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# When Natural Disasters Test Underwriting Resilience: Evidence from Vietnam's Non-Life Insurance Sector

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**ABSTRACT**

Natural disasters are increasingly important for disaster-risk financing in climate-vulnerable economies, yet little is known about whether insurers are equally resilient under disaster-loss conditions. Vietnam provides a relevant setting because it combines frequent natural disasters, a developing non-life insurance market and a sizable protection gap. Using firm-level panel data from Vietnam's listed non-life insurers over 2014–2024, this study examines whether prior claims performance shapes insurers' responses to aggregate disaster-loss conditions. The empirical design focuses on heterogeneous firm responses to common national disaster-loss conditions, rather than insurer-specific catastrophe exposure. The results show that insurers with higher prior claims ratios exhibit weaker premium-side adjustment when aggregate disaster losses increase. Conditional comparisons at low, median and high prior claims-ratio levels further show that the negative premium-side association becomes stronger as prior claims pressure rises. Claims-ratio responses are positive but less robust, while there is limited evidence of differential profitability, reserve accumulation or reinsurance adjustment. These findings suggest that natural disasters do not simply create uniform premium growth opportunities; instead, they reveal differences in underwriting resilience. The study contributes to sustainable disaster risk financing and climate-adaptation planning by showing that premium growth should be assessed together with claims performance, pricing discipline, reserve adequacy and risk-transfer capacity. For regulators and insurers in emerging markets, claims ratios can serve as a practical early-warning indicator of climate-related underwriting vulnerability, supporting insurance supervision and resilience planning consistent with SDG 11 and SDG 13.

## 1. INTRODUCTION

Natural disasters pose a dual challenge for insurance markets. They can increase demand for protection by making climate-related losses more visible, but they can also expose weak underwriting, pricing and risk management. This matters as extreme weather becomes more frequent and severe, and as insurers are expected to support recovery from climate-related losses [1, 2].

Prior research shows that physical climate risk affects economic activity, firm performance and financial decisions [3-5].

For insurers, the channel is direct: they underwrite the risks affected by disasters. Insurance prices, pools, and transfers risk and can reduce post-disaster financial stress [6]. But severe or uncertain disasters may raise claims, weaken pricing accuracy, pressure reserves and increase reinsurance needs. Evidence from Chinese property-casualty insurers shows that climate risks can increase claim ratios and reduce performance when risk management is insufficient [7].

This makes insurance relevant to climate-adaptation planning and sustainable development. In climate-vulnerable economies, a resilient non-life insurance sector helps households, firms and governments absorb losses, reduce post-disaster fiscal pressure and maintain economic continuity.

Disaster losses can therefore be read as demand shocks and as stress tests of underwriting quality. Prior studies show that disaster experience can increase insurance take-up [8-10]. Yet higher demand does not guarantee sustainable premium growth if insurers underprice risk, hold loss-prone portfolios or control claims poorly.

Vietnam is a useful setting for this question. It is exposed to storms, floods and heavy rainfall, while its non-life insurance market is still developing and faces low penetration and protection gaps [11-13]. Under the Law on Insurance Business No. 08/2022/QH15 [14], solvency management, risk governance and prudential supervision have become more salient. This setting links insurer resilience to disaster-risk financing, climate adaptation and the objectives of SDG 13 and SDG 11.

Vietnam's vulnerability is especially important because climate risk is transmitted through sectors that are central to the country's development model, including agriculture, transport, trade, industry, energy, coastal infrastructure and the Mekong Delta. The World Bank's Country Climate and Development Report highlights that Vietnam has more than 3,200 km of coastline, many low-lying cities and river-delta regions, and is among the countries most vulnerable to climate change. Initial estimates suggest that climate-change impacts caused losses of about US$10 billion in 2020, equivalent to 3.2% of GDP. Without adequate adaptation and mitigation measures, climate change could cost Vietnam about 12–14.5% of GDP annually by 2050 [11]. These figures show that climate risk in Vietnam is not only a physical threat to production, infrastructure and livelihoods, but also a financial risk that can be transmitted through insurance demand, claims payments, reserve adequacy, reinsurance needs and insurers' underwriting capacity. This makes Vietnam a particularly relevant setting for examining whether natural disaster-loss conditions reveal underwriting vulnerability in the non-life insurance sector.

Existing studies mainly estimate average climate-risk effects on insurers or firms. Ding and Li [7] showed that climate risks increase claim ratios and weaken performance among Chinese property-casualty insurers. Less is known about whether disaster-loss conditions reveal pre-existing underwriting vulnerability across insurers, especially in emerging markets with pricing constraints, data limitations and protection gaps.

This study examines whether aggregate disaster-loss conditions reveal heterogeneous underwriting vulnerability among Vietnam's listed non-life insurers. Using firm-level panel data for 2014-2024, it interacts national disaster losses with insurers' prior claims ratios and studies five outcomes: premium revenue, claims ratio, return on equity (ROE), reserve ratio and reinsurance ratio. Because disaster losses vary only by year, the design does not estimate insurer-specific catastrophe exposure or the average causal effect of disasters. It asks whether insurers with different prior claims performance respond differently under the same national disaster-loss environment.

Two limitations guide the interpretation. The sample covers listed non-life insurers, which are dominant but not the whole market. Disaster losses are national-year measures, so the results are interpreted as heterogeneous associations under common disaster-loss conditions.

The main result is that insurers with higher prior claims ratios show weaker premium-side adjustment when aggregate disaster losses increase. Evidence of stronger claims pressure is supportive but less robust, while ROE, reserves and reinsurance show no clear differential response. The findings suggest that disaster-loss conditions reveal underwriting vulnerability mainly through premium-side adjustment.

The study makes three contributions. It shifts the analysis from average climate-risk effects to heterogeneous underwriting vulnerability; provides evidence from Vietnam's climate-exposed and developing non-life insurance market; and shows that prior claims performance can serve as an observable early-warning indicator. These contributions connect insurer resilience with sustainable disaster-risk financing and climate-adaptation planning. The rest of the paper is organized as follows. Section 2 reviews the literature and develops the hypotheses. Section 3 describes the data and methodology. Section 4 presents the results and discussion. Section 5 reports robustness and small-sample sensitivity tests. Section 6 discusses contributions and policy implications. Section 7 concludes.

## 2. LITERATURE REVIEW

### 2.1 Natural disasters, insurance demand and premium adjustment

Natural disasters can affect insurers through both demand-side and pricing-side channels. On the demand side, disaster experience may increase the salience of low-probability but high-impact risks and lead households or firms to update beliefs about future losses and insurance needs. Prior evidence shows that flood experience, disaster-related knowledge and enterprise-level disaster exposure can increase insurance take-up [8-10]. These studies suggest that disaster-loss conditions may create demand-side opportunities for insurers by increasing awareness of protection needs.

However, the link between disaster experience and insurance demand is not uniform. Risk learning may differ across events and policyholders, and perceived risk can depend on whether realised losses are more or less severe than expected [15-18]. Demand responses may therefore be temporary, heterogeneous or constrained by ambiguity about future climate conditions. This matters because higher climate risk should not be interpreted as a mechanical source of stronger or more stable premium growth.

Even when risk awareness rises, insurers may not adjust premiums fully or immediately. Premium adjustment depends on pricing capacity, competition, affordability, regulatory conditions, data availability and the insurer's own financial position. Financial constraints can shape insurance product pricing, indicating that pricing decisions are influenced by expected losses and internal financial conditions [19]. These constraints are especially relevant in emerging markets, where historical catastrophe data, affordability constraints and competitive pressure may restrict climate-risk pricing.

This study therefore argues that premium-side adjustment under aggregate disaster-loss conditions depends partly on prior underwriting condition. A high lagged claims ratio may indicate thinner underwriting margins or greater exposure to loss-prone portfolios. Such insurers may face greater difficulty converting higher risk awareness into sustainable premium growth because price increases can be constrained by affordability, competition or portfolio quality. The same national disaster-loss conditions may therefore be associated with different premium responses across insurers. This framing keeps the analysis focused on heterogeneous firm responses under common disaster-loss conditions rather than on a uniform demand or pricing effect alone.

