Climate Losses and Insurer Portfolio Reallocation

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Abstract

This paper examines how underwriting losses affect portfolio reallocation among U.S. property and casualty insurers using insurer-year panel data from NAIC statutory filings over 2017–2024. Underwriting losses are followed by higher cash holdings and lower bond exposure, while equity holdings are largely unchanged. The response is concentrated in the upper tail of the loss distribution, is stronger for insurers that rely more heavily on investment income and have more concentrated geographic exposure, and is absent among well-diversified and low-climate-exposure insurers. Underwriting losses, which capture premium shortfalls and expenses beyond realized claims, drive the adjustment; realized claims alone do not. This points to broader balance-sheet pressure rather than a mechanical claims-payment effect. The same losses reduce statutory surplus and lower overall portfolio risk. I establish a five-step transmission chain linking surplus compression to portfolio de-risking through cash accumulation, and show that the response is concentrated among capital-constrained insurers and absent when losses are zero. This pattern is consistent with precautionary liquidity accumulation under risk-based capital constraints rather than with flight-to-safety or gambling for resurrection. To address endogeneity, I instrument realized claims using predetermined geographic premium exposure interacted with state-year disaster costs from NOAA, restricting outcomes to the post-2020 period where weights are strictly predetermined. The preferred specification yields a Kleibergen–Paap F-statistic of 17.64, above the Stock–Yogo 10% maximal IV size critical value of 16.38. Disaster-driven claims lead insurers to rebalance toward liquidity. A falsification test confirms the instrument operates through the liquid claims channel: it predicts cash and bond adjustments but not illiquid asset categories. Climate risk affects insurers through their balance sheets, not only through pricing and underwriting.

Keywords: underwriting losses, climate risk, P&C insurance, portfolio reallocation, liquidity, risk-based capital, instrumental variables

1. Introduction

The frequency and severity of climate-related disasters have increased in recent years, with flooding, wildfires, and storms generating substantial economic losses. In the United States, the number of billion-dollar disasters has risen steadily since the 1980s, with the 2020–2024 period alone accounting for about 115 events and total losses exceeding $700 billion.[1] As a result, claims have grown beyond historical levels, placing pressure on insurers operating in high-risk areas. Insurance markets have not fully adjusted to this evolving environment, as premiums and regulatory frameworks often lag behind changes in underlying risk. Although insurance costs have increased, particularly in climate-sensitive states,[2] pricing adjustments remain imperfect, leaving insurers exposed to increasingly volatile risk.

These developments generate underwriting losses that reduce profitability and erode statutory surplus. Under risk-based capital regulation, declines in surplus tighten balance-sheet constraints and increase the value of liquidity. As a result, underwriting losses are not fully absorbed over time but instead trigger adjustments in insurers' asset allocation. This provides a channel through which climate risk affects insurers' balance sheets through portfolio reallocation.

This paper studies how underwriting losses affect insurers' portfolio allocation, and whether these shocks primarily lead to reductions in risk exposure or to active increases in liquidity under regulatory capital constraints. Using insurer-year panel data from NAIC statutory filings over 2017–2024, I examine how shocks to underwriting performance translate into changes in asset composition. The key institutional feature driving the analysis is the Risk-Based Capital (RBC) framework: cash carries zero capital charge, making it the rational buffer when surplus is compressed, regardless of broader risk appetite. This is what distinguishes precautionary liquidity accumulation from a generic flight-to-safety response.

[1]NOAA (2025). *U.S. Billion-Dollar Weather and Climate Disasters*. Available at: https://www.ncei.noaa.gov/access/billions/

[2]NAIC (2024). *Property & Casualty Insurance Industry*. Available at: https://content.naic.org/sites/default/files/2024-annual-property-casualty-and-title-insurance-industries-analysis-report.pdf

To address identification, I use an instrumental-variable strategy based on predetermined geographic exposure and state-level disaster costs from NOAA, restricting outcomes to the post-2020 period where pre-period weights are strictly predetermined.

Insurers generate income from underwriting and investment activities. Underwriting income is typically volatile and often negative, while investment income is more stable. Although investment returns offset underwriting losses at the aggregate level, this smoothing breaks down for insurers exposed to large shocks. For these firms, portfolio allocation becomes an active margin of adjustment rather than a passive source of returns.

Despite a growing body of research on climate risk and insurance markets, existing work typically studies pricing, claims, or insurer exit separately from portfolio allocation. However, underwriting losses simultaneously affect capital and investment decisions. It remains unclear whether these shocks primarily operate through reductions in overall risk exposure or through active increases in liquidity as a distinct margin of adjustment. This distinction is central to understanding how balance-sheet pressure translates into portfolio adjustment.

The results show that underwriting losses lead insurers to increase cash holdings and reduce bond exposure, with only limited changes in equity positions. This pattern is consistent with precautionary liquidity accumulation under RBC constraints rather than with flight-to-safety or risk-shifting behavior. The preferred baseline coefficient is 0.145 for cash and -0.115 for bonds, stable across a regression ladder of four specifications. A one-standard-deviation increase in underwriting losses raises the cash share by approximately 0.65 percentage points, modest on average but larger in the loss tail where capital constraints bind. The response is absent when losses are zero, concentrated among capital-constrained insurers, and amplified for insurers with high climate exposure and low geographic diversification. These patterns are consistent with RBC constraints driving the adjustment, not with a generic bad-year tendency or shareholder-signaling mechanism.

This paper makes three contributions. First, it identifies cash accumulation as the primary adjustment margin after underwriting losses, which is more consistent with the RBC charge structure than with a generic flight-to-safety response. Cash carries zero capital charge; bonds carry positive charges. When surplus is compressed, shifting into cash restores the RBC ratio at minimal cost. Second, it establishes a five-step mechanism chain that directly links surplus compression to portfolio de-risking through cash accumulation, and shows that the response is concentrated among capital-constrained insurers and insignificant when losses are zero. Third, it provides causal identification through a shift-share IV constructed from insurer geographic exposure and NOAA disaster costs, with a falsification test confirming that the instrument operates primarily through the liquid claims channel.

