# Pricing climate risk: Hurricane models and home insurance over the last two decades

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# Natural disaster losses ↑, insurance premiums ↑

1) Natural disaster losses are growing
   - Insured losses ↑ 4x in real terms since the 1990s (Insurance Information Institute, 2025)

2) Home insurance premiums are growing
   - 2017–2024: Real premiums grew 28% nationally (Keys & Mulder, 2024)

→ The link between 1) and 2) is still not well understood

> "Insurance premium is a feedback to society about climate change ... this is the bill of what we have collectively done to the planet."

Christian Mumenthaler,
CEO, Swiss Re, 2023

(1) How has risk changed? (2) How has risk been passed through to insurance premiums?

# Our setting: Florida




POST CARD




- 23 million people (3rd in the U.S.)
- $3.6 trillion in residential property (2nd in the U.S.)
- Highest hurricane risk

How have changes in hurricane risk been priced into home insurance?

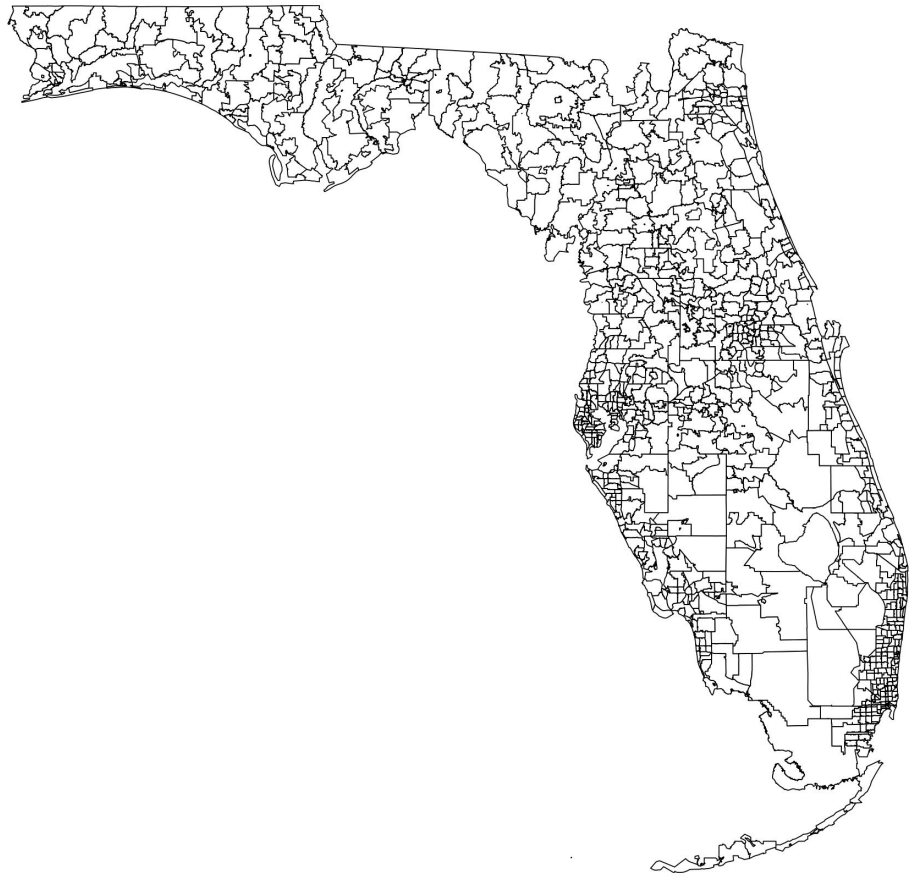
# We compile a new panel dataset on hurricane risk and home insurance premiums

ZIP code-level data for Florida, 2008–2025

1) **How has modeled expected loss (AAL) changed?**
   - 7 state-approved hurricane catastrophe (CAT) models
     - How risky are Florida homes?
     - How do risk estimates vary over time?

2) **How has expected loss been passed through to insurance premiums?**
   - Premium data for the 16 largest insurers representing 68% of policies
     - How are modeled hurricane risks reflected in premiums?
     - Has this pricing changed over time?