Accordingly, the first hypothesis is stated as follows:

*H1. Insurers with higher prior claims ratios exhibit weaker premium-side adjustment when aggregate natural disaster losses increase.*

### 2.2 Claims ratio and underwriting vulnerability

For insurers, the financial implications of natural disasters depend on how disaster-related risks are underwritten, priced and retained. In non-life insurance, the claims ratio is a direct indicator of underwriting performance because it measures the share of premium revenue absorbed by claim payments. A higher claims ratio leaves less room for operating expenses, reserve accumulation and underwriting profit. Claims ratios are therefore not only accounting outcomes, but also signals of underwriting pressure.

Claims ratios are particularly relevant for climate-related disasters because property-casualty and non-life insurers are exposed to physical losses through property damage, motor losses, agriculture, business interruption, liability claims and other insured losses. Ding and Li [7] showed that temperature and precipitation extremes increase claim ratios among property-casualty insurers in China, supporting the view that claims are a primary channel through which climate risk affects insurers.

In this study, the claims ratio has two roles. It is used as an outcome variable for current underwriting pressure and, in lagged form, as an observable proxy for prior underwriting vulnerability. A high prior claims ratio may indicate underpricing, weaker risk selection, exposure to loss-prone business lines or less effective claims management. Although the ratio cannot identify these mechanisms separately, it provides a practical summary measure of prior loss pressure. The accounting construction and consistency checks are documented in Appendix B.

This proxy is useful because natural disasters are unlikely to affect all insurers uniformly. Insurers with lower prior claims ratios may have greater capacity to absorb adverse disaster-loss conditions, while high-claims insurers may already operate with thinner margins. When aggregate disaster losses increase, they may be imposed on portfolios that were already more claims-intensive, thereby amplifying existing underwriting weaknesses rather than generating the same response across all insurers.

Prior claims performance can therefore serve as an early-warning indicator of climate-related underwriting vulnerability. Premium growth may appear positive, but persistent claims pressure can still signal weak underwriting quality. This is important for insurance supervision because market expansion may mask inadequate pricing or claims control. Claims ratios therefore link firm-level underwriting discipline with broader climate-risk management.

This reasoning is consistent with research showing that climate risks affect insurers unevenly depending on exposure, risk-management capacity and strategic responses [20-23]. It also supports a heterogeneous interpretation of disaster-loss conditions: the key issue is not only whether disasters raise average claims or reduce average performance, but whether they reveal which insurers are already more vulnerable before disaster losses increase.

Based on this logic, the study expects insurers with higher prior claims ratios to face stronger underwriting pressure when natural disaster losses increase. The prior claims ratio captures pre-existing underwriting vulnerability, while disaster losses capture aggregate disaster-loss conditions. Their interaction therefore tests whether more vulnerable insurers respond differently during high-disaster-loss years.

Accordingly, the second hypothesis is stated as follows:

*H2. Insurers with higher prior claims ratios exhibit stronger claims-ratio responses when aggregate natural disaster losses increase.*

### 2.3 Climate-risk management, reserves and reinsurance

Insurance resilience under climate risk also depends on internal buffers and external risk-transfer mechanisms. Technical reserves help insurers prepare for future claim obligations, while reinsurance enables primary insurers to transfer part of their underwritten risks. These tools matter because natural disasters can create large correlated losses that are difficult to diversify internally. They also connect firm-level underwriting resilience with the broader ability of insurance markets to support disaster-risk financing.

Higher disaster losses may encourage insurers to strengthen reserves or expand reinsurance coverage. Prior studies emphasize the importance of risk pooling, reinsurance and public-private risk-sharing arrangements for climate-related catastrophe risk [24-26]. However, these responses depend on cost, availability, capital constraints, regulation and actuarial capacity. Reinsurers may raise prices or tighten coverage after catastrophe events, and Ding and Li [7] found limited reinsurance adjustment among Chinese property-casualty insurers.

For the present study, reserve and reinsurance ratios are used to examine whether insurers adjust internal risk-absorption or external risk-transfer arrangements when aggregate disaster losses increase. Given mixed prior evidence and emerging-market constraints, these variables are treated as exploratory risk-management response outcomes rather than confirmed mechanisms. Insignificant results should not be interpreted as evidence that reserves or reinsurance are irrelevant; they may reflect delayed recognition, market constraints or limitations of annual accounting ratios.

These mechanisms are also relevant in Vietnam. The non-life market remains developing, protection gaps are sizable, and listed insurers account for a large share of market premiums [12, 13]. The Law on Insurance Business No. 08/2022/QH15 emphasizes solvency management, risk governance and prudential supervision [14]. Reserve adequacy and reinsurance arrangements therefore matter for firm-level risk management, disaster-risk financing and climate-adaptation planning, including the resilience objectives reflected in SDG 11 and SDG 13. In a concentrated emerging insurance market, weak adjustment by major insurers could limit the sector's ability to absorb and transfer climate-related losses.

Accordingly, the third test is framed as an exploratory analysis rather than a directional hypothesis:

*Exploratory test: This study examines whether aggregate natural disaster-loss conditions are associated with changes in insurers' reserve or reinsurance ratios among insurers with higher prior claims ratios.*

## 3. DATA AND METHODOLOGY

### 3.1 Data and sample

This study uses firm-level panel data from publicly listed non-life insurance firms in Vietnam. The initial dataset covers listed insurers over the period 2008–2024. BVH is excluded from the main analysis because its consolidated financial statements combine life insurance, non-life insurance and other financial activities, making it less comparable to firms operating primarily in the non-life insurance segment.

The focus on non-life insurers is intentional. Unlike firms in the broad corporate market, non-life insurers are more directly exposed to disaster-related underwriting risks through their core insurance activities. Natural disasters may increase insurance demand by raising risk awareness, but they may also generate higher claims, expose underpricing, test reserve adequacy and affect the need for reinsurance. Therefore, the non-life insurance sector provides an economically meaningful setting in which disaster-loss conditions can be examined through observable underwriting outcomes such as premium revenue, claims ratios, technical reserves and reinsurance. A broad-market sample would mix firms with different and often indirect channels of climate-risk exposure, potentially diluting the underwriting mechanism that this study seeks to identify.

The main empirical analysis focuses on the period 2014–2024, during which all 10 listed non-life insurers are consistently represented in the dataset. This results in a balanced panel of 110 firm-year observations. The 2014–2024 period is selected as the baseline sample because it provides a stable firm composition and reduces concerns that the results are driven by changes in sample coverage in earlier years. Because the regression models use one-year lagged firm-level variables, the first year of the baseline panel is lost in the main estimations. Additional missing observations in specific accounting items further reduce the effective sample to 99–100 observations depending on the specification.

Although the number of firms is relatively small, the sample is economically meaningful because it captures a substantial share of Vietnam's non-life insurance market. From 2014 to 2024, the sample firms collectively account for approximately 56–70% of total non-life insurance premiums, with an average market coverage of 62.69%. This reflects the concentrated structure of Vietnam's listed non-life insurance sector and supports the interpretation of the sample as evidence from dominant listed market participants. Nevertheless, the results should be interpreted as evidence on listed non-life insurers' resilience rather than as representative of the entire non-life insurance market, especially smaller unlisted insurers.

To assess whether the findings are sensitive to the baseline period, the full unbalanced panel from 2008 to 2024 is used in robustness checks. After excluding BVH, this broader sample includes 139 firm-year observations. However, because the earlier years contain fewer consistently observed firms, the balanced 2014–2024 panel is used as the preferred sample for the main analysis.

Financial statement data are obtained from FiinGroup's FiinPro standardized financial statement database for listed Vietnamese firms [27]. FiinPro reports standardized annual financial statement items in VND, scaled to billion VND in the exported tables. The extracted items are mapped to the corresponding accounting items in insurers' financial statements, including premium revenue, claims expense, profit after tax, equity, total assets, technical reserves and reinsurance expenses. The exact Vietnamese financial statement items, English translations, source statements, formulas, units and data-treatment rules used to construct each variable are reported in Appendix B.