2. Related Literature

2.1 Climate Risk and Insurance Markets

Climate risk constitutes an increasingly important source of economic and financial risk, with implications for asset pricing across markets. Evidence shows that long-run climate risks are reflected in asset prices, particularly in real estate markets, where exposure to climate-related hazards is capitalized into property values (Giglio et al., 2021). For the insurance sector, the same underlying risks directly affect the distribution of insured losses, especially in property and casualty (P&C) insurance. As catastrophe risk increases, insurers must adjust premiums to reflect higher expected losses, placing upward pressure on pricing (Michel-Kerjan, 2010). These losses are characterized by low-probability, high-impact events, in line with the rare-disaster framework of Barro (2006), which models infrequent but severe contractions in aggregate economic activity.

Insurance prices are closely tied to expected losses and vary with exposure, although market frictions can prevent full risk-based pricing (Einav and Finkelstein, 2011). In the presence of regulation, insurers may face constraints in adjusting premiums, leading to deviations between prices and underlying risk across regions (Oh et al., 2026). Homeowners insurance premiums have increased sharply in recent years, particularly in areas exposed to disaster risk. Using mortgage escrow data covering over 74 million observations between 2014 and 2024, Keys and Mulder (2024) document that average nominal premiums rose from $1,690 in 2017 to $2,750 in 2024, with larger increases concentrated in high-risk regions. The pass-through of disaster risk into premiums more than doubled over this period, coinciding with a doubling of reinsurance prices for U.S. property catastrophe coverage. These higher insurance costs are in turn reflected in housing values, with the reinsurance shock reducing home values by an average of $43,900 among zipcodes in the top decile of catastrophe exposure.

Beyond pricing, climate risk also affects the availability of insurance. Keys and Mulder (2024) show that increases in catastrophe risk and reinsurance costs led to non-renewal rates increasing by approximately 30 percent among counties in the top decile of catastrophe exposure between 2018 and 2023, pointing to emerging constraints on availability.

A key mechanism behind these dynamics is the limited capacity of private insurers to absorb extreme losses. Catastrophe risk is subject to supply constraints arising from capital market imperfections, which limit the amount of risk that can be transferred and increase the cost of coverage (Froot, 2001). Following large loss events, these constraints can tighten, reducing the supply of insurance. Sastry et al. (2023) provide evidence that insurance markets can become increasingly reliant on financially fragile insurers in high-risk environments. In particular, weaker capitalization and limited diversification increase the likelihood of insurer distress and insolvency, raising concerns about the long-term stability of insurance provision.

Overall, these findings suggest that climate risk affects both the pricing and availability of insurance, creating sustained pressure on insurers' balance sheets. Yet while the literature establishes that climate risk generates persistent underwriting losses, less is known about how these losses translate into adjustments on the asset side of insurers' balance sheets. This is the starting point of the analysis.

2.2 Financial Institutions' Behavior After Shocks

Insurers, like other financial intermediaries, adjust their balance sheets following negative shocks. However, the form of adjustment depends on the nature of the shock as well as on firm-specific characteristics such as financial strength, business model, and exposure. Because insurers rely on both underwriting and investment income, portfolio decisions become an important component of the response (Ge and Weisbach, 2021). In this setting, underwriting outcomes, investment choices, and capital positions interact in shaping balance-sheet adjustments. Deteriorating financial conditions affect insurers' risk-taking behavior, with evidence showing that insurers reduce risk exposure following negative shocks (Ge and Weisbach, 2021; Kirti, 2024). Portfolio reallocation should therefore be understood as part of a broader balance-sheet response rather than as an isolated investment decision.

The literature points to two broad responses following negative shocks. One is a reduction in risk, often described as a flight to safety. The other is an increase in risk-taking under financial pressure, reflecting incentives that arise when charter value declines (Keeley, 1990). Flight-to-safety predicts a shift toward safe assets, but it does not specifically predict cash over bonds, and it does not predict that the response is stronger for capital-constrained insurers. Gambling for resurrection predicts the opposite sign entirely. Unlike life insurers, whose long-tail liabilities may create incentives for yield-seeking behavior over longer horizons, P&C insurers rarely reach the level of distress where gambling for resurrection becomes rational after a single bad year. A third possibility, and the one this paper documents, is precautionary liquidity accumulation, where insurers hoard cash at $t + 1$ after losses at t. This is driven specifically by the RBC capital charge structure: cash carries zero capital charge, making it the rational buffer when surplus is compressed.

Evidence from banking provides support for both mechanisms, though the dominant response varies across settings. In some cases, distress has been associated with increased risk-taking, as illustrated by the buildup of risk in the Icelandic banking system prior to the crisis (Baldursson and Portes, 2013). In contrast, evidence from U.S. banks shows that distressed institutions tend to deleverage, reduce risk, and strengthen their balance sheets (Ben-David et al., 2019). These findings suggest that the response to financial distress depends on the interaction between incentives, constraints, and institutional features.

Empirical evidence from the insurance sector provides strong support for risk reduction. Ge and Weisbach (2021) document that U.S. P&C insurers respond to operating losses by shifting their portfolios toward safer and more liquid securities. Kirti (2024) find that insurers exposed to larger underwriting losses reduce their risk-taking relative to less affected firms. These findings suggest that deteriorating financial conditions lead insurers to rebalance toward safer and more liquid assets.

At the same time, other studies provide evidence consistent with risk-taking under constraints. Drexler and King (2021) show that insurers with limited ability to raise equity increase the riskiness of their asset portfolios following capital shocks. Similarly, Beyer (2025) find that insurers initially shift toward safer assets at the onset of stress, but subsequently re-enter higher-yield corporate bonds, indicating dynamic adjustments over time.

