_{i,t_e^S-1} + \text{Interacted FE} + \epsilon_{i,e}, \tag{21}$$

The coefficient of interest is β, captures the semi-elasticity of drawdowns to the ex ante insurer shares. The ex ante insurer shares are measured in the quarter prior to the start of each event window, i.e., at time $t_e^S - 1$, in order to avoid concerns of reverse causation. The regression includes fixed effects for several security characteristics, which are as follows: Bond credit rating, measured using S&P and Moody's ratings, Bond duration, clustered into categories, Bond size, captured by dummies for deciles of value outstanding, Bond seniority, captured by a binary dummy variable, Bond coupon type, either floating-rate or variable-rate, and Bond callability, a binary dummy variable.

The results from estimating equation 21 are presented in Table 2. Column 1 shows the baseline regression, which estimates the relationship between insurer bond holdings and price drawdowns during financial crises, without any additional fixed effects. In this initial specification, we observe a strong negative and statistically significant relationship between the insurer share and bond price drawdowns. Specifically, a 10 percentage point increase in the share of bonds held by insurers is associated with a 6.7% reduction in bond price declines, with a p-value of less than 0.01. This baseline result underscores the key role that insurers play in stabilizing bond prices during periods of market stress.

In Columns 2 through 6, we progressively add controls to test the robustness of this

relationship. Column 2 introduces event fixed effects to account for differences in crisis severity and market conditions across time, while Columns 3 and 4 incorporate bond characteristics such as size, duration, and rating. The inclusion of these variables aims to control for potential confounding factors that might influence both the allocation of bonds to insurers and their subsequent performance. Even with these additional controls, the coefficient on the insurer share remains negative and highly significant.

By the time we introduce issuer fixed effects in Column 6, which absorb any variation at the firm level and account for issuer-specific characteristics that could influence bond performance, the magnitude of the effect decreases somewhat. Nonetheless, a 10 percentage point increase in insurer ownership is still associated with a 1.4% reduction in bond price declines, with a p-value of less than 0.01. This attenuation in the coefficient is expected as the model becomes more saturated with controls, yet the persistence of the negative and significant effect is notable.

The stability of these results across specifications highlights the robustness of the relationship between insurer ownership and bond performance during crises. Importantly, the insurer share continues to play a critical role in mitigating bond price volatility, even after controlling for a wide range of bond-specific characteristics and firm-level factors. This suggests that the accounting treatment of HTM bonds, which allows insurers to avoid marking down their bond holdings during crises, contributes to the stabilization of bond prices. Moreover, the results provide strong evidence that insurers, through their unique accounting discretion, act as stabilizing forces in the corporate bond market during times of financial distress.

These findings are consistent with our theoretical expectations and reinforce the view that the regulatory framework governing insurers' accounting practices plays a key role in shielding bond prices from the full effects of market downturns. The next sections will explore the mechanism behind this stabilizing effect in greater detail, including how insurers' accounting treatment compares to the mark-to-market (MTM) requirements

imposed on other institutional investors such as mutual funds.

6.2 Insurance vs Mutual Fund Shares

Having established the stabilizing role of insurer share ownership during crises, we now shift our attention to how mutual fund ownership influences bond performance during financial downturns. Unlike insurers, mutual funds are required to mark their assets to market, which may exacerbate price declines during periods of market stress. To explore this, we examine whether bonds predominantly held by mutual funds experience more severe drawdowns compared to those held by insurers.

Table 4 presents the regression results from estimating equation 21, substituting mutual fund shares for insurer shares. In Column 1, we begin with the baseline model without fixed effects. The coefficient on mutual fund share is positive and statistically significant, indicating that higher mutual fund ownership is associated with greater bond price declines during crises. Specifically, a 10 percentage point increase in mutual fund share is associated with a 7.5% increase in bond price drawdowns, with a p-value less than 0.01.

As additional controls are introduced in Columns 2 through 6, including bond characteristics and issuer fixed effects, the positive relationship between mutual fund share and bond drawdowns remains robust. For instance, in Column 6, which includes the full set of controls and issuer fixed effects, a 10 percentage point increase in mutual fund ownership is associated with a 6.2% increase in bond price drawdowns, with a p-value less than 0.01. These results suggest that the adverse impact of mutual fund ownership on bond prices during crises is persistent across different specifications.

To understand the broader impacts of insurer and mutual fund ownership on bond price dynamics during financial crises, we begin by examining Figure 8. This figure illustrates the relative bond sales of insurers and mutual funds during the Great Recession, showing the par value changes in bond holdings starting from the first quarter of 2008.

The figure highlights a distinct pattern: mutual funds, driven by MTM accounting requirements, exhibit a marked increase in bond sales during this period. These forced sales are likely a response to redemption pressures and declining market prices, which prompt mutual funds to liquidate assets to maintain liquidity. In contrast, insurers, who use HTM accounting, show more stable holdings, reflecting their insulation from short-term market fluctuations. The relative stability of insurer-held bonds reinforces the potential of HTM accounting to provide a countercyclical buffer during market downturns, as insurers are less compelled to sell assets in a distressed market environment.

Building on this context, we directly compare the effects of insurer and mutual fund ownership in Table 5. Table 5 presents a regression model that includes both ownership shares. Both the insurer share and the mutual fund share are standardized to have a mean of zero and a standard deviation of one, enabling an apples-to-apples comparison between the two investor types. Columns 1 and 2 of Table 5 show that the negative effect of insurer share on bond drawdowns remains significant, even after controlling for various covariates. A one standard deviation increase in insurer share is associated with a statistically significant reduction in bond price declines of approximately 4.5%. This underscores the protective role that insurer ownership plays during financial crises. The HTM accounting practices typical of insurers help insulate bond valuations from short-term market fluctuations, mitigating the downward pressure on prices that can trigger fire sales and further price declines.

In contrast, Columns 3 and 4 reveal a starkly different impact for mutual fund ownership. A one standard deviation increase in mutual fund share is associated with a statistically significant increase in bond price declines of approximately 6.2%. This finding highlights the destabilizing effect of mutual fund ownership during crises. Mutual funds, which are required to mark their assets to market, are more susceptible to selling pressures as they adjust asset valuations to reflect current market conditions. This dynamic can create a feedback loop where declining prices prompt further sales, exacerbating bond

price declines.

Figure 6 provides a visual illustration of the differential effects of insurer and mutual fund ownership on bond price drawdowns. Bonds held predominantly by insurers (in higher deciles of insurer ownership) exhibit significantly smaller drawdowns than those held by mutual funds. This pattern reinforces the findings from Tables 4 and 5, demonstrating that mutual fund ownership is associated with greater bond price volatility during crises, whereas insurer ownership acts as a stabilizing force.

These findings underscore the critical role of accounting practices and investor composition in shaping bond market outcomes during periods of financial stress. While the HTM accounting practices employed by insurers help mitigate bond price declines, the MTM requirements for mutual funds tend to amplify these declines. The differential impacts of insurer and mutual fund ownership have important implications for understanding how accounting practices influence financial stability and the broader behavior of institutional investors during crises.

6.3 Mechanism Test: Impact of Rating Downgrades on Bond Price Changes

In this section, we explore the mechanism behind the stabilizing effect of insurer ownership on bond prices by examining how rating downgrades affect bond price changes, particularly distinguishing between bonds held by property and casualty (P&C) insurers and life insurers. As discussed in the introduction, the accounting treatments for speculative-grade assets differ significantly between these two types of insurers. While P&C insurers are required to mark their downgraded bonds to market, life insurers can continue to hold downgraded bonds at amortized cost, unless significant impairment is recognized. This divergence provides a natural experiment to isolate the impact of accounting practices on bond price volatility.

We begin by examining the dynamics of bond price changes around a downgrade

between as a function of the insurer shares in Figure 9.The event study in Figure 9 shows the dynamic impact of insurer ownership on bond price changes around a rating downgrade, comparing bonds held predominantly by Property and Casualty (P&C) insurers (blue line) and Life insurers (red line). The vertical line at period 13 marks the timing of the downgrade. The results highlight a stark contrast between the two types of insurers. Prior to the downgrade, bond prices remain relatively stable for both groups. However, immediately following the downgrade, bonds held by P&C insurers experience a sharp and significant decline, consistent with the effects of MTM accounting, which forces P&C insurers to recognize losses in real time. This immediate and steep drop reflects the pressure that MTM rules exert on P&C insurers to adjust asset values to reflect current market conditions, exacerbating price declines.

In contrast, bonds held by Life insurers show a much more gradual and muted response to the downgrade. The red line indicates that life insurers, who use HTM accounting, experience significantly smaller price declines. This stabilizing effect can be attributed to HTM accounting, which allows life insurers to avoid marking down their bond holdings immediately, insulating them from short-term market volatility. Over time, bonds held by life insurers exhibit a quicker recovery, while P&C-held bonds continue to trade at lower prices. This persistent gap between the two groups underscores the role of accounting practices in driving bond price dynamics during financial downturns.