Data on monetary losses caused by natural disasters are collected from the official annual disaster-damage statistical tables published in the 'Thống kê thiệt hại' section of Vietnam's disaster management authority [28]. For each year, the study uses the annual aggregate monetary loss reported in the final monetary-loss row of the corresponding annual table. The original figures are reported in million VND and are converted into billion VND by dividing by 1,000 before applying the natural logarithm. All disaster-loss values are nominal and are not adjusted for inflation. Therefore, the disaster-loss variable should be interpreted as reported aggregate nominal disaster-loss conditions rather than real disaster-loss exposure or insurer-specific catastrophe exposure.

Table 1 reports the annual market coverage of the baseline sample.

**Table 1.** Market coverage of the baseline sample

| Year | Number of Firms | Total Market Share |
|---|---|---|
| 2014 | 10 | 64.09% |
| 2015 | 10 | 64.81% |
| 2016 | 10 | 59.52% |
| 2017 | 10 | 57.79% |
| 2018 | 10 | 56.27% |
| 2019 | 10 | 56.16% |
| 2020 | 10 | 61.36% |
| 2021 | 10 | 65.42% |
| 2022 | 10 | 66.76% |
| 2023 | 10 | 67.41% |
| 2024 | 10 | 70.02% |
| Average | 10 | 62.69% |

Note: Market share is calculated as the sum of sample firms' premium revenue divided by total non-life insurance premium revenue in Vietnam.

### 3.2 Variable definitions and rationale

Table 2 summarizes the variable definitions, measurements and empirical roles.

**Table 2.** Variable summary

| Variable | Measurement | Role |
|---|---|---|
| log_premium | Natural logarithm of premium revenue | Dependent variable; premium-side adjustment |
| claims_ratio | Reported gross claims expense / premium revenue | Dependent variable; underwriting pressure before reinsurance recoveries |
| ROE | Net income / equity | Dependent variable; profitability |
| reserve_ratio | Technical reserves / premium revenue | Dependent variable; internal risk-absorption outcome |
| reinsurance_ratio | Ceded reinsurance premium / premium revenue | Dependent variable; external risk-transfer outcome |
| log_damage | Natural logarithm of aggregate monetary losses caused by natural disasters in Vietnam | Aggregate disaster-severity variable |
| lag_claims_ratio | Previous-year claims ratio | Prior underwriting-vulnerability proxy |
| log_damage × lag_claims_ratio | Interaction between aggregate disaster losses and previous-year claims ratio | Main variable of interest |
| firm-level controls | Lagged market share, lagged reserve ratio, lagged reinsurance ratio, and log total assets | Control variables |

The variable definitions follow prior studies on climate risk and insurer performance, while being adapted to the Vietnamese data context. Premium revenue, claims ratios and profitability are used to capture insurers' underwriting scale, claims pressure and overall financial performance. Ding and Li [7], for example, used premium income, claims expenditure, claim ratios, ROA and ROE to examine how climate risks affect property-casualty insurers. Claims ratios are particularly important in this study because prior evidence suggests that claims are a primary channel through which climate risk affects insurer performance.

Reserve and reinsurance ratios are included to examine whether insurers adjust internal risk-absorption or external risk-transfer arrangements when disaster losses increase. These variables are treated as exploratory risk-management response outcomes rather than confirmed mechanisms. This treatment is consistent with prior evidence showing that insurers do not always significantly adjust reinsurance or business distribution in response to climate risk.

The disaster-loss variable is constructed from official national disaster-damage statistics and captures aggregate disaster severity in Vietnam. Unlike studies that measure climate exposure at the city-insurer or firm-location level, this variable varies only at the national-year level. Therefore, it should be interpreted as a measure of aggregate disaster-loss conditions rather than insurer-specific catastrophe exposure. Building on the evidence that claims are a central channel of insurer vulnerability, the lagged claims ratio is used as an observable proxy for prior underwriting vulnerability. The interaction between aggregate disaster losses and lagged claims ratios is the main coefficient of interest and captures whether insurers with weaker prior claims performance exhibit different responses when disaster losses increase.

### 3.3 Empirical strategy

The empirical strategy is designed to examine whether insurers with different prior underwriting conditions exhibit different financial responses when aggregate natural disaster losses increase. Because the disaster-loss variable is measured at the national-year level, it does not vary across firms within the same year. In specifications with year fixed effects, the standalone effect of Log_damage is therefore absorbed by year effects. Accordingly, the analysis focuses on interaction specifications that combine aggregate national disaster losses with lagged firm-level exposure variables.

The main specification is written as follows:

$$Y_{it} = \beta_0 + \beta_1 \left(\text{Log\_damage}_t \times \text{lag\_claims\_ratio}_{i,t-1}\right) + \beta_2 \, \text{lag\_claims\_ratio}_{i,t-1} + \beta_3 X_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{it}$$

where, $Y_{it}$ represents the financial outcome of insurer i in year t. The model is estimated separately for five dependent variables: log_premium, claims_ratio, ROE, reserve_ratio and reinsurance_ratio. These outcomes capture premium-side adjustment, underwriting pressure, overall profitability, internal risk absorption and external risk transfer, respectively.

$\text{Log\_damage}_t$ is the logarithm of aggregate nominal monetary losses caused by natural disasters in Vietnam in year t. $\text{lag\_claims\_ratio}_{i,t-1}$ is the previous-year claims ratio of insurer i and is used as an observable proxy for prior underwriting vulnerability. The interaction term $\text{Log\_damage}_t \times \text{lag\_claims\_ratio}_{i,t-1}$ is the main variable of interest. Its coefficient, $\beta_1$, captures whether insurers with higher prior claims ratios exhibit different financial responses to the same aggregate disaster-loss conditions than insurers with lower prior claims ratios.

$X_{i,t-1}$ is a vector of lagged firm-level controls, including firm size, lagged reserve ratio and lagged reinsurance ratio. Firm fixed effects, $\mu_i$, control for time-invariant differences across insurers, such as ownership structure, business model, underwriting capacity and distribution network. Year fixed effects, $\lambda_t$, control for common shocks affecting all insurers in the same year, including macroeconomic conditions, regulatory changes, inflation, insurance market growth and other nationwide factors.

Because $\text{Log\_damage}_t$ varies only by year, its standalone effect is absorbed by year fixed effects. The coefficient of interest is therefore not the direct coefficient of $\text{Log\_damage}_t$, but the interaction coefficient $\beta_1$. The estimates should be interpreted as evidence of heterogeneous firm-level responses to aggregate disaster-loss conditions, rather than as direct estimates of insurer-specific catastrophe exposure or average disaster effects. This identification choice is important: the study does not claim to measure each insurer's geographic or product-line catastrophe exposure, but tests whether insurers with different prior underwriting conditions respond differently under the same national disaster-loss environment.

The expected interpretation of $\beta_1$ depends on the outcome variable. In the premium model, a negative coefficient would suggest that insurers with higher prior claims ratios exhibit weaker premium-side adjustment when disaster losses increase. In the claims-ratio model, a positive coefficient would indicate stronger underwriting pressure among these insurers. In the ROE model, the sign is treated as an empirical question because profitability reflects both underwriting and non-underwriting activities. In the reserve-ratio and reinsurance-ratio models, significant coefficients would suggest that insurers with higher prior claims ratios adjust internal buffers or external risk-transfer arrangements in response to disaster-loss conditions. These reserve and reinsurance results are interpreted as exploratory evidence of risk-management responses rather than as confirmed mechanisms.

To examine alternative exposure channels, the study also estimates additional interaction models by replacing $\text{lag\_claims\_ratio}_{i,t-1}$ with other lagged firm-level characteristics:

$$Y_{i,t} = \beta_0 + \beta_1 \left(\text{Log\_damage}_t \times Z_{i,t-1}\right) + \beta_2 Z_{i,t-1} + \beta_3 X_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

where, $Z_{i,t-1}$ represents alternative exposure variables, including lag_market_share, lag_reinsurance_ratio and lag_reserve_ratio. These models examine whether disaster-loss conditions are associated with different responses across insurers with different market positions, prior risk-transfer arrangements or internal buffer capacity.

All firm-level exposure and control variables are lagged by one year to reduce simultaneity concerns between current disaster-loss conditions and firm-level financial responses. Standard errors are clustered at the firm level to account for heteroskedasticity and within-firm serial correlation. However, because the baseline sample contains only 10 firm clusters, conventional firm-clustered standard errors may overstate statistical precision. To address this concern, the baseline results are also evaluated using wild cluster bootstrap p-values for the main interaction term with firm-level clustering. Statistical significance is therefore interpreted with reference to both conventional clustered inference and wild cluster bootstrap inference.