Insurance-specific evidence also highlights the role of capital regulation and accounting incentives. Ellul et al. (2015) document that insurers engage in gains trading, selectively realizing capital gains on assets to improve regulatory capital positions. More broadly, financial frictions raise the shadow cost of capital and distort insurers' pricing and balance-sheet decisions (Koijen and Yogo, 2015). Across these studies, liquidity emerges as a central component of the adjustment process (Brunnermeier and Pedersen, 2009; Ellul et al., 2015).

At the same time, liquidity is typically embedded within broader measures of portfolio risk rather than analyzed as a distinct adjustment margin in the insurance literature. Most studies focus on changes in risk exposure, either through shifts toward safer assets or through increased risk-taking under financial pressure. As a result, it remains unclear whether insurers primarily adjust overall risk exposure or actively increase liquidity in response to underwriting losses.

2.3 Regulation and Insurer Adjustment

Regulation also shapes how insurers respond to losses, particularly through capital requirements, investment rules, and premium setting. Regulators in the U.S. impose capital requirements on insurers, linking regulatory oversight to solvency outcomes (Chen et al., 2019). Premium setting is subject to regulatory approval at the state level, which can prevent prices from fully reflecting underlying risk (Liu and Liu, 2024; Oh et al., 2026). Investment regulations can also constrain portfolio choices (Boyer et al., 2019), and limiting insurers' ability to price risk can generate adverse selection (Handel et al., 2015).

These constraints are directly relevant to the empirical setting. Cash and government securities carry favorable treatment under the RBC framework. The C-1 component of required capital assigns charge factors to each asset class: cash carries essentially zero charge, government bonds are near zero, investment-grade corporates run roughly 1–5 percent depending on rating, and equities carry charges of 15–30 percent. After losses compress surplus, maintaining the RBC ratio becomes easier by shifting into zero-charge assets. This is what makes cash a particularly attractive margin of adjustment, not risk aversion in general but the specific incentive created by the charge structure.

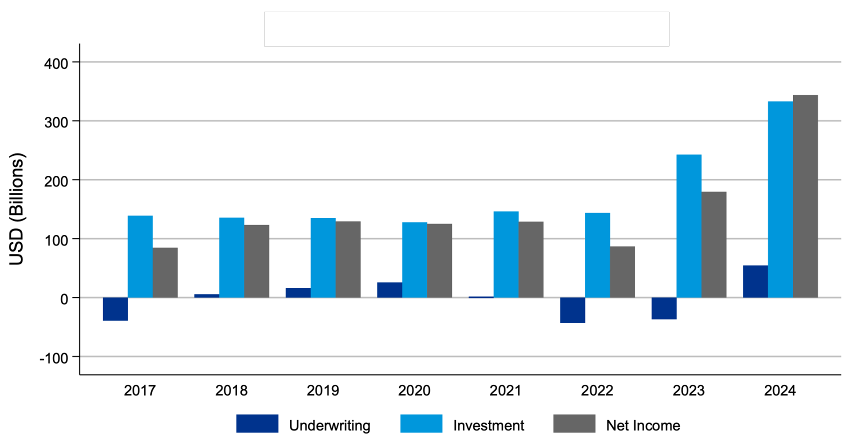
Existing work shows that insurers shift toward safer and more liquid assets after operating losses (Ge and Weisbach, 2021; Kirti, 2024), but treats liquidity as a byproduct of risk reduction rather than a margin in its own right. The framing is typically flight-to-safety or gambling for resurrection, which leaves open why insurers build cash specifically instead of simply cutting risk. Cash is low-risk, available on demand to meet claims, and carries low capital charges under the RBC framework. This paper focuses on that margin and asks whether underwriting losses, rather than realized claims alone, drive the reallocation.

3. Institutional Setting

3.1 Insurers as Institutional Investors

Property and casualty insurers combine underwriting with large investment portfolios. Premiums collected from policyholders are invested in cash, bonds, equities, and other assets, and these portfolios fund future claim payments. Income comes from both sides of the business: underwriting income is often negative and varies sharply year to year, while investment income is steadier and typically larger in magnitude. Figure 1 shows this pattern for U.S. P&C insurers. Investment income covers underwriting shortfalls in aggregate, but not for every insurer in every year. For firms absorbing large underwriting losses, portfolio allocation becomes an active margin of adjustment.

Figure 1: Underwriting, Investment, and Net Income of U.S. P&C Insurers, 2017–2024



Source: NAIC statutory filings.

Insurance liabilities are uncertain in both timing and magnitude, particularly in the presence of catastrophic climate risk. Because claims can arise unexpectedly, insurers must balance income generation with liquidity. Portfolio composition is therefore directly linked to balance-sheet management and the ability to meet claims when losses occur.

3.2 Regulatory Environment and Capital Constraints

Property and casualty insurers in the U.S. operate under the Risk-Based Capital (RBC) framework implemented by the National Association of Insurance Commissioners (NAIC). The RBC ratio is defined as:

$$\text{RBC Ratio} = \frac{\text{Total Adjusted Capital}}{\text{Required Capital}}$$

The numerator is statutory surplus plus any additional items recognized under statutory accounting. The denominator is the baseline required capital figure built from four risk components: C-1 (asset risk), C-2 (underwriting risk), C-3 (interest rate risk), and C-4 (business risk). The ratio must stay above regulatory thresholds: corrective actions are triggered as it falls below 200 percent, regulatory orders at 150 percent, and regulator control at 100 percent.

The component most relevant to portfolio reallocation is C-1, which applies to invested assets and assigns a charge factor to each asset class. Cash carries essentially zero charge. Government bonds are near zero. Investment-grade corporates run roughly 1–5 percent depending on rating, and equities carry charges of 15–30 percent. After losses reduce statutory surplus, the numerator of the RBC ratio falls while the denominator stays fixed because portfolio composition has not changed yet. The ratio drops, and the same portfolio of bonds and equities now requires more surplus per dollar of invested assets than before. Shifting into cash restores the ratio at lower cost than any other asset class because cash contributes nothing to the required capital denominator.