To formally assess these effects, we estimate the following regression model:

$$\Delta\text{Price}_{i,t} = \alpha + \beta_1 \text{InsurerShare}_{i,t} + \beta_2 \text{BondCharacteristics}_{i,t} + \gamma_t + \delta_i + \epsilon_{i,t}. \quad (22)$$

Where: $\Delta\text{Price}_{i,t}$ is the percentage change in bond prices for bond i at time t. $\text{InsurerShare}_{i,t}$ is the share of the bond held by P&C or Life insurers. $\text{BondCharacteristics}_{i,t}$ includes controls for bond-specific features like duration, rating, and issuance size. γ_t represents time-fixed effects to control for market-wide shocks. δ_i represents bond-specific fixed effects and $\epsilon_{i,t}$ is the error term. This specification allows us to estimate the impact of

insurer ownership on bond price dynamics, controlling for key bond characteristics and broader market conditions.

The results of this regression are shown in Table 6. In Column 1, we estimate the effect of P&C insurer ownership on bond price changes following downgrades. The coefficient on P&C insurer share is negative and statistically significant, indicating that bonds held by P&C insurers experience sharper price declines after a downgrade. A 10 percentage point increase in the share of bonds held by P&C insurers corresponds to an additional 1.17 decline in bond prices.

In contrast, Column 2 reveals that Life insurer ownership does not have a statistically significant effect on bond price changes. Bonds held by Life insurers experience only minimal price declines, suggesting that their ability to avoid marking assets to market mitigates the downward pressure. In Column 3, we include both P&C and Life insurer shares in the same regression. The results show that the coefficient on P&C insurer share remains negative, while the Life insurer share becomes negative and statistically significant. This indicates that Life insurer ownership, even after controlling for P&C ownership, has a stabilizing effect on bond prices during downgrades, underscoring the protective role of HTM accounting.

The magnitude of the divergence in price behavior between bonds held by P&C insurers and life insurers is further illustrated in Figure 10. The figure depicts the predicted returns around rating downgrades as a function of insurer share, separately for P&C and life insurers. Bonds held predominantly by P&C insurers exhibit more pronounced declines in value following downgrades, consistent with the mark-to-market accounting requirements faced by these insurers. In contrast, bonds held by life insurers are less affected, underscoring the stabilizing effect of held-to-maturity accounting.

These results confirm that the accounting treatment of speculative-grade assets is a key mechanism through which insurer ownership influences bond price stability. The mark-to-market requirements imposed on P&C insurers amplify bond price declines

following downgrades, while the held-to-maturity accounting practices of life insurers help insulate bond prices from the full impact of market fluctuations. This differential accounting treatment highlights the importance of regulatory frameworks and accounting choices in shaping the behavior of institutional investors and their impact on financial markets during crises.

The magnitude of the divergence between bonds held by P&C and Life insurers is further illustrated in Figure **??**. This figure presents the predicted bond price changes as a function of insurer share, ranging from 0 to 50%. As the share of P&C insurer ownership increases, bonds experience sharper declines in value following a downgrade. This dynamic is driven largely by the MTM accounting rules that P&C insurers must follow, requiring them to adjust the value of their assets to reflect real-time market prices. Consequently, when a downgrade occurs, these institutions must immediately recognize losses, which amplifies the price decline and creates additional pressure to manage their capital positions. For example, bonds with high P&C insurer ownership exhibit declines of approximately 7-8%. This process may also prompt further bond sales due to regulatory or capital constraints, exacerbating the downward pressure on bond prices.

In contrast, bonds held by Life insurers experience smaller, more gradual declines in response to downgrades. This stabilizing effect is primarily due to HTM accounting, which allows Life insurers to avoid marking their bonds to market after a downgrade. As shown in the figure, bonds with higher Life insurer ownership experience declines that are significantly less than those held by P&C insurers. HTM accounting provides Life insurers with insulation from short-term market fluctuations, enabling them to retain downgraded bonds without the need to immediately recognize losses. This mitigates bond price volatility and fosters greater price stability. Moreover, because Life insurers are not forced to sell bonds during periods of market downturn, they avoid contributing to the feedback loops that can lead to further price declines.

Taken together, these findings further suggest that the accounting discretion afforded

to life insurers under the held-to-maturity framework provides a buffer against market volatility, reducing the likelihood of fire sales and mitigating the severity of price declines. This accounting mechanism plays a key role in explaining the broader stabilizing effect of insurers in the corporate bond market during financial downturns.

6.4 Instrumental Variable Strategy: Initial Issuance Buying Proclivity

To address potential endogeneity concerns in our estimation of the effect of insurer ownership on bond performance, we employ a shift-share IV approach. This method leverages the quasi-random allocation of bonds to insurers at issuance to capture the exogenous component of insurer ownership. The approach is motivated by several institutional features of the corporate bond market, as detailed in Coppola (2022).

Insurers, particularly large ones, typically acquire bonds on the primary market and hold them for extended periods, as shown in Figure 7. This practice implies that the investor base for a bond is largely determined at the time of issuance, with relatively little turnover in bondholders after the initial allocation. Given that insurers purchase only a small subset of bonds available at any given time, the composition of a bond's investor base is influenced by the idiosyncratic timing of individual insurers' liquidity needs and their relationships with underwriters. Additionally, the distribution of insurer size is highly skewed, with a few large insurers and many smaller ones, further contributing to the random-like assignment of bond holdings. This setup creates a quasi-random allocation of bonds to insurers, which allows us to instrument for insurer ownership using the initial buying proclivity of insurers.

The shift-share instrument is constructed by taking the average insurer ownership share for bonds issued in the same quarter and maturity category as the bond of interest, and subtracting the average ownership share for bonds in the same quarter and maturity category but with different credit ratings. This construction generates a measure that isolates the deviation of a bond's ownership composition from what would be expected

based on its observable characteristics.

Formally, the shift-share instrument Z_i is defined as follows:

$$Z_i = \sum_{j \in J} \xi_{i,j} \bar{\phi}_j, \tag{23}$$

where $\xi_{i,j}$ is a binary indicator that takes the value of 1 if insurer j purchased bond i at issuance, and $\bar{\phi}_j$ represents the average size of insurer j's primary market bond purchases relative to the aggregate insurance sector. Insurer size ($\bar{\phi}_j$) is measured as the average size of insurer j's primary market bond purchases relative to the aggregate insurance sector, ensuring that $\sum_{j \in J} \bar{\phi}_j = 1$. This instrument captures the collective size of the set of insurers acquiring bond i at issuance, where the purchase indicators $\xi_{i,j}$ function as the shares, and the size coefficients $\bar{\phi}_j$ function as the shifters.

Our identification strategy begins with an accounting decomposition that highlights the various sources of identifying variation in the OLS regression. The insurer share $\theta_{i,t}$ is the sum of its value at issuance $\theta_{i,\tau(i)}$ and deviations from it due to trading on the secondary market, $\widehat{\theta}_{i,t} = \theta_{i,t} - \theta_{i,\tau(i)}$. One can further decompose the insurer share at issuance $\theta_{i,\tau(i)}$ by summing over potential outcomes for individual insurers:

$$\theta_{i,t} = \sum_{j \in J} \xi_{i,j} \cdot \tilde{\phi}_{i,j,\tau(i)} + \widehat{\phi}_{i,t} \tag{24}$$

where J represents the set of insurers included in the sample, $\xi_{i,j}$ is a binary variable indicating if insurer j acquired bond i at issuance, and $\tilde{\phi}_{i,j,\tau(i)}$ represents the share in bond i that would be acquired by insurer j on the primary market, conditional on the insurer purchasing the bond. This potential outcome is influenced by the insurer's available capital and other relevant factors.

This decomposition has three sets of terms, corresponding to three distinct sources of variation: secondary-market trading ($\widehat{\phi}_{i,t}$), the intensive margin of primary-market trading ($\tilde{\phi}_{i,j,\tau(i)}$), and the extensive margin of primary market trading ($\xi_{i,j}$). The shift-share

instrument isolates the variation coming from the extensive margin, which is captured by the purchase indicators $\xi_{i,j}$.

To construct the instrument, we remove the secondary-market component $\widehat{\phi}_{i,t}$ and replace the intensive margin terms $\tilde{\phi}_{i,j,\tau(i)}$ with measures of insurer size that are time and bond invariant. The resulting instrument Z_i captures the collective size of the set of insurers acquiring bond i at issuance, providing a high value if the insurers involved are particularly large.