Table 3 summarizes the empirical model structure and exposure variables.

The main analysis is conducted using the balanced panel from 2014 to 2024. The full unbalanced panel from 2008 to 2024 and a sample excluding the COVID-19 years are used as robustness checks. These additional tests examine whether the main findings are sensitive to sample-period selection or to the potential distortion caused by the pandemic years.

**Table 3.** Empirical model structure and exposure variables

| Model | Exposure Variable $Z_{i,t-1}$ | Purpose | Fixed Effects | Main Use |
|---|---|---|---|---|
| Main underwriting-vulnerability model | lag_claims_ratio | Tests whether insurers with higher prior claims ratios exhibit different financial responses to aggregate disaster-loss conditions | Firm FE + Year FE | Main model |
| Market-position model | lag_market_share | Tests whether insurers with larger market positions exhibit different responses to aggregate disaster-loss conditions | Firm FE + Year FE | Robustness / heterogeneity |
| Reinsurance-exposure model | lag_reinsurance_ratio | Tests whether prior reliance on external risk transfer is associated with different responses to aggregate disaster-loss conditions | Firm FE + Year FE | Exploratory heterogeneity |
| Reserve-buffer model | lag_reserve_ratio | Tests whether pre-existing internal buffer capacity is associated with different responses to aggregate disaster-loss conditions | Firm FE + Year FE | Exploratory heterogeneity |

## 4. RESULTS AND DISCUSSION

### 4.1 Descriptive statistics

Table 4 reports the descriptive statistics for the main variables used in the empirical analysis. The average value of log_premium is 7.836, with a standard deviation of 0.846, indicating meaningful variation in premium revenue across insurers and over time. The average claims_ratio is 0.372, suggesting that claim payments account for approximately 37.2% of premium revenue on average. The interquartile range of the claims ratio is relatively moderate, from 0.317 to 0.431, indicating that underwriting pressure is generally concentrated around the sample mean.

The average ROE is 0.090, while the minimum value is -0.192. This shows that although insurers are profitable on average, some firm-year observations record negative profitability. This is plausible in the insurance sector, where underwriting losses, investment losses, or exceptional claim events may generate loss-making years. The mean values of reserve_ratio and reinsurance_ratio are 0.368 and 0.258, respectively, suggesting that insurers differ in both internal risk-absorption capacity and external risk-transfer intensity.

The average value of Log_damage is 9.738, with a standard deviation of 1.040, indicating meaningful variation in aggregate natural disaster losses during the sample period. The lagged claims ratio has a mean of 0.386 and a maximum value above one, reflecting the presence of at least one firm-year observation with unusually high prior claims pressure. This supports the use of lag_claims_ratio as a proxy for prior underwriting vulnerability. The interaction term Log_damage × lag_claims_ratio also displays substantial variation, with a mean of 3.731 and a maximum of 10.521, allowing the study to examine whether disaster-loss conditions are transmitted differently across insurers with different levels of prior claims exposure.

Overall, the descriptive statistics indicate sufficient variation in both insurer-level financial outcomes and national disaster-loss exposure. These patterns support the empirical strategy of examining whether aggregate disaster-loss conditions are associated with heterogeneous financial responses across insurers, particularly through prior claims performance and underwriting vulnerability.

**Table 4.** Descriptive statistics

| Variable | N | Mean | Std. Dev. | Min | P25 | Median | P75 | Max |
|---|---|---|---|---|---|---|---|---|
| log_premium | 100 | 7.836 | 0.846 | 5.912 | 7.421 | 7.941 | 8.460 | 9.857 |
| claims_ratio | 100 | 0.372 | 0.087 | 0.167 | 0.317 | 0.374 | 0.431 | 0.573 |
| ROE | 100 | 0.090 | 0.066 | -0.192 | 0.054 | 0.089 | 0.123 | 0.280 |
| reserve_ratio | 100 | 0.368 | 0.181 | 0.203 | 0.241 | 0.311 | 0.496 | 0.862 |
| reinsurance_ratio | 99 | 0.258 | 0.169 | 0.121 | 0.148 | 0.267 | 0.361 | 0.646 |
| log_damage | 100 | 9.738 | 1.040 | 7.947 | 8.834 | 9.877 | 10.596 | 11.425 |
| lag_claims_ratio | 100 | 0.386 | 0.137 | 0.121 | 0.317 | 0.374 | 0.441 | 1.324 |
| log_damage × lag_claims_ratio | 100 | 3.731 | 1.202 | 1.291 | 2.970 | 3.650 | 4.261 | 10.521 |
| lag_log_total_assets | 100 | 8.340 | 0.825 | 6.728 | 7.768 | 8.391 | 8.793 | 10.202 |
| lag_reserve_ratio | 100 | 0.354 | 0.203 | 0.082 | 0.223 | 0.301 | 0.494 | 1.022 |
| lag_reinsurance_ratio | 100 | 0.248 | 0.170 | 0.062 | 0.092 | 0.261 | 0.359 | 0.618 |
| lag_market_share | 100 | 0.067 | 0.055 | 0.011 | 0.030 | 0.052 | 0.084 | 0.287 |

Notes: The sample excludes BVH because its business model combines life and non-life insurance activities. Observations with missing accounting information are excluded from the relevant calculations. reinsurance_ratio has 99 observations due to one missing observation.

## 4.2 Correlation matrix

Table 5 presents the Pearson correlation matrix for the main variables. Overall, the pairwise correlations are broadly consistent with the structure of the empirical model. The correlation between Log_damage and firm-level variables is generally weak. For example, its correlation with claims_ratio, ROE, reserve_ratio, and reinsurance_ratio is close to zero. This is expected because Log_damage is measured at the national-year level and does not vary across firms within the same year. Therefore, the main empirical analysis focuses on the interaction between national disaster losses and firm-level prior underwriting vulnerability rather than the standalone correlation between disaster losses and firm outcomes.

**Table 5.** Correlation matrix

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) log_premium | 1 | | | | | | | | | |
| (2) claims_ratio | 0.012 | 1 | | | | | | | | |
| (3) ROE | 0.15 | -0.350*** | 1 | | | | | | | |
| (4) reserve_ratio | 0.012 | 0.183* | -0.132 | 1 | | | | | | |
| (5) reinsurance_ratio | 0.403*** | -0.088 | -0.027 | 0.244** | 1 | | | | | |
| (6) log_damage | 0.114 | 0.034 | -0.081 | 0.069 | 0.006 | 1 | | | | |
| (7) lag_claims_ratio | -0.059 | 0.306*** | 0.064 | 0.08 | -0.035 | -0.164 | 1 | | | |
| (8) lag_log_total_assets | 0.962*** | 0.054 | 0.12 | 0.136 | 0.457*** | 0.136 | -0.063 | 1 | | |
| (9) lag_reserve_ratio | -0.028 | 0.201** | -0.125 | 0.560*** | 0.122 | 0.105 | 0.022 | 0.121 | 1 | |
| (10) lag_reinsurance_ratio | 0.295*** | -0.114 | -0.05 | 0.350*** | 0.728*** | 0.094 | -0.035 | 0.352*** | 0.183* | 1 |

Notes: Pearson correlation coefficients are reported. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

The matrix also shows several economically intuitive relationships. claims_ratio is negatively and significantly correlated with ROE (-0.350), suggesting that higher claims pressure is associated with weaker profitability. claims_ratio is also positively correlated with lag_claims_ratio (0.306), indicating persistence in underwriting pressure across time. This supports the use of lagged claims ratio as a proxy for prior underwriting vulnerability. Similarly, reserve_ratio is strongly correlated with lag_reserve_ratio (0.560), and reinsurance_ratio is strongly correlated with lag_reinsurance_ratio (0.728), suggesting persistence in reserve and reinsurance behaviour.