This is the mechanism the paper tests. Insurers do not shift toward cash because it is safer in general, or because they are scared. They shift toward cash because it is the cheapest way to rebuild their RBC ratio after surplus has been compressed by underwriting losses. The insurer faces a situation similar to the financially constrained firms in **?**, where external capital is costly and slow, making internal liquidity the preferred buffer.

Capital regulation also interacts with accounting rules. Changes in asset values affect regulatory capital, creating incentives to adjust portfolios or realize gains to maintain capital ratios (Ellul et al., 2015). Differences in capital charges across asset classes further influence allocation by favoring assets with lower regulatory costs (Becker, 2016).

3.3 Testable Hypotheses

Three hypotheses follow from this framework.

H1: Underwriting losses at t predict an increase in cash share and a decrease in bond share at $t+1$, within insurer over time. This is the direct prediction of the RBC mechanism, where surplus shortfall raises the regulatory cost of investment assets and cash becomes the rational buffer.

H2: The response is stronger for insurers with low surplus ratios, high investment income dependence, concentrated geographic exposure, and high climate risk, which face sharper RBC pressure from a given loss. Diversified and well-capitalized insurers face less pressure and should respond less.

H3: The portfolio de-risking takes place through cash accumulation rather than bond reduction alone. Because cash carries zero capital charge, it dominates as the vehicle for RBC repair. This distinguishes precautionary liquidity accumulation from a generic flight-to-safety response, which would not specifically predict cash over other safe assets.

4. Empirical Strategy

4.1 Empirical Setting and Variables

The analysis examines how underwriting performance affects subsequent portfolio reallocation. The main explanatory variable is underwriting losses scaled by total assets (UWLoss_TA), which captures the severity of underwriting outcomes relative to balance sheet size.

The dependent variable is the change in portfolio share across asset classes. For each asset class k (cash, bonds, or equities), the change between two consecutive balance sheet dates is defined as:

$$\Delta Share^k_{i,t\to t+1} = Share^k_{i,t+1} - Share^k_{i,t}$$

Portfolio shares are defined over invested assets rather than total assets because this is the margin insurers actively adjust in response to underwriting shocks. Underwriting outcomes are measured in year t, while portfolio reallocation is measured between t and $t+1$. This timing reflects the structure of NAIC statutory filings, where income is realized within the year and portfolio adjustments occur subsequently.

In addition to underwriting performance, the analysis considers losses incurred (LossInc_TA) as an alternative measure of realized shocks.

4.2 Baseline Specification

The baseline specification relates underwriting performance to subsequent portfolio reallocation:

$$\Delta Share^k_{i,t\to t+1} = \beta\, UWLoss\_TA_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

The coefficient β captures within-insurer changes in portfolio allocation associated with underwriting performance. Insurer fixed effects (α_i) absorb time-invariant heterogeneity such as investment strategy, business model, or geographic focus. Year fixed effects (γ_t) capture common macroeconomic and financial conditions that may affect both underwriting outcomes and portfolio allocation. Identification therefore comes from within-insurer variation over time.

Additional specifications include controls for insurer size and capital position. Size is measured as the logarithm of total assets, and capital is captured by the surplus ratio (SurpRatio). The specification is estimated following a regression ladder: starting with pooled OLS, then adding insurer and year fixed effects, then insurer size, and finally both size and the surplus ratio. If the coefficient on underwriting losses stays stable across these four steps, it is hard to attribute the result to omitted size or capital effects. Regressions are estimated using ordinary least squares with standard errors clustered at the insurer level.

4.3 Identification Strategy

Estimating the relationship between underwriting performance and portfolio allocation raises several identification concerns. Insurers with higher risk tolerance may both take on riskier underwriting exposure and hold different portfolios. Anticipation effects may also be present: insurers that anticipate losses may start reallocating before year-end, so part of the adjustment happens before the loss is formally recorded. Timing noise in loss recognition weakens OLS coefficients downward.

To address these concerns, the analysis uses an instrumental-variable strategy based on predetermined geographic exposure and variation in disaster costs across states and years. The identification focuses on losses incurred, which map directly into realized claims. While underwriting losses capture broader balance-sheet pressure and dominate in OLS horse races, realized claims are the natural match for the IV because NOAA disaster costs directly generate claims payments rather than affecting premiums or expense ratios.

The instrument combines predetermined geographic exposure and state-year disaster costs. Insurers differ in their exposure to individual states through their underwriting activity. When disasters occur, insurers with greater exposure to affected states experience higher realized claims, generating variation in losses driven by exogenous disaster realizations. Exposure is measured using Schedule T premium weights averaged over 2018–2020 and held fixed across the sample. Outcomes are restricted to 2021–2023, ensuring that pre-period weights are strictly predetermined relative to the outcome window. This separation is the key design choice: it prevents any overlap between the weight construction period and the outcome period, which would mechanically weaken the exclusion restriction.

$$Z_{i,t}^{raw} = \sum_{s} w_{i,s}^{pre} \times DisasterCost_{s,t}$$

$$Z_{i,t} = \frac{Z_{i,t}^{raw}}{TA_{i,t-1}}$$

The first stage relates losses to disaster exposure:

$$LossInc\_TA_{i,t} = \pi Z_{i,t} + \alpha_i + \gamma_t + u_{i,t}$$

The second stage estimates the effect of disaster-driven losses on portfolio reallocation:

$$\Delta Share_{i,t\to t+1}^{k} = \beta \widehat{LossInc\_}TA_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

The identifying assumption is that geographic exposure is predetermined and disaster realizations are exogenous. Conditional on fixed effects, variation in the instrument reflects differences in realized claims rather than endogenous underwriting or portfolio choices. The main concern would be that disasters affect asset prices in a way that mechanically shifts portfolio shares, but this would apply broadly across insurers within a year and is absorbed by the year fixed effects. I validate the exclusion restriction empirically through a falsification test: the instrument significantly predicts cash and bond adjustments but not illiquid asset categories such as mortgage loans and real estate, which cannot be rapidly liquidated to pay disaster claims. If the instrument were picking up a broad financial condition effect, it should predict illiquid assets too. It does not.