The exclusion restriction requires that $E[Z_i \epsilon_{i,e} | F_{i,e}] = 0$, where $F_{i,e}$ contains all the observable included in the regressions, and $\epsilon_{i,e}$ is the error term from the linear model. The identifying assumption is that the matching between individual insurers and particular bonds on the primary market in a given quarter is uncorrelated with unobserved determinants of future drawdowns that are not explained by issuer effects and observed bond characteristics. This identification approach, which relies on the exogeneity of the shares in the shift-share instrument, is similar to the methodology described by Goldsmith-Pinkham et al. (2020).

6.4.1 Two-Stage Least Squares (2SLS) Estimation

To estimate the causal effect of insurer ownership on bond drawdowns during financial crises, we implement a two-stage least squares (2SLS) regression. In the first stage, we regress the insurer share of bond holdings on the shift-share instrument Z_i:

$$\phi_{i,t_{Se-1}} = \gamma Z_i + \text{Interacted FE} + \nu_{i,e}, \tag{25}$$

where $\nu_{i,e}$ is the error term in the first stage. The predicted values from this regression are then used in the second stage to estimate the impact of insurer ownership on bond drawdowns:

$$\log(1 + \xi_{i,e}) = \alpha + \beta \widehat{\phi}_{i,t_{Se-1}} + \text{Interacted FE} + \epsilon_{i,e}, \tag{26}$$

where $\widehat{\phi}_{i,t_{Se-1}}$ are the fitted values from the first stage.

Table 3 presents the results of the 2SLS regression. In the first stage, the coefficient on the shift-share instrument is positive and highly significant, with an F-statistic well above the threshold for weak instruments. This indicates that the shift-share instrument is strongly correlated with insurer ownership at issuance, validating our identification strategy.

In the second stage, we find that an increase in insurer share has a significant and negative effect on bond price drawdowns during crises. Specifically, a 10 percentage point increase in instrumented insurer share leads to a 1.12 to 1.16 percentage point reduction in bond price declines, with a p-value of less than 0.01 across specifications. This result not only confirms the stabilizing effect of insurer ownership but also strengthens the causal interpretation of the relationship, as the IV strategy addresses potential endogeneity concerns related to the selection of bonds by insurers.

Overall, the 2SLS results provide robust evidence that the accounting discretion exercised by insurers—particularly their ability to classify bonds as held-to-maturity—plays a critical role in mitigating bond price declines during financial downturns. The instrumental variable strategy ensures that the observed relationship is not driven by endogenous factors, but rather reflects the causal impact of insurer ownership on bond stability.

6.5 Real Effects: Insurer Share and Firms' Capital Investment Post Crisis

In this section, we investigate the real economic effects of insurer bond ownership by examining how firms whose bonds are primarily held by insurers adjust their capital investment and acquisition behavior in the post-crisis period. As outlined in our framework above, one of the key hypotheses of this study is that the accounting discretion afforded to insurers, particularly through HTM accounting, has tangible consequences not only for bond price stability but also for the firms that issue these bonds. By mitigating bond

price volatility during crises, insurers help stabilize the cost of debt for firms, enabling them to maintain or even increase capital expenditures and acquisitions in the aftermath of financial downturns.

To test this hypothesis, we examine firm-level outcomes in the years following a crisis, focusing on CAPEX and AQC activity. Table 7 presents the regression results from a difference-in-differences specification that compares firms with higher insurer bond ownership to those with lower insurer ownership, before and after the crisis period. The primary independent variable of interest is the interaction between the insurer share of bond holdings and the post-crisis indicator. We also include a range of firm-level controls such as firm size, leverage, and bond characteristics to ensure that the observed effects are not driven by other factors.

Column 1 of Table 7 shows that an increase in insurer bond share is associated with a statistically significant rise in firm-level capital expenditures post-crisis. Specifically, a 10 percentage point increase in insurer share leads to a 1.8% increase in CAPEX, with a p-value of less than 0.01. This result indicates that firms benefit from lower debt costs when a larger portion of their bonds are held by insurers, who are insulated from the full volatility of market fluctuations due to their HTM accounting practices. The stability in bond prices afforded by insurers reduces the effective interest rates on these bonds, allowing firms to invest more in growth opportunities and infrastructure.

In Columns 2 and 3, we extend the analysis to acquisitions (AQC) and total investment activity (CAPEX + AQC). The results are consistent with those for capital expenditures alone: firms with a higher share of bonds held by insurers exhibit a significant increase in acquisition activity in the post-crisis period. A 10 percentage point increase in insurer share is associated with a 5.69 percentage point increase in total investment (CAPEX + AQC), with a p-value of less than 0.05. These results further reinforce the idea that the reduced cost of debt for firms with insurer-held bonds enables them to pursue strategic acquisitions, expanding their operations or entering new markets.

Figure 11 visually illustrates the dynamic relationship between insurer bond ownership and firm investment behavior. The figure presents an event study analysis of CAPEX and acquisition activity, comparing firms with high insurer bond shares to those with low insurer bond shares over the crisis and post-crisis periods. As shown in the figure, firms with a greater proportion of bonds held by insurers experience a pronounced increase in capital expenditures and acquisitions in the years following a crisis, while those with lower insurer ownership exhibit more muted recovery patterns. This divergence highlights the real economic impact of insurer ownership on firm-level outcomes.

The positive relationship between insurer bond ownership and post-crisis firm investment is robust across various model specifications, as shown in Table 7. Columns 4 and 5 introduce the IV estimates to address potential endogeneity concerns related to the allocation of bonds to insurers. Using the shift-share IV strategy described earlier, we find that the estimated effects of insurer ownership on capital expenditures and acquisitions are even larger when instrumenting for insurer share. A 10 percentage point increase in insurer share leads to a 7.7 percentage point increase in CAPEX, and an 11.35 percentage point increase in total investment (CAPEX + AQC), both significant at the 1% level. The use of the IV approach strengthens the causal interpretation of these findings, confirming that the observed relationship is driven by insurer ownership rather than other firm characteristics or market dynamics.

These results underscore the real effects of accounting discretion on firm behavior. By stabilizing bond prices and reducing the cost of debt during and after crises, insurers enable firms to invest more heavily in capital expenditures and acquisitions, supporting their long-term growth and resilience. The findings suggest that firms whose bonds are predominantly held by insurers are better positioned to weather economic downturns and emerge from crises in a stronger financial position.

To summarize, the accounting choices of insurers, particularly their ability to classify bonds as held-to-maturity, have far-reaching consequences for the firms that issue these

bonds. The reduction in bond price volatility during crises translates into lower debt costs for firms, which in turn facilitates greater investment in capital expenditures and acquisitions. These real effects demonstrate the critical role that accounting practices play not only in financial market stability but also in supporting firm-level growth and strategic decision-making during periods of economic recovery.

7 Conclusion

This study examines the real effects of accounting discretion by investigating how the exemption of insurance companies from mark-to-market accounting during financial crises impacts bond performance and firm investment behavior. Leveraging a comprehensive dataset of corporate bonds held by insurance companies and mutual funds, we find that bonds held by insurance companies experience significantly lower drawdowns during financial crises compared to those held by mutual funds. This finding underscores the stabilizing effect of insurance ownership on bond prices, driven by the ability to classify bonds as HTM rather than marking them to market. We employ a shift-share IV approach to address potential endogeneity concerns and isolate the exogenous variation in insurer ownership. This rigorous methodological framework provides strong causal evidence that an increase in insurer bond share leads to a significant reduction in bond price declines during crises.

Beyond bond performance, we explore the real effects of these accounting practices on firm behavior. Our results reveal that firms with bonds that have a largely held by insurers benefit from lower debt costs, which in turn facilitates greater capital expenditures and acquisition activities in the post-crisis period. This evidence highlights a critical channel through which accounting discretion enhances financial stability: by reducing funding costs, firms are better positioned to maintain operations, pursue growth opportunities, and navigate economic downturns more effectively.

Our study contributes to the literature by providing robust evidence on the importance of accounting practices in financial markets. The findings suggest that regulatory frameworks allowing HTM accounting for insurance companies can mitigate the adverse effects of financial crises on bond prices and support firm-level investment. By highlighting the stabilizing role of HTM accounting, our study underscores the necessity for thoughtful regulatory frameworks that support financial stability while enabling firms to continue investing during periods of economic stress. Future research could extend these insights by exploring the long-term implications of accounting practices on financial markets and economic growth, further shedding light into the interplay between accounting discretion, regulation, and financial stability.

References

Allen, F. and E. Carletti (2008). Mark-to-market accounting and liquidity pricing. *Journal of accounting and economics 45*(2-3), 358–378.

Becker, B., M. M. Opp, and F. Saidi (2022). Regulatory forbearance in the us insurance industry: The effects of removing capital requirements for an asset class. *The Review of Financial Studies 35*(12), 5438–5482.