Florida ZIP codes



# Literature and contributions

- **Climate risk and its effects:** Cella & Schubert, 2024; Collier et al., 2023, 2024; Cookson et al., 2025; Deryugina, 2017; Ge et al., 2022, 2025; Issler et al., 2025; Jerch et al., 2023; Moore, 2024; Sastry et al., 2024, 2026; Schubert, 2023

- **Insurance supply:** Boomhower et al., 2024; Buschbom et al., 2025; Heitfield, 2026; Keys & Mulder, 2024; Kim et al., 2026; Kousky, 2018; Oh et al., 2026; Wagner, 2022; Wallace, 2026

- **Managing catastrophe risks:** Aron-Dine, 2025; Boyer & Nyce, 2013; Cummins & Lewis, 2003; Cutler & Zeckhauser, 1999; Froot & O'Connell, 1999; Kunreuther & Michel-Kerjan, 2009; Solomon, 2025; Zanjani, 2002

# The Florida home insurance market

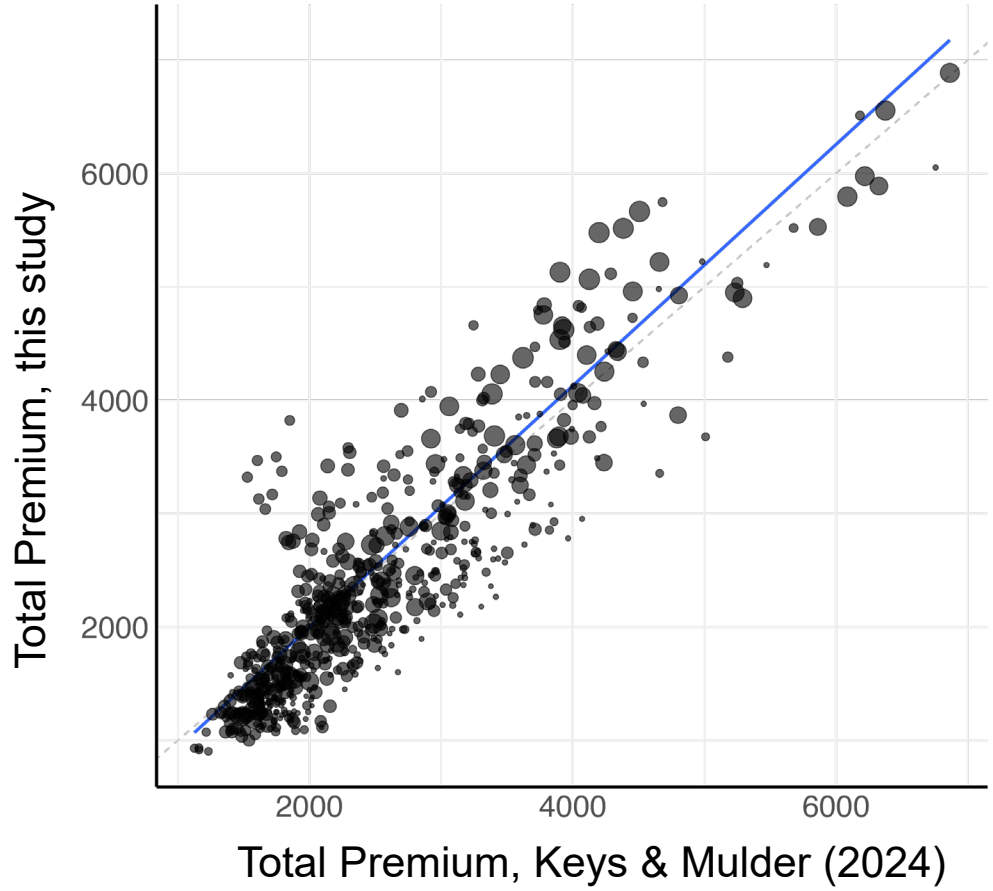
- Florida Office of Insurance Regulation (FLOIR): Oversees market
- Home insurance provides coverage (dwelling, personal property, loss of use, liability) against:
  - Hurricane wind
  - Other perils (e.g., non-hurricane wind, hail, fire, theft, ...)
- Types of insurers
  - Diversified national insurers / “pups”, e.g.,
    - State Farm → State Farm Florida
    - Allstate → Castle Key
  - “Florida domestics”: Florida-specific, independent insurers (Sastry et al., 2026), e.g.,
    - Universal
    - Slide
  - Citizens Property Insurance Corporation: Public insurer, large market share, limits on rate growth