The IV identifies a local average treatment effect (LATE) for insurers most exposed to disaster variation. These insurers tend to be geographically concentrated and more exposed to climate risk, which is consistent with the heterogeneity evidence in Section 6.5. The IV estimate is therefore better interpreted as an upper bound on the average treatment effect for the full sample rather than as a precise causal estimate of the population average.

5. Data

The empirical analysis uses an insurer–year panel constructed from U.S. property and casualty statutory filings. The dataset combines insurer-level information from the National Association of Insurance Commissioners (NAIC) with state-level disaster data from the National Oceanic and Atmospheric Administration (NOAA), linking insurer balance sheets to climate-related shocks across states and over time.

5.1 Sources of Data

Insurer-level data are obtained from annual NAIC statutory filings from 2017 to 2024, including the Assets, Liabilities (including surplus), Statement of Income, and Schedule T, which reports insurer-state level exposure through premiums.

The data provide information on balance sheets, income, and geographic exposure. Portfolio shares (cash, bonds, and equities) are measured relative to invested assets. Capital is proxied by statutory surplus, while income variables include underwriting losses, losses incurred, and investment income.

To capture climate shocks, disaster cost data are obtained from NOAA at the state–year level. Disaster cost ranges are converted into midpoint values and combined with insurer exposure to construct the instrumental variable.

5.2 Sample Construction

The unit of observation is insurer–year. The main sample period spans 2018–2024, with 2017 values used to construct changes in portfolio shares. Observations with missing or non-positive values are excluded to ensure that variables and portfolio shares are well defined. Insurers with identifiers below 10,000 are also excluded as they represent groups of companies. The final sample contains 20,717 insurer–year observations. The IV sample is restricted to outcome years 2021–2023, yielding 6,665 observations.

5.3 Variable Construction

The main explanatory variables are underwriting losses scaled by total assets (UWLoss_TA) and losses incurred scaled by total assets (LossInc_TA). The dependent variables are changes in portfolio shares for cash, bonds, and equities between t and $t+1$. Controls include the log of total assets and the surplus ratio. The instrument combines predetermined Schedule T premium weights (averaged over 2018–2020) with state-year disaster costs from NOAA, scaled by lagged total assets. Table A.1 in the appendix reports full variable definitions, sources, and timing.

5.4 Summary Statistics

Table 1 reports summary statistics for the main variables. The sample contains 20,717 insurer-year observations over 2017–2024. Underwriting losses are frequent but small on average: the mean of UWLoss_TA is 2 percent of total assets, the median is zero, and the 90th percentile is 6 percent. Losses incurred are larger, averaging 11 percent of total assets, since they measure realized claims rather than net underwriting outcomes. Changes in portfolio shares are centered near zero, with standard deviations of 12 percentage points for ΔCash and ΔBonds and roughly a third that for ΔEquities. The surplus ratio averages 0.55 (SD 0.27), and median total assets are around $76 million.

Table 1: Summary Statistics

Variable	N	Mean	SD	P10	P50	P90
UWLoss_TA	20,717	0.0198	0.0450	0.0000	0.0000	0.0627
LossInc_TA	20,717	0.1147	0.1384	0.0000	0.0676	0.3102
ΔCash	17,850	0.0023	0.1207	-0.0962	0.0000	0.1061
ΔBonds	17,850	-0.0012	0.1192	-0.1046	0.0000	0.0980
ΔEquities	17,850	-0.0010	0.0399	-0.0300	0.0000	0.0273
Capital Ratio (Surplus/TA)	20,717	0.5483	0.2650	0.2389	0.4991	0.9716
ln(Assets)	20,717	18.2583	2.0406	15.7370	18.1428	21.0474

6. Results

This section presents the main empirical results on how insurers adjust portfolio allocation following underwriting losses. I first report baseline estimates from a regression ladder, then examine alternative loss measures and variation across the loss distribution, followed by the RBC transmission mechanism, cross-sectional heterogeneity, and finally causal results using an instrumental-variable strategy.

6.1 Baseline Results

I begin by estimating the relationship between underwriting losses and subsequent portfolio reallocation following a regression ladder. The analysis starts with a pooled OLS specification without fixed effects, then introduces insurer and year fixed effects, then adds insurer size, and finally includes both size and the surplus ratio.

Table 2: Baseline Relationship Between Underwriting Losses and Portfolio Reallocation

	OLS	FE	FE + Size	FE + Size + Capital
Δ *Cash*				
UWLoss_TA	0.095***	0.136***	0.135***	0.145***
	(0.026)	(0.044)	(0.044)	(0.045)
Δ *Bonds*				
UWLoss_TA	-0.075***	-0.118***	-0.115***	-0.115***
	(0.025)	(0.042)	(0.042)	(0.043)
Δ *Equities*				
UWLoss_TA	-0.019**	-0.022*	-0.024*	-0.033***
	(0.009)	(0.013)	(0.013)	(0.013)
Controls	No	No	$\ln(Assets)_{i,t}$	$\ln(Assets)_{i,t}$ + SurpRatio
Observations	17,762	17,762	17,762	17,762

Table 2 reports the results. The coefficient on cash is positive and statistically significant in all four specifications. The pooled OLS coefficient starts at 0.095 and increases to 0.136

after adding insurer and year fixed effects. After including size and capital controls, the preferred coefficient reads 0.145. For bonds, the coefficient is negative and statistically significant throughout, reaching −0.115 in the preferred specification. The equity coefficient is also negative and statistically significant in the preferred specification (−0.033), though smaller in magnitude, consistent with equities being a secondary adjustment margin given that they represent around 12 percent of the average insurer portfolio.

The coefficients remain highly stable across the regression ladder. Adding insurer size and the surplus ratio does not materially change the estimated effect of UWLoss_TA. This indicates that the estimates reflect genuine within-insurer adjustments rather than cross-sectional differences between large and small or well- and poorly-capitalized firms.