Bischof, J., C. Laux, and C. Leuz (2020). Accounting for financial stability: Lessons from the financial crisis and future challenges. Technical report, SAFE Working Paper.

Bischof, J., C. Laux, and C. Leuz (2021). Accounting for financial stability: Bank disclosure and loss recognition in the financial crisis. *Journal of Financial Economics 141*(3), 1188–1217.

Chen, B. and D. J. Fixler (n.d.). Measuring the services of property-casualty insurance in the nipas changes in concepts and methods. *National Bureau of Economic Research*.

Chen, Q., I. Goldstein, and W. Jiang (2010). Payoff complementarities and financial fragility: Evidence from mutual fund outflows. *Journal of Financial Economics 97*(2), 239–262.

Coppola, A. (2022). In safe hands: The financial and real impact of investor composition over the credit cycle. *Working Paper*.

Corsetti, G., A. Dasgupta, S. Morris, and H. S. Shin (2004). Does one soros make a difference? a theory of currency crises with large and small traders. *The Review of Economic Studies 71*(1), 87–113.

Coval, J. and E. Stafford (2007). Asset fire sales (and purchases) in equity markets. *Journal of Financial Economics 86*(2), 479–512.

Dick-Nielsen, J. (2014). How to clean enhanced trace data. *Available at SSRN 2337908*.

Ellul, A., C. Jotikasthira, C. Lundblad, and Y. Wang (2015). Is historical cost accounting a panacea? market stress, incentive distortions, and gains trading. *Journal of Finance 70*(6), 2489–2538.

Ellul, A., C. Jotikasthira, and C. T. Lundblad (2011). Regulatory pressure and fire sales in the corporate bond market. *Journal of Financial Economics 101*(3), 596–620.

Ferreira, M. A., A. Keswani, A. F. Miguel, and S. B. Ramos (2012). The flow-performance relationship around the world. *Journal of Banking & Finance 36*(6), 1759–1780.

Gigler, F., C. Kanodia, and R. Venugopalan (2016). Mark-to-market: Real effects and social welfare. Technical report, Working paper, University of Minnesota.

Gilchrist, S. and E. Zakrajšek (2012). Credit spreads and business cycle fluctuations. *American economic review 102*(4), 1692–1720.

Goldsmith-Pinkham, P., I. Sorkin, and H. Swift (2020). Bartik instruments: What, when, why, and how. *American Economic Review 110*(8), 2586–2624.

Goldstein, I., H. Jiang, and D. T. Ng (2017). Investor flows and fragility in corporate bond funds. *Journal of Financial Economics 126*(3), 592–613.

Haddad, V., A. Moreira, and T. Muir (2021). When selling becomes viral: Disruptions in debt markets in the covid-19 crisis and the fed's response. *The Review of Financial Studies 34*(11), 5309–5351.

Heaton, J. C., D. Lucas, and R. L. McDonald (2010). Is mark-to-market accounting destabilizing? analysis and implications for policy. *Journal of Monetary Economics 57*(1), 64–75.

Laux, C. and C. Leuz (2009). The crisis of fair-value accounting: Making sense of the recent debate. *Accounting, organizations and society 34*(6-7), 826–834.

Laux, C. and C. Leuz (2010). Did fair-value accounting contribute to the financial crisis? *Journal of economic perspectives 24*(1), 93–118.

Ma, Y., K. Xiao, and Y. Zeng (2022). Mutual fund liquidity transformation and reverse flight to liquidity. *The Review of Financial Studies 35*(10), 4674–4711.

Milbradt, K. (2012). Level 3 assets: Booking profits and concealing losses. *The Review of Financial Studies 25*(1), 55–95.

Plantin, G., H. Sapra, and H. S. Shin (2008). Marking-to-market: panacea or pandora's box? *Journal of accounting research 46*(2), 435–460.

Santomero, A. M. and D. L. Eckles (2000). The determinants of success in the new financial services environment: Now that firms can do everything, what should they do and why should regulators care? *Risk Management and Insurance Review*.

Sapra, H. (2008). Do accounting measurement regimes matter? a discussion of mark-to-market accounting and liquidity pricing. *Journal of Accounting and Economics 45*(2-3), 379–387.

Shleifer, A. and R. W. Vishny (2011). Fire sales in finance and macroeconomics. *Journal of Economic Perspectives 25*(1), 29–48.

Siani, K. (2022). Raising bond capital in segmented markets. *Available at SSRN 4239841*.

Zeng, Y. (2017). A dynamic theory of mutual fund runs and liquidity management. *Available at SSRN 2907718*.

Zhong, S., G.-q. Zhao, and S. Zhang (2021). Impact of the operating attribute diversity of life insurance institutions on the stability of financial market. *Journal of Financial Economics*.

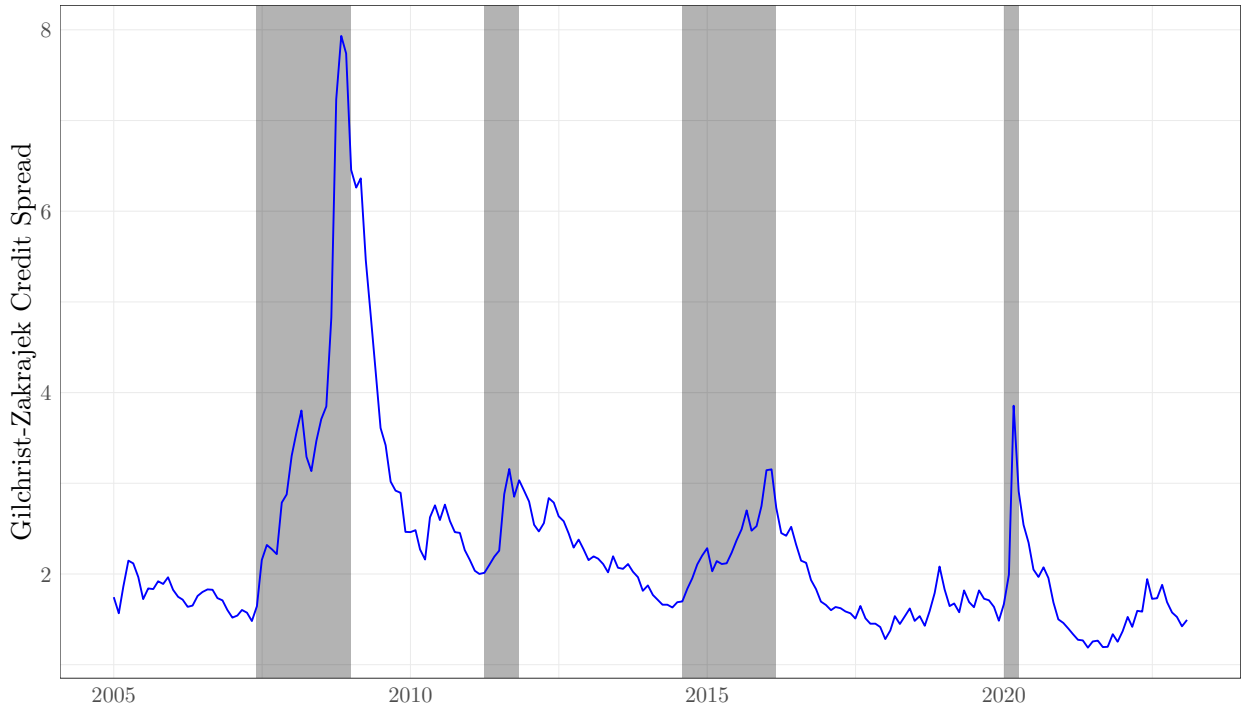


Figure 5: Crisis Events

Note: The figure features a solid blue line representing the Gilchrist and Zakrajšek (2012) index, which serves as a comprehensive indicator of credit spreads across U.S. corporate bonds. Additionally, the figure includes shaded gray areas, delineating the specific event windows employed in our analysis for estimating bond drawdowns. These event windows are determined based on a systematic approach, with their start and end dates corresponding respectively to the preceding trough and the subsequent peak in the Gilchrist and Zakrajšek index.