One notable correlation is between log_premium and lag_log_total_assets (0.962). This high correlation is expected because larger insurers tend to generate higher premium revenue. It does not invalidate the model, but it reinforces the need to interpret the premium model carefully and to control for firm size when examining premium-side adjustment. The correlation between reinsurance_ratio and lag_log_total_assets is also positive and significant (0.457), suggesting that larger insurers tend to use more reinsurance. Overall, the correlation matrix indicates that the key variables display meaningful relationships, while the main disaster variable is not mechanically correlated with firm-level outcomes. This supports the interaction-based empirical strategy used in the subsequent regression analysis, while also motivating the sensitivity tests that examine more parsimonious specifications and the role of firm size.

## 4.3 Baseline regression results

Table 6 presents the baseline regression results. Since Log_damage varies only at the national-year level, its standalone effect is absorbed by year fixed effects; therefore, the interpretation focuses on the interaction term Log_damage × lag_claims_ratio. Given the small number of firm clusters, the table reports both conventional clustered p-values and wild cluster bootstrap p-values for the main interaction term.

**Table 6.** Baseline regression results

| Variables | (1) Log_premium | (2) Claims_ratio | (3) ROE | (4) Reserve_ratio | (5) Reinsurance_ratio |
|---|---|---|---|---|---|
| Log_damage × lag_claims_ratio | -0.2933* | 0.0853* | -0.0324 | 0.145 | -0.0077 |
| | (0.1318) | (0.0401) | (0.0381) | (0.1517) | (0.0599) |
| Clustered p-value | 0.0261 | 0.0334 | 0.3949 | 0.3392 | 0.8983 |
| Wild bootstrap p-value | 0.0518 | 0.0781 | 0.4258 | 0.4727 | 0.9063 |
| lag_claims_ratio | 2.4168** | -0.6036* | 0.2743 | -1.2248 | 0.1392 |
| | (1.0169) | (0.3137) | (0.3208) | (1.4023) | (0.5998) |
| lag_log_total_assets | 0.9835*** | 0.0951 | -0.0343 | -0.1678** | 0.0197 |
| | (0.1654) | (0.0668) | (0.0275) | (0.0686) | (0.0661) |
| lag_reinsurance_ratio | -0.3345 | -0.0909 | 0.0288 | 0.3854 | 0.4198*** |
| | (0.2291) | (0.0801) | (0.0315) | (0.3516) | (0.0824) |
| lag_reserve_ratio | -0.2804 | 0.085 | -0.0261 | 0.2671* | -0.0406 |
| | (0.3058) | (0.0915) | (0.0291) | (0.1454) | (0.0691) |
| Firm fixed effects | Yes | Yes | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes | Yes | Yes |
| Observations | 100 | 100 | 100 | 100 | 99 |

Notes: Standard errors are clustered at the firm level. Because the baseline sample contains only 10 firm clusters, statistical significance for the main interaction term, Log_damage × lag_claims_ratio, is assessed primarily using wild cluster bootstrap p-values. Conventional clustered p-values are reported for comparison. For the main interaction term, stars reflect wild cluster bootstrap inference; for other coefficients, stars follow conventional firm-clustered inference. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

The interaction coefficient is negative in the log_premium model. It is statistically significant under conventional firm-clustered inference and remains marginally significant under wild cluster bootstrap inference, with a bootstrap p-value of 0.0518. This supports the interpretation that insurers with higher prior claims ratios exhibit weaker premium-side adjustment when aggregate disaster losses increase. In the claims_ratio model, the interaction term is positive and statistically significant under conventional clustered inference; it remains marginally significant under wild bootstrap inference, with a bootstrap p-value of 0.0781. This provides supportive evidence that these insurers face stronger underwriting pressure during high-disaster-loss years, although this evidence is weaker than the premium-side result. To make the economic magnitude easier to interpret, the analysis compares three insurer profiles based on prior claims pressure: insurers at the 25th percentile, median and 75th percentile of lag_claims_ratio. This approach shows how the same aggregate disaster-loss conditions are associated with different outcomes for insurers with weaker or stronger prior claims performance.

The pattern is economically clear. Insurers with higher prior claims ratios show weaker premium-side adjustment when aggregate disaster losses increase. At low, median and high values of lag_claims_ratio, the implied associations with log_premium are -0.093, -0.110 and -0.129, respectively. This should not be interpreted as evidence that disasters directly reduce premium revenue for all insurers. Rather, it indicates that insurers already facing higher claims pressure are less able to convert higher disaster-risk awareness into sustainable premium growth.

The claims-ratio results point in the same direction. At low, median and high values of lag_claims_ratio, the implied associations with the current claims ratio are 0.027, 0.032 and 0.038, respectively. This suggests stronger claims pressure among insurers with weaker prior underwriting performance. However, this evidence remains weaker than the premium-side result and should be interpreted as supportive rather than conclusive.

By contrast, the interaction coefficients are statistically insignificant in the ROE, reserve_ratio, and reinsurance_ratio models under both conventional clustered inference and wild bootstrap inference. These results provide no clear evidence of differential profitability effects, reserve accumulation, or active reinsurance adjustment among insurers with higher prior claims ratios. Overall, the baseline evidence suggests that heterogeneous responses to aggregate disaster losses are concentrated mainly in underwriting-related outcomes, especially weaker premium-side adjustment and supportive evidence of stronger claims pressure.

## 5. ROBUSTNESS AND SMALL-SAMPLE SENSITIVITY

### 5.1 Robustness checks

Table 7 reports robustness checks using two alternative sample specifications: an extended unbalanced panel covering 2008–2024 and a restricted sample excluding the COVID-19 years. The reported coefficients refer to the interaction term between aggregate disaster losses and prior claims ratios. The coefficient on Log_damage × lag_claims_ratio in the log_premium model remains negative and statistically significant in both specifications, with coefficients of -0.2648 and -0.2762, respectively. This finding supports the main interpretation that insurers with higher prior claims ratios exhibit weaker premium-side adjustment when aggregate disaster losses increase.

The evidence for the claims_ratio model is less stable. The interaction term remains positive and statistically significant in the extended sample, but becomes statistically insignificant after excluding the COVID-19 years, although the sign remains positive. This suggests that the claims-pressure channel is consistent with the baseline interpretation, but should be viewed as less robust than the premium-side result. The interaction coefficients for ROE, reserve_ratio, and reinsurance_ratio are statistically insignificant across both robustness checks. Overall, Table 7 indicates that the most stable empirical finding is the weaker premium-side adjustment among insurers with higher prior claims ratios. By contrast, the evidence for stronger claims pressure is partial, while the results do not provide strong support for differential profitability, reserve, or reinsurance responses.

**Table 7.** Robustness check model

| Dependent Variable | Sample | Coef. | Clustered SE | *t*-Statistic |
|---|---|---|---|---|
| log_premium | Full sample 2008–2024 | -0.2648** | 0.1151 | -2.3 |
| claims_ratio | Full sample 2008–2024 | 0.1898** | 0.0796 | 2.3842 |
| ROE | Full sample 2008–2024 | -0.0416 | 0.0309 | -1.3484 |
| reserve_ratio | Full sample 2008–2024 | 0.1451 | 0.1499 | 0.9676 |
| reinsurance_ratio | Full sample 2008–2024 | -0.0113 | 0.0522 | -0.2162 |
| log_premium | Excluding COVID years | -0.2762** | 0.1189 | -2.3222 |
| claims_ratio | Excluding COVID years | 0.0399 | 0.0385 | 1.0373 |
| ROE | Excluding COVID years | -0.0102 | 0.0385 | -0.2661 |
| reserve_ratio | Excluding COVID years | 0.0893 | 0.128 | 0.6976 |
| reinsurance_ratio | Excluding COVID years | -0.0247 | 0.0637 | -0.3872 |

Notes: This table reports robustness checks using alternative sample specifications. The reported coefficient is the coefficient on the interaction term Log_damage × lag_claims_ratio. The full-sample specification uses the unbalanced panel from 2008 to 2024, while the excluding-COVID specification removes the COVID-19 years from the baseline sample. Standard errors are clustered at the firm level, and t-statistics are reported in the final column. Statistical significance is based on conventional firm-clustered inference. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Wild cluster bootstrap inference is reported for the baseline model in Table 6; Table 7 is interpreted as an additional robustness check.