The magnitudes are economically meaningful. A one-standard-deviation increase in UWLoss_TA (4.5 percentage points) is associated with an increase in the cash share of approximately 0.65 percentage points and a decline in the bond share of similar size. The average effect is modest because it pools mild and severe losses together; the nonlinear results in Section 6.3 show that the response is concentrated in the upper tail.

To check that the estimates are not driven by any single catastrophe cycle, Table 3 splits the sample into high- and low-shock years. The pattern holds in both subsamples, indicating that the response reflects a systematic reaction to underwriting conditions rather than a specific disaster episode.

Table 3: External Validity: Portfolio Response Across Loss Environments

	Low-Shock Years	High-Shock Years
Δ Cash Share	0.198**	0.130**
	(0.096)	(0.062)
Δ Bond Share	-0.174*	-0.122**
	(0.091)	(0.060)
Δ Equity Share	n.s.	n.s.
Insurer FE	Yes	Yes
Year FE	Yes	Yes
Controls	Yes	Yes

6.2 Alternative Loss Measures

The baseline uses underwriting losses (UWLoss_TA), which combine realized claims with premium shortfalls, expenses, and reserve revisions. A natural question is whether the results are driven by claims alone or by the broader underwriting outcome. To address this, I compare UWLoss_TA with losses incurred (LossInc_TA), which captures only the realized claims component.

Table 4: Alternative Shock Measures: Underwriting Losses vs. Losses Incurred

	Separate Specification			Joint Specification		
	Δ Cash	Δ Bonds	Δ Equities	Δ Cash	Δ Bonds	Δ Equities
UWLoss_TA	0.145***	-0.115***	-0.033***	0.120**	-0.099**	-0.020
LossInc_TA	0.048**	-0.046**	-0.008	0.019	-0.022	-0.003
Insurer FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Table 4 reports the results. Entered separately, both measures produce the same qualitative pattern: higher losses raise cash holdings and reduce bond allocations, with limited effects on equities. The coefficients on UWLoss_TA are larger than on LossInc_TA, suggesting that the broader measure carries additional information beyond realized claims. The joint specification confirms this. When both enter at the same time, UWLoss_TA remains significant while LossInc_TA becomes insignificant. Realized claims alone do not drive the adjustment. What matters is the total underwriting outcome, which includes revisions to reserves and gaps between premiums and expenses. This is consistent with portfolio adjustment responding to balance-sheet pressure rather than to any single component of losses, and it matches the mechanism in Section 6.4, where surplus is the state variable most closely tied to the reallocation. For the IV, the natural match is with claims, not the broader underwriting outcome, because NOAA disaster costs directly generate claims payments rather than affecting premiums or expense ratios.

6.3 Loss Severity

The baseline specification treats the relationship as linear. If the adjustment is driven by balance-sheet pressure, the response should be stronger for losses that are large enough to materially affect capital positions. To test this, I restrict the sample to observations with positive underwriting losses and estimate the response separately across quartiles of the loss distribution, with the first quartile as the omitted category.

Table 5: Portfolio Reallocation Across Underwriting Loss Quartiles

	Δ Cash	Δ Bonds	Δ Equities
Q2 (moderate loss)	0.001	-0.005	0.000
	(0.006)	(0.005)	(0.002)
Q3 (large loss)	0.006	-0.007	-0.002
	(0.006)	(0.006)	(0.002)
Q4 (severe loss)	0.013^{*}	-0.016^{**}	-0.001
	(0.007)	(0.007)	(0.003)
Insurer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	7,157	7,157	7,157

Table 5 reports the results. The response is concentrated in the upper tail of the loss distribution. Moderate and large losses in the second and third quartiles generate no statistically significant portfolio adjustment, while severe losses in the top quartile drive the shift toward cash and away from bonds. This nonlinearity is consistent with the balance-sheet pressure interpretation: small losses leave surplus largely intact, so the RBC constraint does not bind much. Severe losses compress it enough that the incentive to shift toward zero-charge assets actually matters. The baseline linear coefficients should therefore be read as averages that mask a concentrated response in the upper tail.

6.4 Mechanism: The RBC Transmission Chain

The baseline results show that underwriting losses are associated with a shift toward cash and away from bonds. This section tests the transmission mechanism directly. If losses operate through balance-sheet pressure under the RBC framework, there should be a specific chain of effects: losses should first compress surplus, that surplus compression should reduce the overall risk of the portfolio, cash should be the vehicle through which this happens, the response should be concentrated among capital-constrained insurers, and it should be absent when losses are zero.

I test this chain in five steps using a portfolio risk index defined as $\text{RiskIndex} = 0 \times \Delta\text{Cash}$ $+1 \times \Delta\text{Bonds}$ $+3 \times \Delta\text{Equities}$, where the weights reflect the RBC C-1 charge structure (cash at zero, bonds at one, equities at three). A decline in RiskIndex means the portfolio has de-risked toward lower-charge assets.

Table 6 reports the five-step chain. T1 confirms that underwriting losses reduce the surplus ratio (-0.495, $p < 0.01$): losses compress the capital buffer that absorbs shocks. T2 shows that the same losses reduce the overall portfolio risk index (-0.185, $p < 0.01$): the portfolio de-risks. T3 shows that cash accumulation is the vehicle through which this happens: ΔCash strongly and negatively predicts RiskIndex (-1.118, $p < 0.01$, $R^2 = 0.784$), confirming that cash is the dominant margin. T4 splits insurers by the 2018–2020 median

Table 6: The RBC Transmission Chain

	T1	T2	T3	T4		T5
	SurpRatio	ΔRiskIndex	ΔRiskIndex	Low Cap	High Cap	Pos. Loss
UWLoss_TA	-0.495***	-0.185***	0.155***	0.155***	0.088	0.108*
	(0.046)	(0.055)	(0.054)	(0.054)	(0.075)	(0.059)
ΔCash			-1.118***			
			(0.009)			
Insurer FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	20,652	17,762	17,762	8,857	8,664	7,157
R^2	0.856	0.103	0.784	0.083	0.077	0.151