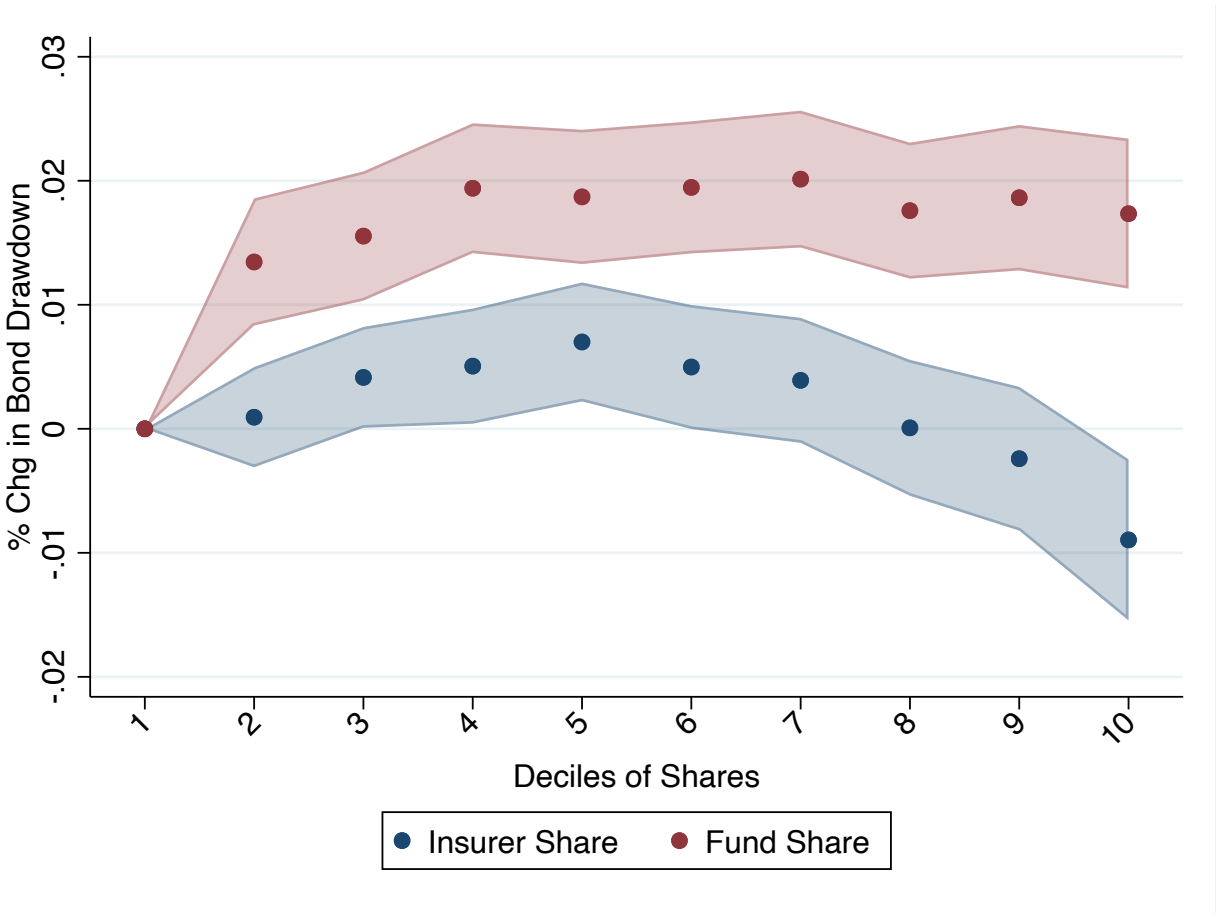


Figure 6: Difference in Bond Drawdown Insurer vs Mutual Fund Ownership

Note: The figure illustrates estimates from a modified version of the regression model described in equation (21). In this variation, we substitute the continuous measure of insurer shares with indicators for each decile. The decile indicators for insurer shares are plotted in blue. For comparison, the figure also includes a red line representing regression coefficients from the decile-based measure of ownership shares for mutual funds and ETFs, rather than insurer shares.

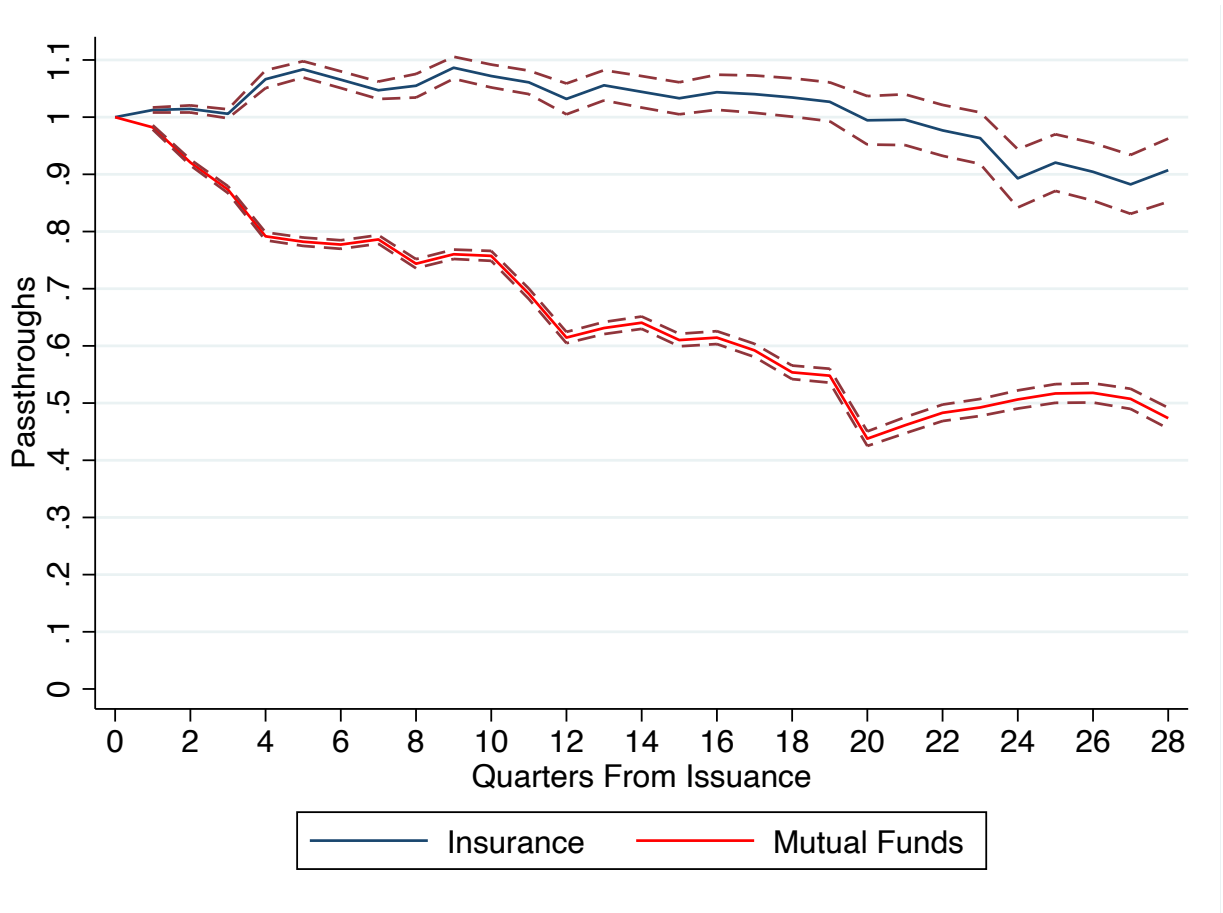


Figure 7: Insurer vs Mutual Fund Persistence of holding decisions for bonds acquired at issuance

Note: The figure presents estimates derived from the regression model outlined in equation (X). It features a solid blue line that represents the estimated passthrough coefficients, correlating insurer holdings with the quarterly horizon s. For the purpose of comparison, a red line is also plotted, which depicts the regression coefficients obtained using ownership shares of mutual funds and ETFs instead of insurer shares.