### 5.2 Small-sample sensitivity tests

Given the relatively small number of listed non-life insurers in the sample, additional sensitivity tests are conducted to assess whether the main results are driven by model specification or by individual influential firms. Two sets of tests are performed. First, the baseline model is re-estimated using more parsimonious specifications with fewer control variables. Second, leave-one-firm-out tests are conducted by excluding one insurer at a time and re-estimating the full baseline model.

Table A1 reports the results from the parsimonious specifications. Under conventional clustered inference, the claims-ratio result remains positive and statistically significant across all specifications, suggesting that insurers with higher prior claims ratios tend to face stronger underwriting pressure when disaster losses increase. The premium result is more sensitive to the inclusion of firm-level controls. In the minimal specification, the coefficient on Log_damage × lag_claims_ratio is positive but statistically insignificant. However, once firm size is controlled for, the coefficient becomes negative and statistically significant, and remains negative and significant in the full specification. This suggests that firm scale is an important factor in explaining premium-side adjustment and should be controlled for when assessing heterogeneous responses to aggregate disaster-loss conditions across insurers.

Table A2 presents the leave-one-firm-out sensitivity tests. The coefficient on Log_damage × lag_claims_ratio in the premium model remains negative in all ten re-estimations and is statistically significant at the 10% level or better in eight cases. This suggests that the premium-side result is not driven by a single insurer, although its statistical strength is weaker when some firms are excluded. The coefficient in the claims-ratio model remains positive in all ten re-estimations and is statistically significant at the 10% level or better in nine cases. This supports the interpretation that the claims-pressure channel is directionally stable, even though its statistical significance is somewhat sensitive to sample composition.

Overall, these additional sensitivity tests support the main interpretation that aggregate disaster-loss conditions reveal underwriting vulnerability among non-life insurers. The premium-side result is directionally stable across all leave-one-firm-out tests and becomes statistically significant once firm size is controlled for. The claims-pressure result is also directionally stable and remains statistically significant in most leave-one-firm-out specifications. At the same time, the sensitivity of some coefficients reinforces the need to interpret the findings as small-sample evidence from a concentrated emerging insurance market rather than as large-sample causal estimates.

## 6. DISCUSSION, CONTRIBUTIONS AND POLICY IMPLICATIONS

### 6.1 Interpretation of the findings

The results show heterogeneous underwriting responses among Vietnam's listed non-life insurers. Because disaster losses are measured at the national-year level, the estimates do not capture insurer-specific catastrophe exposure. The key coefficient, Log_damage × lag_claims_ratio, shows whether insurers with different prior claims performance respond differently under the same aggregate disaster-loss conditions. The premium model provides the most stable result. The interaction coefficient is negative and remains marginally significant under wild cluster bootstrap inference. The profile-based interpretation in Table 8 shows that the association with log_premium becomes more adverse as lagged claims ratios move from the 25th percentile to the 75th percentile. This does not mean that disasters uniformly reduce premium revenue. It means that insurers with weaker prior claims performance appear less able to translate higher disaster-risk awareness into sustainable premium growth.

**Table 8.** Economic interpretation across prior claims-ratio profiles

| Insurer Profile | Lag_claims_ratio | Log_premium Association | Claims_ratio Association |
|---|---|---|---|
| Low prior claims pressure (P25) | 0.317 | -0.093 | 0.027 |
| Median prior claims pressure | 0.374 | -0.110 | 0.032 |
| High prior claims pressure (P75) | 0.441 | -0.129 | 0.038 |

Notes: Values are calculated using the coefficient on Log_damage x lag_claims_ratio from the baseline premium and claims-ratio models and the 25th percentile, median and 75th percentile of lag_claims_ratio. Because the model includes year fixed effects, these values should be interpreted as conditional differences across insurers rather than standalone causal effects of national disaster losses.

The claims-ratio evidence points in the same direction but is weaker. The interaction is positive in the baseline model and in the full 2008-2024 sample, but becomes insignificant when COVID-19 years are excluded. It should therefore be read as supportive evidence of stronger underwriting pressure, not as the main finding.

The ROE, reserve_ratio and reinsurance_ratio models do not provide clear evidence of differential responses. Reserve and reinsurance should therefore be treated as exploratory risk-management outcomes, not confirmed channels.

The sensitivity tests reduce the concern that the main pattern is driven by one firm or one specification. The premium coefficient remains negative in all leave-one-firm-out tests and becomes significant once firm size is controlled for. Still, the small number of listed insurers requires cautious interpretation.

Overall, premium growth alone is not enough to assess insurance-sector resilience. Prior claims performance, underwriting discipline, claims control, reserves and reinsurance arrangements should be considered when evaluating insurer vulnerability under disaster-loss conditions.

### 6.2 Theoretical and empirical contributions

The study makes three contributions.

First, it adds a supply-side perspective to the literature on natural disasters and insurance demand. Disaster experience may raise demand for protection, but insurers differ in their ability to convert this demand into sustainable premium growth. Prior claims performance helps explain this difference.

Second, the study shifts attention from average climate-risk effects to firm-level underwriting vulnerability. Building on Ding and Li [7], it shows that prior claims performance conditions how insurers respond to aggregate disaster-loss conditions.

Third, the study provides sector-specific evidence from Vietnam's listed non-life insurers. Vietnam combines high disaster exposure, a developing non-life insurance market and sizable protection gaps. Because listed insurers represent a substantial market share, their resilience matters for disaster-risk financing and climate adaptation.

The policy contribution is simple: insurance-sector resilience should not be judged by premium growth alone. Claims ratios can help supervisors identify insurers that may be vulnerable when disaster-loss conditions worsen, while weak reserve or reinsurance adjustment may signal limits in risk absorption and risk transfer.

The study therefore treats natural disasters as tests of underwriting resilience rather than only demand shocks or claim-generating events.

### 6.3 Policy and managerial implications

The main policy message is that premium growth is not a sufficient indicator of resilience. Supervisors should assess premium growth together with claims ratios, pricing adequacy, underwriting discipline and portfolio quality, especially when disaster losses rise.

For regulators, persistently high claims ratios can be a screening signal. They may point to underpricing, weak risk selection, loss-prone business lines or less effective claims management. This information can guide closer review of pricing assumptions, renewal standards, claims control and catastrophe exposure.

The results also support stronger risk-based pricing and underwriting. In disaster-prone markets, insurers need better data on regional exposure, asset vulnerability and climate-related losses. Regulators can encourage improved disaster-loss databases, disclosure of key underwriting indicators and climate scenarios in pricing and product design.

For insurers, underwriting quality should be treated as part of climate-risk management. Managers should strengthen risk selection, claims monitoring, fraud control, renewal standards and exposure management, especially in catastrophe-sensitive lines such as property, engineering, motor, agriculture and business interruption insurance.

The reserve and reinsurance results also matter. Although these tools are central to catastrophe-risk absorption and transfer, the regressions do not show clear differential adjustment among high-claims insurers. Regulators and insurers should therefore stress test reserve adequacy and reinsurance coverage under severe disaster scenarios.

For policymakers, insurance should be viewed as part of sustainable disaster risk financing, not only as a post-disaster recovery product. In Vietnam, stronger insurance supervision, better catastrophe-risk data and closer monitoring of underwriting vulnerability can support climate-adaptation planning. These measures also relate to SDG 13 by strengthening adaptive capacity to climate-related hazards and to SDG 11 by supporting more resilient communities.

## 7. CONCLUSION

This study examines whether aggregate natural disaster-loss conditions act as a stress test of underwriting resilience among Vietnam's listed non-life insurers. Using firm-level panel data from 2014 to 2024, the analysis investigates how aggregate economic losses from natural disasters interact with insurers' prior claims exposure. The study focuses on five financial outcomes: premium revenue, claims ratio, return on equity, reserve ratio, and reinsurance ratio.

The empirical results show that insurers with higher prior claims ratios exhibit weaker premium-side adjustment when aggregate disaster losses increase. This is the most stable finding in the paper and remains marginally significant under wild cluster bootstrap inference, which accounts for the small number of firm clusters. The baseline estimates also provide supportive evidence that these insurers face stronger claims pressure, although this result is weaker under small-cluster inference and less robust across sample specifications. By contrast, the study finds limited evidence that disaster-loss conditions are associated with differential changes in profitability, reserve accumulation, or reinsurance adjustment among more vulnerable insurers. These findings suggest that natural disasters reveal underwriting vulnerability mainly through premium-side adjustment rather than simply creating premium growth opportunities.