Notes: T1: underwriting losses compress the surplus ratio. T2: underwriting losses reduce the portfolio risk index. T3: cash reduces the risk index (the key mapping step confirming cash is the vehicle for de-risking). T4: split at the 2018–2020 median SurpRatio; the response is significant only for low-capital insurers. T5: split by loss incidence; the response is present only when underwriting losses are strictly positive. RiskIndex $= 0 \times \Delta$Cash $+1 \times \Delta$Bonds $+3 \times \Delta$Equities, using RBC C-1 charge weights. Standard errors clustered by insurer.

surplus ratio. For low-capital insurers, the cash response is 0.155 ($p < 0.01$); for high-capital insurers it is 0.088 and insignificant. The response is concentrated where the RBC constraint is more likely to bind. T5 splits by loss incidence: the response is 0.108 ($p < 0.10$) when underwriting losses are strictly positive, and zero otherwise. The mechanism has no entry point when there is no surplus compression. Taken together, these five steps rule out a generic flight-to-safety explanation (which would predict both groups respond in T4), a bond-driven de-risking explanation (ruled out by T3, since cash is invisible to the RiskIndex), and a general bad-year tendency (ruled out by T5).

6.5 Cross-Sectional Heterogeneity

The mechanism predicts that the response should be stronger for insurers facing greater balance-sheet pressure from a given loss. I examine five dimensions of heterogeneity.

Table 7 summarizes the results. The stock–mutual split shows that the response holds

Table 7: Cross-Sectional Heterogeneity

	Stock vs. Mutual		Capital		Geographic HHI		Climate Exposure	
	Stock	Mutual	Low Cap	High Cap	High HHI	Low HHI	High	Low
Δ *Cash*								
UWLoss_TA	0.142**	0.249***	0.155***	0.088	0.167***	0.017	0.125**	0.094
Δ *Bonds*								
UWLoss_TA	-0.133**	-0.131	-0.135**	-0.004	-0.135**	0.004	-0.114**	-0.037
Insurer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Stock vs. Mutual split uses NAIC company type codes. Capital split at 2018–2020 median SurpRatio. HHI = $\sum$(state premium share)^2, averaged over 2018–2020; High HHI = above median (concentrated). Climate Exposure = pre-period share of premiums in high-risk states. Standard errors clustered by insurer in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

for both ownership forms and is if anything larger for mutuals. Since mutuals face no equity market pressure, this rules out shareholder signaling as the mechanism. The capital split confirms T4 from the mechanism tests: the response is concentrated among low-capital insurers (0.155, $p < 0.01$) and absent among high-capital insurers (0.088, insignificant). The geographic HHI split is the sharpest result: among geographically concentrated insurers, the cash coefficient is 0.167 ($p < 0.01$); among diversified insurers it is 0.017 and insignificant. Geographic diversification reduces idiosyncratic loss exposure and therefore mutes the RBC pressure from any single shock. The climate exposure split mirrors this: among insurers with above-median pre-period exposure to high-risk states, the cash coefficient is 0.125 ($p < 0.05$); among low-exposure insurers it is 0.094 and insignificant. A mechanical accounting story or generic flight-to-safety would produce a similar response across exposure levels. It does not.

The five tests tell a consistent story. The response is concentrated precisely among the insurers for whom a given underwriting loss is most likely to create financial strain: those with lower capital, more concentrated geographic footprints, and greater exposure to climate risk. This points to the balance-sheet channel rather than an ownership or signaling mechanism.

Separately, the interaction between UWLoss_TA and investment income share (InvShare) is 0.994 ($p < 0.01$) for cash and -0.857 ($p < 0.01$) for bonds. Insurers that depend more heavily on investment income accumulate more cash and reduce bond exposure more aggressively. When underwriting losses erode surplus and simultaneously threaten the investment income base, the precautionary response is sharper.

6.6 Instrumental-Variable Evidence

The baseline estimates may be affected by endogeneity. Insurers with higher risk tolerance may both take on riskier underwriting exposure and hold different portfolios. Anticipation effects and timing noise in loss recognition push OLS estimates downward. To address these concerns, I use the shift-share IV described in Section **??**. The preferred specification uses pre-period weights fixed over 2018–2020 and restricts outcomes to 2021–2023, ensuring strict predetermination of the geographic weights relative to the outcome window.

Table 8: Instrumental Variable Estimation — Shift-Share NOAA Costs

	Panel A: First Stage	Panel B: Second Stage (2SLS)		
	LossInc_TA	Δ Cash	Δ Bonds	Δ Equities
Z_{it} (scaled)	0.0000200***			
	(0.0000048)			
$\widehat{LossInc\_TA}_{it}$		1.732**	-1.436**	-0.797
		(0.750)	(0.578)	(0.716)
Insurer FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	6,665	6,665	6,665	6,665
KP F-statistic	17.64			

Notes: Preferred specification. Pre-period weights fixed over 2018–2020. Outcome window: 2021–2023. Weighted by lagged total assets. KP F-statistic of 17.64 exceeds the Stock–Yogo 10% maximal IV size critical value of 16.38. Standard errors clustered by insurer in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8 reports the results. The first stage shows that the instrument strongly predicts realized losses: insurers with greater pre-period exposure to states hit by large disaster costs incur higher realized losses. The Kleibergen–Paap F-statistic of 17.64 exceeds the Stock–Yogo 10% maximal IV size critical value of 16.38, providing strong first-stage relevance. The second stage gives the same qualitative pattern as the OLS. Disaster-driven claims lead to higher cash holdings (1.732, $p < 0.05$) and lower bond exposure (-1.436, $p < 0.05$). The equity coefficient is -0.797 but not statistically significant, indicating that the reallocation takes place primarily between cash and bonds.