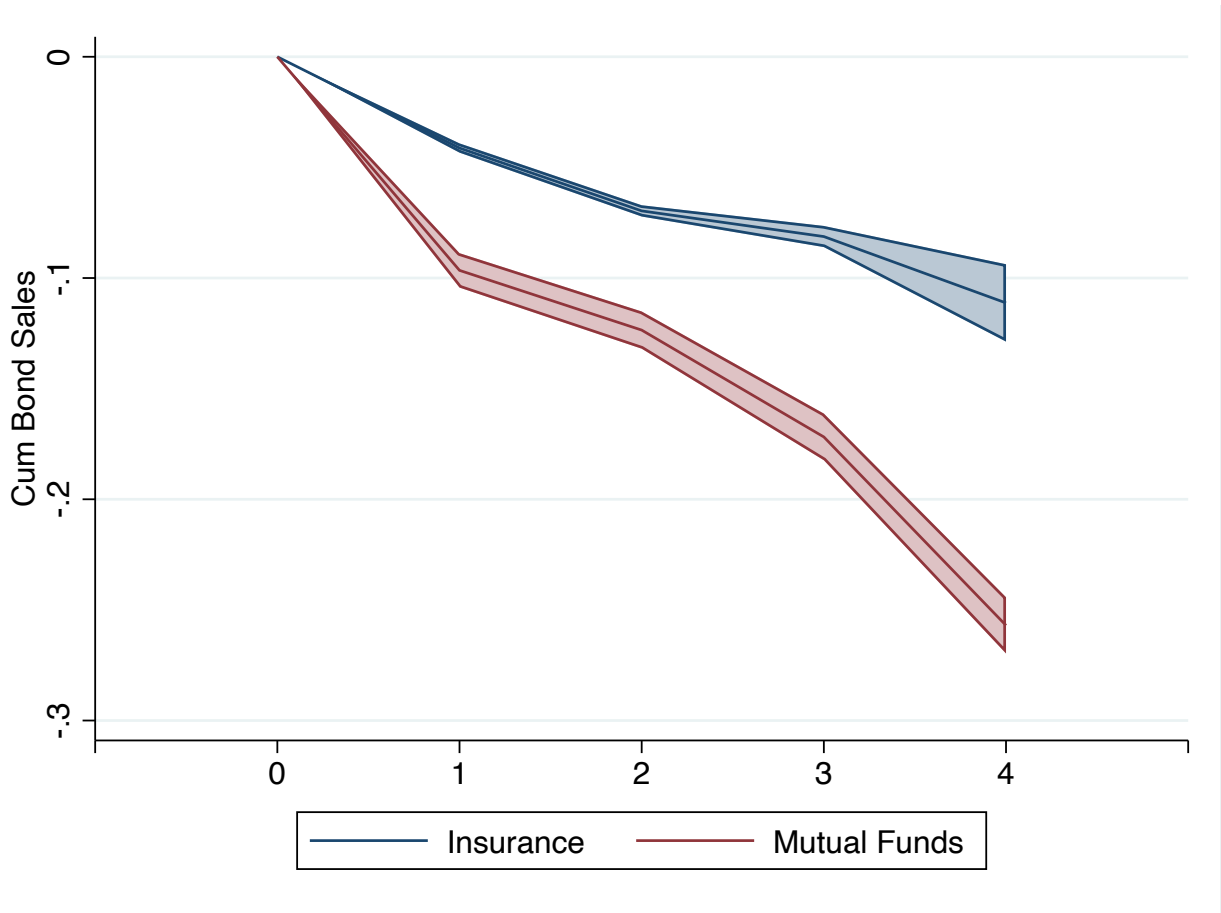


Figure 8: Insurer vs Mutual Fund Bond Sales During Great Recession

Note: The figure shows a blue line indicating how the average insurer's corporate bond holdings changed during the Great Recession, starting from the first quarter of 2008 (2008Q1). These changes are measured in par values, which means they show the actual amount of bonds held, without being affected by market price changes. A red line represents similar changes for the average mutual fund or ETF. The shaded areas around these lines show the 95 percent confidence intervals for these estimates.

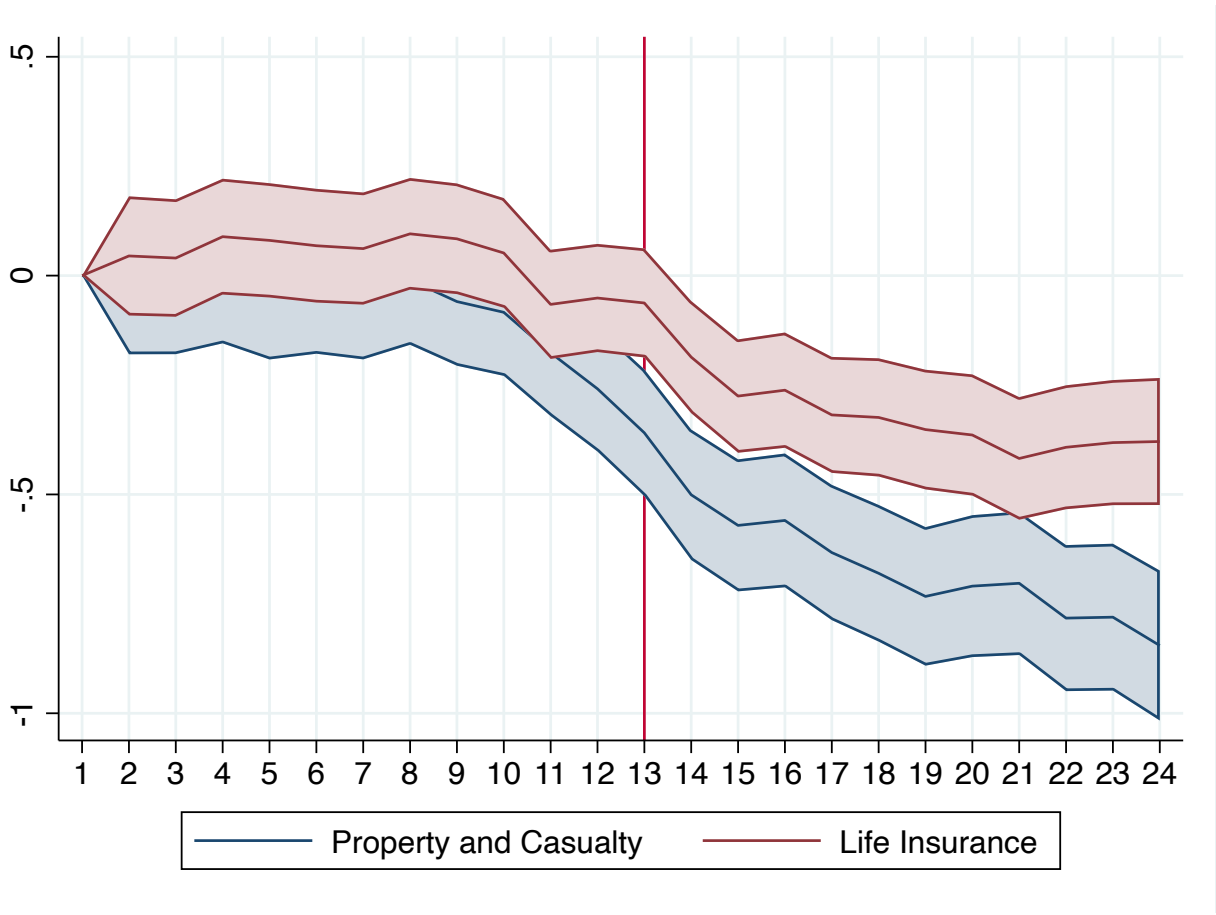


Figure 9: Rating Downgrade - Event Study

Note: This figure presents estimated coefficients from two separate regressions examining the relationship between bond price changes and insurer ownership around a rating downgrade. The regressions are run separately for bonds held predominantly by Property and Casualty (P&C) insurers and Life insurers. The dependent variable is the log of insurer share ownership, and the regressions include time-fixed effects, bond duration category controls, and time (year-quarter) fixed effects to account for temporal and bond-specific factors. Bonds held by P&C insurers (blue line), subject to mark-to-market accounting, experience sharper price declines following a downgrade, while bonds held by Life insurers (red line), using held-to-maturity accounting, show more stability. Standard errors are clustered at the firm level, and 95 percent confidence intervals are displayed.