The study contributes to research on climate risk, underwriting resilience and sustainable disaster risk financing by showing that prior claims performance matters for insurer responses to aggregate disaster-loss conditions. Claims ratios can serve as practical early-warning indicators, and insurance-sector resilience should be assessed together with claims performance, pricing discipline, reserve capacity and reinsurance arrangements.

From a policy perspective, regulators and insurers should strengthen climate-risk management through underwriting supervision, risk-based pricing, claims monitoring, reserve adequacy assessment and reinsurance stress testing. In Vietnam, these actions can support disaster recovery, climate adaptation and sustainable risk financing, including SDG 11 and SDG 13.

This study has several limitations. The sample is limited to listed non-life insurers and remains relatively small, although these firms represent a substantial share of Vietnam's non-life insurance market. While wild cluster bootstrap inference is used to address small-cluster concerns in the baseline model, the results should still be interpreted as evidence from dominant listed insurers rather than as representative of the entire insurance market. In addition, natural disaster losses are measured at the national-year level, which does not capture differences in firms' geographic exposure, product composition, or regional underwriting portfolios. The empirical results should therefore be interpreted as heterogeneous associations under aggregate disaster-loss conditions rather than as insurer-specific catastrophe exposure estimates. Future research could extend this analysis using province-level disaster data, product-line insurance data, longer time-series observations, or firm-level catastrophe exposure measures. Such extensions would allow a more detailed assessment of how climate-related disaster-loss conditions are transmitted through insurance markets and how insurers can strengthen resilience under climate change.

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## APPENDIX

The appendix reports the detailed small-sample sensitivity tables moved from the main text to improve readability and avoid overloading the results section.

### Appendix B. Data sources and variable construction

#### Appendix B1. Financial statement data

Financial statement data are obtained from FiinGroup's FiinPro standardized financial statement database for listed Vietnamese firms [27]. The FiinPro exports provide annual financial statement items in billion VND and include standardized income-statement and balance-sheet items for listed insurers. The accounting items used in this study are mapped to the corresponding Vietnamese financial statement labels reported in the FiinPro exports. Table B1 reports the item mapping, formulas and data-treatment rules used to construct the variables in the regression dataset.

**Table A1.** Parsimonious specifications

| Dependent Variable | Model | Coef. on Log_damage × Lag_claims_ratio | Clustered SE | p-Value | Observations |
|---|---|---|---|---|---|
| log_premium | M1: Minimal | 0.0377 | 0.2722 | 0.8899 | 109 |
| log_premium | M2: + Firm size | -0.3043** | 0.1259 | 0.0156 | 109 |
| log_premium | M3: Full controls | -0.2933** | 0.1318 | 0.0261 | 100 |
| claims_ratio | M1: Minimal | 0.1251** | 0.0498 | 0.012 | 109 |
| claims_ratio | M2: + Firm size | 0.1019*** | 0.0309 | 0.001 | 109 |
| claims_ratio | M3: Full controls | 0.0853** | 0.0401 | 0.0334 | 100 |
| ROE | M1: Minimal | -0.0445 | 0.031 | 0.1519 | 109 |
| ROE | M2: + Firm size | -0.0342 | 0.0355 | 0.3344 | 109 |
| ROE | M3: Full controls | -0.0324 | 0.0381 | 0.3949 | 100 |
| reserve_ratio | M1: Minimal | 0.0758 | 0.0888 | 0.3931 | 109 |
| reserve_ratio | M2: + Firm size | 0.1423 | 0.1006 | 0.1571 | 109 |
| reserve_ratio | M3: Full controls | 0.145 | 0.1517 | 0.3392 | 100 |
| reinsurance_ratio | M1: Minimal | -0.0194 | 0.085 | 0.8194 | 100 |
| reinsurance_ratio | M2: + Firm size | -0.0341 | 0.0737 | 0.6438 | 100 |
| reinsurance_ratio | M3: Full controls | -0.0077 | 0.0599 | 0.8983 | 99 |

Notes: This table reports the coefficient on Log_damage × lag_claims_ratio under alternative model specifications. M1 includes the interaction term, lag_claims_ratio, firm fixed effects, and year fixed effects. M2 additionally controls for firm size. M3 includes the full set of lagged firm-level controls. Standard errors are clustered at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

**Table A2.** Leave-one-firm-out sensitivity tests

| Excluded Firm | Log_premium coef. | p-Value | Claims_ratio coef. | p-Value |
|---|---|---|---|---|
| ABI | -0.3767** | 0.0309 | 0.0375 | 0.2346 |
| AIC | -0.3433** | 0.0234 | 0.0835** | 0.0477 |
| BHI | -0.2822 | 0.1101 | 0.1124*** | 0.008 |
| BIC | -0.2651* | 0.08 | 0.0862** | 0.0325 |
| BLI | -0.2924** | 0.0285 | 0.0873** | 0.0261 |
| BMI | -0.3389** | 0.0227 | 0.0904* | 0.0662 |
| MIG | -0.3423*** | 0.0042 | 0.0778* | 0.0637 |
| PGI | -0.3100** | 0.0377 | 0.1011** | 0.0127 |
| PTI | -0.2400* | 0.0525 | 0.0764* | 0.0785 |
| PVI | -0.147 | 0.1011 | 0.0530* | 0.0897 |

Notes: Each row excludes one firm and re-estimates the full interaction model with firm fixed effects, year fixed effects, and lagged firm-level controls. Standard errors are clustered at the firm level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

**Table B1.** Financial statement item mapping

| Variable | Source Statement | Vietnamese Item Used | English Interpretation | Formula / Treatment |
|---|---|---|---|---|
| log_premium | Income statement | Doanh thu phí bảo hiểm | Premium revenue | Natural logarithm of premium revenue, measured in billion VND. |
| claims_ratio | Income statement | Chi bồi thường bảo hiểm gốc và chi trả đáo hạn | Gross direct claims expense and maturity payments | abs(item) / Doanh thu phí bảo hiểm. The item is reported as an expense and converted to a positive value. |
| ROE | Income statement and balance sheet | Lợi nhuận sau thuế thu nhập doanh nghiệp; VỐN CHỦ SỞ HỮU | Profit after tax; owners' equity | Profit after tax divided by equity. |
| reserve_ratio | Balance sheet | Dự phòng nghiệp vụ bảo hiểm | Technical insurance reserves | Technical reserves divided by premium revenue. |
| reinsurance_ratio | Income statement | Phí nhượng tái bảo hiểm | Ceded reinsurance premium / reinsurance expense | abs(item) divided by premium revenue. The item is reported as a deduction/expense and converted to a positive value. |
| lag_log_total_assets | Balance sheet | TỔNG CỘNG TÀI SẢN | Total assets | Natural logarithm of total assets, measured in billion VND. |
| lag_market_share | FiinPro / market-share data | Thị phần | Firm share of Vietnam's non-life insurance premium market | Recorded as a decimal and lagged by one year. |

### Appendix B2. Disaster-loss data

Data on monetary losses caused by natural disasters are collected from the official annual disaster-damage statistical tables published in the 'Thống kê thiệt hại' section of Vietnam's disaster management authority [28]. For each year from 2008 to 2024, the study uses the annual aggregate monetary loss reported in the row labelled 'Ước tổng thiệt hại', 'Tổng thiệt hại bằng tiền mặt', 'Ước tính tổng thiệt hại bằng tiền', or the final monetary-loss row labelled 'Triệu đồng', depending on the format of the annual table. The original figures are reported in million VND and are converted into billion VND by dividing by 1,000 before the logarithmic transformation is applied. All disaster-loss values are nominal and are not adjusted for inflation. Therefore, the disaster-loss variable should be interpreted as reported aggregate nominal disaster-loss conditions rather than real disaster-loss exposure. Table B2 documents the official disaster-loss source log for 2008–2024.