The IV coefficients are larger than the OLS estimates. The OLS specification with fixed effects gives 0.048 for cash and -0.046 for bonds using LossInc_TA; under the IV these become 1.732 and -1.436. Part of this gap reflects reverse causality and measurement error pushing OLS estimates downward. Part reflects the LATE interpretation: the IV identifies the effect for insurers most exposed to disaster variation, which the heterogeneity evidence shows respond more sharply. The IV estimate is therefore better read as an upper bound on the population average than as a direct causal estimate of the UWLoss channel.

Table 9: IV Robustness and Falsification

	B2: Broader Window			B3: High Climate		
	Δ Cash	Δ Bonds	Δ Equities	Δ Cash	Δ Bonds	Δ Equities
$\widehat{LossInc\_TA}$	1.978**	-1.765**	-0.906	1.533**	-1.744**	-0.019
	(0.881)	(0.777)	(0.833)	(0.760)	(0.811)	(0.181)
Observations	13,443	13,443	13,443	3,328	3,328	3,328
KP F-stat	11.45			10.16		
Insurer FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: B2 uses pre-period weights 2018–2020 and extends the outcome window to 2018–2024. B3 uses the same design as the main specification restricted to above-median climate exposure insurers. The falsification test (not shown) confirms that the instrument predicts ΔCash ($p < 0.05$) and ΔBonds ($p < 0.01$) but not illiquid assets such as mortgage loans and real estate, supporting the exclusion restriction. Standard errors clustered by insurer in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9 reports two robustness checks. B2 extends the outcome window to the full panel

(2018–2024). The KP F-statistic drops to 11.45, as expected: including years where the weight construction period and the outcome period overlap weakens the predetermination. Despite the weaker first stage, cash and bond coefficients remain significant at the 5% level. B3 restricts to insurers with above-median pre-period climate exposure. Both cash and bond coefficients remain significant, consistent with the heterogeneity evidence. The falsification test provides empirical support for the exclusion restriction: the instrument significantly predicts cash and bond adjustments but not illiquid asset categories, which cannot be rapidly liquidated to pay claims. This asymmetric pattern is difficult to explain unless the instrument operates specifically through the liquid claims channel.

7. Conclusion

This paper studies how underwriting losses affect portfolio allocation among U.S. property and casualty insurers. Using insurer-level data from NAIC statutory filings over 2017–2024, I examine whether losses in underwriting activity lead insurers to adjust their investment portfolios, and through what mechanism.

The results show that underwriting losses are followed by an increase in cash holdings and a reduction in bond exposure, while equity holdings are largely unchanged. The preferred baseline coefficient is 0.145 for cash and -0.115 for bonds, stable across a four-step regression ladder. The response is concentrated in the upper tail of the loss distribution and is stronger for insurers with less geographic diversification, greater climate exposure, and lower capital buffers. It is absent among diversified low-exposure insurers and when losses are zero. This pattern is consistent with precautionary liquidity accumulation under RBC constraints, not with generic flight-to-safety or risk-shifting.

The five-step RBC transmission chain confirms the mechanism. Losses compress surplus (T1), the portfolio de-risks (T2), cash is the vehicle (T3), the response is concentrated among capital-constrained insurers (T4), and it disappears when losses are zero (T5). A second finding is that underwriting losses, rather than realized claims alone, drive the response, pointing to broader balance-sheet pressure beyond the direct effect of claims. The preferred IV specification, which restricts outcomes to 2021–2023 where pre-period weights are strictly predetermined, delivers a KP F-statistic of 17.64 and confirms the direction and sign of the loss-to-liquidity response. A falsification test supports the exclusion restriction.

These findings point to a channel through which climate-related risk affects insurers' balance sheets. Insurers respond to losses not only through pricing and underwriting, which prior work has documented, but also through the composition of their assets. Liquidity emerges as an active margin of adjustment, not a byproduct of a broader reduction in risk.

The analysis is subject to several limitations. The sample focuses on statutory data and does not capture intra-year portfolio adjustments. The IV identifies a LATE for insurers most exposed to disaster variation and is better read as an upper bound on the average treatment effect than as a precise causal estimate of the population average. Future work could examine how these adjustments evolve over longer horizons and whether similar patterns arise in other segments of the insurance market.

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Appendix

Table A.1: Construct Definitions

Construct	Definition	Source	Timing
UWLoss_TA	$-\min(\text{Premiums} - \text{Losses} - \text{Expenses}, 0)$ scaled by total assets. Main explanatory variable; captures full underwriting shock.	NAIC Income	t
LossInc_TA	Losses incurred scaled by total assets. Captures only realized claims; used as endogenous variable in IV.	NAIC Income	t
ΔCash	Change in cash share of invested assets between t and $t+1$.	NAIC Assets	$t \to t+1$
ΔBonds	Change in bond share of invested assets between t and $t+1$.	NAIC Assets	$t \to t+1$
ΔEquities	Change in equity share of invested assets between t and $t+1$.	NAIC Assets	$t \to t+1$
RiskIndex	$0 \times \Delta\text{Cash} + 1 \times \Delta\text{Bonds} + 3 \times \Delta\text{Equities}$. Portfolio risk measure using RBC C-1 charge weights.	Constructed	$t \to t+1$
InvShare	$\lvert\text{NetInvInc}\rvert/(\lvert\text{NetInvInc}\rvert + \lvert\text{UWGainLoss}\rvert + \varepsilon)$, winsorized at 1st and 99th percentiles.	NAIC Income	t
ln_assets	Natural logarithm of total assets. Control for insurer size.	NAIC Assets	t
SurpRatio	Statutory surplus scaled by total assets. Captures capital position and RBC pressure.	NAIC Balance Sheet	t
Geographic HHI	$\sum_s(\text{state premium share})^2$, averaged over 2018–2020. Higher values indicate greater geographic concentration.	NAIC Schedule T	2018–2020
ClimateShare	Pre-period share of premiums written in high climate-risk states.	NAIC Schedule T	2018–2020
IV (Z)	$\sum_s w_{i,s}^{pre} \times \text{DisasterCost}_{s,t}$, scaled by lagged total assets. Pre-period weights fixed over 2018–2020; outcomes restricted to 2021–2023.	Schedule T + NOAA	t