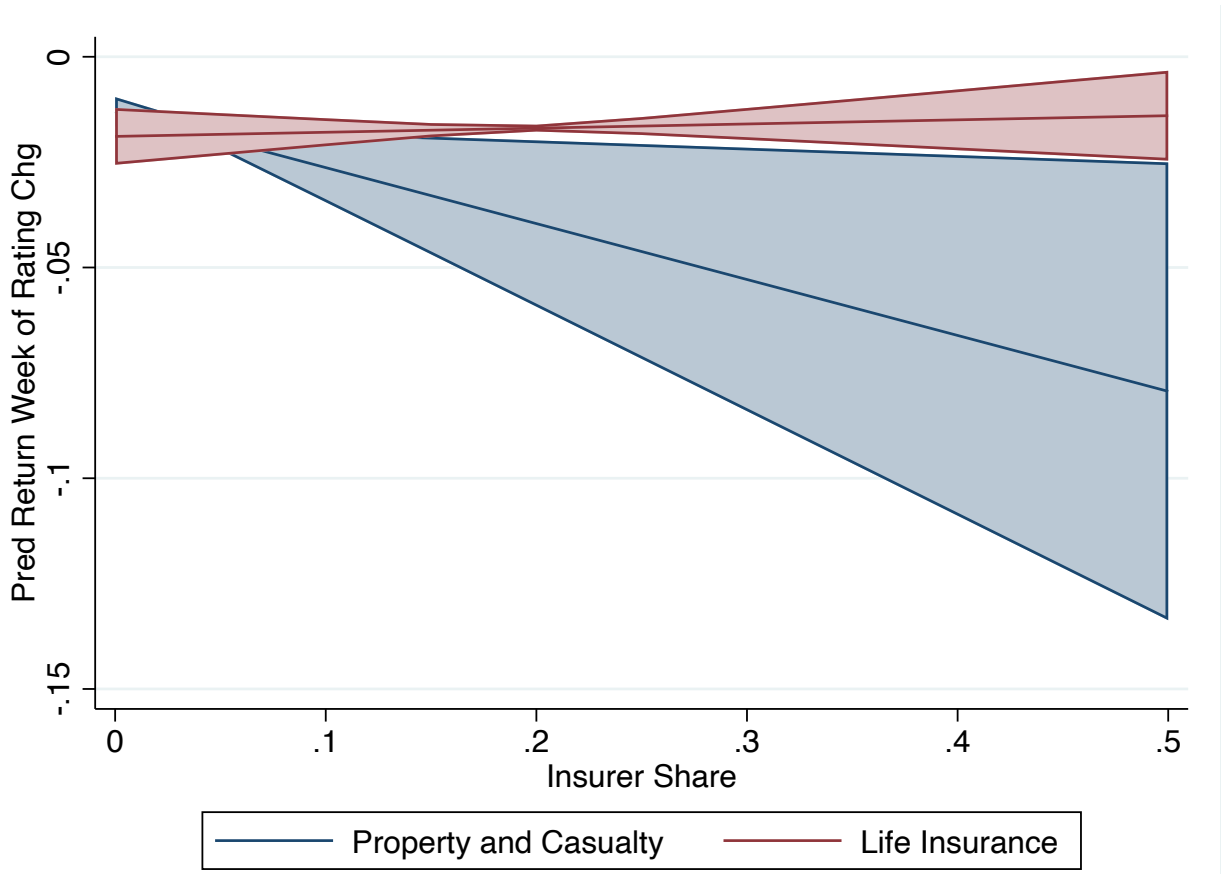


Figure 10: Predicted Returns around Downgrades as a Function of Insurer Shares

Note: This figure illustrates the predicted bond price declines following a rating downgrade, based on insurer ownership. The blue line represents Property and Casualty insurers, subject to mark-to-market accounting, while the red line represents Life insurers, who use held-to-maturity accounting. Bonds held predominantly by P&C insurers experience sharper price declines due to immediate loss recognition, while bonds held by Life insurers exhibit more gradual declines. These predictions are generated from the regression model presented in Table 6. Standard errors are clustered at the firm level, and 95 percent confidence intervals are displayed.

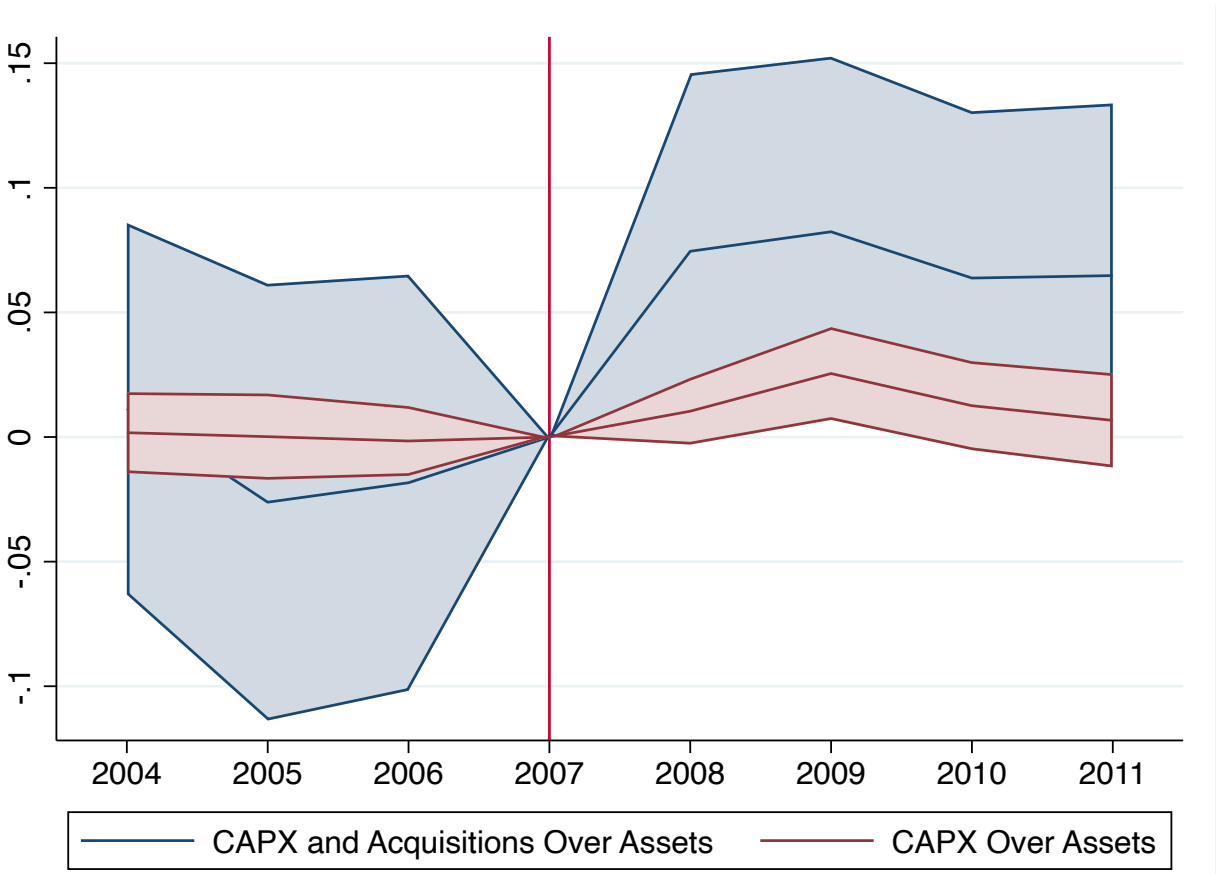


Figure 11: Investment Event Study

Note: This figure displays the estimated coefficients derived from the difference-in-differences analysis specified in equation (26). The analysis is based on a dataset comprising U.S. firms that had outstanding bonds as of the first quarter of 2007 (2007Q1). These coefficients elucidate the dynamic relationship between the investment rates of firms and the proportion of their bonds held by domestic insurers in 2007Q1. The model includes an array of firm-level control variables, measured in the pre-period and interacted with time dummies. These controls encompass deciles of average duration of the firm's outstanding bonds and deciles for both firm size and leverage. The blue line represents the estimates for capital expenditures (CAPX) relative to lagged total assets, whereas the red line illustrates the estimates for the sum of CAPX and acquisitions relative to lagged total assets. Standard errors are clustered at the firm level, and the bars indicate 95 percent confidence intervals.

Table 1: Descriptive Statistics

Panel A: Bond Level Analysis

	Mean	SD	P25	P75
Log Bond Drawdown	0.12	0.12	0.04	0.16
Insurer Share	0.34	0.25	0.13	0.53
Fund Share	0.08	0.10	0.00	0.12
Decile Bond Size	5.69	2.82	3.00	8.00
Duration Category	3.67	1.22	3.00	5.00
Bond Rating Category	9.39	6.32	3.00	15.00
Senior Bond Indicator	0.87	0.33	1.00	1.00
Coupon Bond Indicator	1.07	0.26	1.00	1.00
Bond Market Value	56.37	53.04	25.39	66.71
Observations	38,884			

Panel B: Firm Level Analysis

	Mean	SD	P25	P75
CAPEX	0.06	0.07	0.02	0.07
CAPEX+ACQ	0.08	0.15	0.02	0.09
Firm Size (TA)	16,538.71	30,503.19	1,968.97	15,551.00
Leverage	11,922.74	23,548.13	1,230.54	10,274.13
Avg Duration	5.30	2.62	3.69	6.54
Observations	5,876			

Note: This table presents the descriptive statistics for the bond-level and firm-level variables used in the analysis. Panel A reports statistics for bond-level characteristics, including log bond drawdown, insurer and fund ownership shares, bond size, duration categories, bond rating categories, senior bond indicator, coupon bond indicator, and bond market value. The bond drawdown reflects the percentage price decline of a bond during a financial crisis. Insurer and fund shares represent the percentage ownership of the bond by insurance companies and mutual funds, respectively. The decile bond size, duration category, and bond rating category reflect the relative size, duration, and creditworthiness of the bonds. The senior bond and coupon bond indicators show whether a bond has seniority in claims and if it has a fixed coupon, respectively. The bond market value is the market price of the bond at the time of observation reported in millions of dollars. Panel A is based on 38,884 observations. Panel B provides statistics for firm-level variables, including capital expenditures (CAPEX), the sum of capital expenditures and acquisitions (CAPEX+ACQ), firm size measured as total assets (TA), leverage, and the average bond duration for the firm. CAPEX reflects firms' investment in physical assets, while CAPEX+ACQ measures the total investment in both assets and acquisitions. Firm size and leverage are reported in millions of dollars, representing the scale of the firm and its debt load, respectively. Average duration refers to the weighted average duration of bonds held by the firm. Panel B is based on 5,876 firm-year observations.