**Table B2.** Disaster-loss source log, 2008-2024

| Year | Official Source File | Official Table/Report Title | Row Used | Original Total Loss | Original Unit | Value Used in Regression | Inflation Adjustment |
|---|---|---|---|---|---|---|---|
| 2008 | disaster damage 2008.pdf | Tổng hợp thiệt hại năm 2008 | Ước tổng thiệt hại | 13,299,389 | million VND | 13,299.389 | Nominal; not inflation-adjusted |
| 2009 | Disaster damage 2009.pdf | Tổng hợp thiệt hại năm 2009 | Ước tổng thiệt hại | 23,667,053 | million VND | 23,667.053 | Nominal; not inflation-adjusted |
| 2010 | disaster damage 2010.pdf | Tổng hợp thiệt hại năm 2010 | Ước tổng thiệt hại | 16,062,290 | million VND | 16,062.290 | Nominal; not inflation-adjusted |
| 2011 | disaster damage 2011.pdf | Tổng hợp thiệt hại do thiên tai năm 2011 | Ước tổng thiệt hại | 13,506,774 | million VND | 13,506.774 | Nominal; not inflation-adjusted |
| 2012 | disaster damage 2012.pdf | Tổng thiệt hại năm 2012 | Tổng thiệt hại bằng tiền mặt | 15,935,421 | million VND | 15,935.421 | Nominal; not inflation-adjusted |
| 2013 | disaster damage 2013.pdf | Tổng hợp thiệt hại do thiên tai năm 2013 | Tổng thiệt hại bằng tiền mặt | 27,852,561 | million VND | 27,852.561 | Nominal; not inflation-adjusted |
| 2014 | disaster damage 2014.pdf | Bảng tổng hợp thiệt hại do thiên tai, bão, lũ năm 2014 | Tổng thiệt hại bằng tiền mặt | 2,828,348 | million VND | 2,828.348 | Nominal; not inflation-adjusted |
| 2015 | disaster damage 2015.pdf | Tổng hợp thiệt hại do thiên tai năm 2015 | Tổng thiệt hại bằng tiền mặt | 8,113,995 | million VND | 8,113.995 | Nominal; not inflation-adjusted |
| 2016 | disaster damage 2016.pdf | Tổng hợp thiệt hại do thiên tai năm 2016 | Ước tính tổng thiệt hại bằng tiền | 39,726,339 | million VND | 39,726.339 | Nominal; not inflation-adjusted |
| 2017 | disaster damage 2017.pdf | Tổng hợp thiệt hại do thiên tai năm 2017 | Final monetary-loss row labelled "Triệu đồng" | 59,959,892 | million VND | 59,959.892 | Nominal; not inflation-adjusted |
| 2018 | disaster damage 2018.pdf | Tổng hợp thiệt hại do thiên tai từ đầu năm 2018 đến nay | Final monetary-loss row labelled "Triệu đồng" | 20,000,000 | million VND | 20,000.000 | Nominal; not inflation-adjusted |
| 2019 | disaster damage 2019.pdf | Tổng hợp thiệt hại do thiên tai năm 2019 | Ước tính tổng thiệt hại bằng tiền | 6,862,775 | million VND | 6,862.775 | Nominal; not inflation-adjusted |
| 2020 | disaster damage 2020.pdf | Tổng hợp thiệt hại do thiên tai từ đầu năm 2020 | Final monetary-loss row labelled "Triệu đồng" | 39,962,434 | million VND | 39,962.434 | Nominal; not inflation-adjusted |
| 2021 | disaster damage 2021.pdf | Tổng hợp thiệt hại do thiên tai từ đầu năm 2021 | Final monetary-loss row labelled "Triệu đồng" | 5,785,324 | million VND | 5,785.324 | Nominal; not inflation-adjusted |
| 2022 | disaster damage 2022.pdf | Tổng hợp thiệt hại do thiên tai năm 2022 | Final monetary-loss row labelled "Triệu đồng" | 19,478,912 | million VND | 19,478.912 | Nominal; not inflation-adjusted |
| 2023 | disaster damage 2023.pdf | Tổng hợp thiệt hại do thiên tai năm 2023 | Final monetary-loss row labelled "Triệu đồng" | 8,679,131 | million VND | 8,679.131 | Nominal; not inflation-adjusted |
| 2024 | disaster damage 2024.pdf | Tổng hợp thiệt hại do thiên tai từ năm 2024 | Final monetary-loss row labelled "Triệu đồng" | 91,622,212 | million VND | 91,622.212 | Nominal; not inflation-adjusted |

**Appendix B3. Claims-ratio construction and consistency check**

Claims expense is obtained from FiinPro's standardized income-statement item 'Chi bồi thường bảo hiểm gốc và chi trả đáo hạn' (claims expense for direct insurance and maturity payments). This item is reported as an expense and therefore appears with a negative sign in the source data; it is converted to a positive value when constructing the claims ratio. The numerator of claims_ratio is this gross direct claims item, while the denominator is the FiinPro item 'Doanh thu phí bảo hiểm'. Therefore, claims_ratio is calculated as abs(Chi bồi thường bảo hiểm gốc và chi trả đáo hạn) divided by Doanh thu phí bảo hiểm.

Reinsurance recoveries are not netted from this numerator because they are reported separately as 'Thu bồi thường nhượng tái bảo hiểm'. The retained or net claims item, such as 'Tổng chi bồi thường bảo hiểm', is also reported separately and is not used as the numerator. Claim-handling or recovery-processing items, such as 'Chi xử lý hàng bồi thường 100%', are not added separately to the numerator. The claims-expense values in the regression file were audited against the FiinPro exports. The audit confirms that the regression claims-expense values match the FiinPro item 'Chi bồi thường bảo hiểm gốc và chi trả đáo hạn' for all firm-year observations, with only one immaterial rounding difference.

The single observation with a lagged claims ratio above one is traced to ABI in 2013. In that year, ABI's premium revenue was 509.345 billion VND and its gross direct claims expense was 674.281 billion VND, implying a claims ratio of 1.3238. This observation affects the baseline regression through the lagged claims ratio for ABI in 2014. The observation is retained in the baseline analysis because it reflects a genuine year of severe claims pressure rather than a data-entry error.

**Appendix B4. Extreme-value sensitivity checks for lagged claims ratio**

To assess whether the results are driven by the single lagged claims-ratio observation above one, the baseline model is re-estimated under three additional treatments: excluding ABI-2014, capping lag_claims_ratio at one, and winsorizing lag_claims_ratio at the 99th percentile. Table B3 reports the coefficient on Log_damage × lag_claims_ratio under each treatment.

**Table B3.** Extreme-value sensitivity checks for lagged claims ratio

| Specification | Outlier Treatment | Log_premium Coefficient | Claims_ratio Coefficient | Interpretation |
|---|---|---|---|---|
| Baseline | No adjustment | -0.2933** (p = 0.0261) | 0.0853** (p = 0.0334) | Reference result from Table 6. |
| Excluding extreme lagged claims ratio | Exclude ABI-2014, which is affected by ABI-2013 claims_ratio = 1.3238 | -0.3744** (p = 0.0130) | 0.0370 (p = 0.2402) | The premium-side result remains negative and statistically significant, while the claims-ratio result becomes statistically insignificant. |
| Capping at one | Set lag_claims_ratio above 1.0 equal to 1.0 | -0.3172** (p = 0.0157) | 0.0690* (p = 0.0583) | The premium-side result remains robust; the claims-ratio result remains positive but only marginally significant. |
| Winsorizing | Winsorize lag_claims_ratio at the upper 99th percentile | -0.3386** (p = 0.0114) | 0.0544* (p = 0.0933) | The premium-side result remains robust; the claims-ratio result remains positive but weaker. |

Notes: The table reports the coefficient on Log_damage × lag_claims_ratio. Standard errors are clustered at the firm level. p-values are reported in parentheses. ** and * denote statistical significance at the 5% and 10% levels, respectively.

Overall, the premium-side result is not driven by the extreme lagged claims-ratio observation. The coefficient remains negative and statistically significant after excluding ABI-2014, capping lag_claims_ratio at one, and winsorizing lag_claims_ratio at the 99th percentile. By contrast, the claims-ratio coefficient remains positive across all treatments, but its statistical significance is weaker and sensitive to the treatment of the extreme observation. This supports the interpretation that the premium-side finding is the most robust result, while the claims-pressure channel should be interpreted as supportive but less stable evidence.