Table 2: Insurer Shares and Bond Drawdowns

	(1)	(2)	(3)	(4)	(5)	(6)
Insurer Share	-0.067***	-0.071***	-0.114***	-0.050***	-0.017***	-0.014***
	(0.006)	(0.005)	(0.005)	(0.006)	(0.003)	(0.003)
Adjusted R^2	0.02	0.25	0.37	0.49	0.85	0.85
Event Dummy	No	Yes	Yes	Yes	Yes	Yes
Bond Size	No	No	Yes	Yes	Yes	Yes
Bond Duration	No	No	Yes	Yes	Yes	Yes
Bond Rating	No	No	No	Yes	Yes	Yes
Issuer FE	No	No	No	No	Yes	Yes
Coupon Indicator	No	No	No	No	No	Yes
Senior Indicator	No	No	No	No	No	Yes
Num Issuers	7039	7039	7004	6426	5673	5673
Obs	42044	42044	41825	38884	38131	38131

Note: This table reports the estimates of the regression specification in equation (21) in the sample of actively traded U.S. corporate bonds. The specification in column 1 is the unconditional relation while column 2 includes crisis event fixed effects. Column 3 includes interacted event by bond size decile by duration category fixed effects. Columns 4 and 5 add additional interactions with rating and issuer dummies. Column 6 includes the fully-saturated set of interacted fixed effects, which include all of the above variables plus dummies for bond seniority, and coupon type. *** p<0.01, ** p<0.05, * p<0.10.

Table 3: Insurer Shift-Share IV Regression

	(1)	(2)	(3)	(4)
Insurer Share	-0.026***	-0.022**	-0.112***	-0.116***
	(0.009)	(0.009)	(0.027)	(0.035)
Adjusted R^2	0.87	0.87	-0.09	-0.11
Event Dummy	Yes	Yes	Yes	Yes
Bond Size	Yes	Yes	Yes	Yes
Bond Duration	Yes	Yes	Yes	Yes
Bond Rating	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes
Coupon Indicator	No	Yes	No	Yes
Senior Indicator	No	Yes	No	Yes
Num Issuers	1185	1185	1185	1185
Obs	4468	4468	4468	4468
First Stage F			132	95

Note: This table reports the estimates of the shift-share instrumental variable regression in the sample of actively traded U.S. corporate bonds, alongside the baseline OLS estimates (for comparison). The OLS estimates are shown in columns 1 and 2, while the two-stage least squares (2SLS) IV estimates are shown in columns 3 and 4. The various columns correspond to differing sets of bond characteristics included in the interacted fixed effects. Standard errors are clustered at the issuer by event level and are reported in parentheses.

Table 4: Fund Shares and Bond Drawdowns

	(1)	(2)	(3)	(4)	(5)	(6)
Fund Share	0.063***	0.122***	0.169***	0.017*	0.014**	0.011*
	(0.012)	(0.011)	(0.011)	(0.010)	(0.006)	(0.006)
Adjusted R^2	0.00	0.24	0.35	0.48	0.85	0.85
Event Dummy	No	Yes	Yes	Yes	Yes	Yes
Bond Size	No	No	Yes	Yes	Yes	Yes
Bond Duration	No	No	Yes	Yes	Yes	Yes
Bond Rating	No	No	No	Yes	Yes	Yes
Issuer FE	No	No	No	No	Yes	Yes
Coupon Indicator	No	No	No	No	No	Yes
Senior Indicator	No	No	No	No	No	Yes
Num Issuers	7039	7039	7004	6426	5673	5673
Obs	42044	42044	41825	38884	38131	38131

Note: This table reports the estimates of the regression specification in equation (21) in the sample of actively traded U.S. corporate bonds. The specification in column 1 is the unconditional relation while column 2 includes crisis event fixed effects. Column 3 includes interacted event by bond size decile by duration category fixed effects. Columns 4 and 5 add additional interactions with rating and issuer dummies. Column 6 includes the fully-saturated set of interacted fixed effects, which include all of the above variables plus dummies for bond seniority, and coupon type. *** p<0.01, ** p<0.05, * p<0.10.

Table 5: Insurer & Fund Shares and Bond Drawdowns

	(1)	(2)	(3)	(4)	(5)	(6)
Std Insurer Share	-0.017***	-0.015***	-0.025***	-0.013***	-0.004***	-0.003***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Std Fund Share	0.000	0.007***	0.010***	-0.000	0.001	0.001
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Adjusted R^2	0.02	0.25	0.38	0.49	0.85	0.85
Event Dummy	No	Yes	Yes	Yes	Yes	Yes
Bond Size	No	No	Yes	Yes	Yes	Yes
Bond Duration	No	No	Yes	Yes	Yes	Yes
Bond Rating	No	No	No	Yes	Yes	Yes
Issuer FE	No	No	No	No	Yes	Yes
Coupon Indicator	No	No	No	No	No	Yes
Senior Indicator	No	No	No	No	No	Yes
Num Issuers	7039	7039	7004	6426	5673	5673
Obs	42044	42044	41825	38884	38131	38131

Note: This table reports the estimates of the regression specification in equation (21) in the sample of actively traded U.S. corporate bonds. The specification in column 1 is the unconditional relation while column 2 includes crisis event fixed effects. Column 3 includes interacted event by bond size decile by duration category fixed effects. Columns 4 and 5 add additional interactions with rating and issuer dummies. Column 6 includes the fully-saturated set of interacted fixed effects, which include all of the above variables plus dummies for bond seniority, and coupon type. *** p<0.01, ** p<0.05, * p<0.10.

Table 6: Returns around Rating Changes P&C vs Life

	(1)	(2)	(3)
P&C Ins Share	-0.117*		-0.117*
	(0.070)		(0.069)
Life Ins Share		0.010	0.010
		(0.018)	(0.018)
Adjusted R^2	0.41	0.41	0.41
Firm X Ins Ind FE	Yes	Yes	Yes
Year X Ins Ind FE	Yes	Yes	Yes
Bond Size Dec X Ins Ind FE	Yes	Yes	Yes
Bond Duration Dec X Ins Ind FE	Yes	Yes	Yes
Num Issuers	271	271	271
Obs	1426	1426	1426

Note: This table reports the estimates of the regression specification in equation (X) in the sample of actively traded U.S. corporate bonds which were downgraded from investment-grade (BBB- and above) to speculative-grade (BB+ and below). The specification in column 1 is the unconditional relation while column 2 includes crisis event fixed effects. Column 3 includes interacted event by bond size decile by duration category fixed effects. Columns 4 and 5 add additional interactions with rating and issuer dummies. Column 6 includes the fully-saturated set of interacted fixed effects, which include all of the above variables plus dummies for bond seniority, and coupon type. *** p<0.01, ** p<0.05, * p<0.10.

Table 7: Real Effects: Investments

	CAPEX			CAPEX+ACQ		
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Firm Ins Share	0.018***	0.014**	0.569**	0.077***	0.079***	1.135*
	(0.006)	(0.006)	(0.275)	(0.016)	(0.017)	(0.595)
Adjusted R^2	0.69	0.70	-2.84	0.25	0.25	-1.39
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm Size Dec X Post	No	Yes	Yes	No	Yes	Yes
Firm Leverage Dec X Post	No	Yes	Yes	No	Yes	Yes
Bond Duration Dec X Post	No	Yes	Yes	No	Yes	Yes
Estimator	OLS	OLS	IV	OLS	OLS	IV
N Firms	851	844	842	828	821	819
Obs	5924	5876	5859	5574	5527	5512
First Stage F						

Note: This table reports estimates from the difference-in-differences specification around the great recession. The dependent variables in these regressions are firm-level annual investment rates: CAPEX Columns 1-3 and CAPEX plus AQC in Columns 4-6. The coefficient $Post \times Firm\ Ins\ Share$ captures the effect of the interaction between the insurer share and the post-period dummy. All regressions include two-way fixed effects for firm and year, as well as controls for firm-level covariates, measured in the pre-period and interacted with the post-period dummy. Columns 3 and 6 show estimates from two-stage least-squares, using a firm-level instrument based on the IV in equation (26), interacted with the post-period dummy. The remaining columns use ordinary least squares. Standard errors are clustered at the firm level and reported in parentheses.