# Insurance premiums from regulatory filings, 2008–2025

**Regulatory disclosures of each insurer's territory-level premiums**

- Designed for comparability across insurers and over time
- Standardized 1989 masonry home
- Insured value held constant at $150k, deductibles, credit scores, …, standardized at typical values
- Reporting
  - hurricane premium
  - non-hurricane premium
  - sum = total premium

**These data align well with mortgage escrow data – comparison with Keys & Mulder (2024)**



# Florida insurers in the dataset

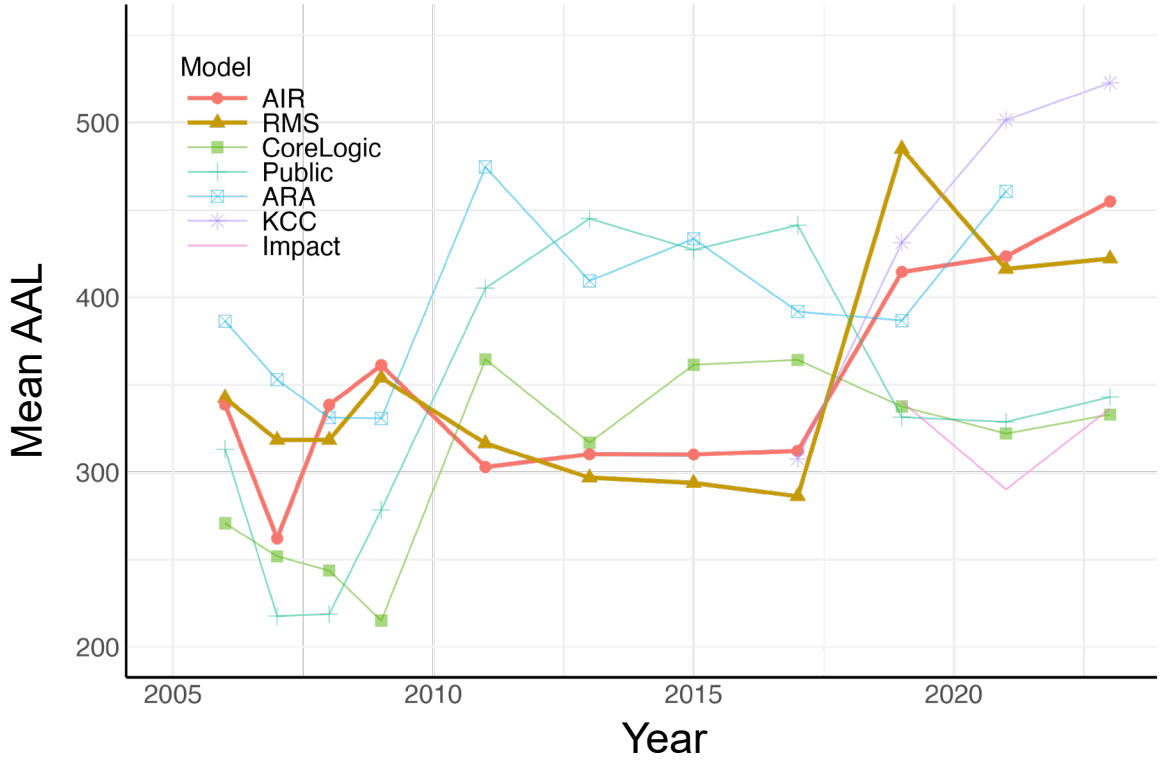
| Insurer | Share 2024 | Share 2010 | Model vendor(s) |
|---|---|---|---|
| Citizens | 15% | 10% | AIR, RMS, CoreLogic, Public |
| State Farm | 10% | 16% | AIR, RMS, CoreLogic |
| Universal P&C | 6% | 6% | RMS |
| Tower Hill | 6% | --- | AIR |
| Slide | 5% | --- | AIR |
| First Protective | 5% | 1% | RMS |
| American Integrity | 4% | 1% | AIR |
| Florida Peninsula | 3% | 2% | AIR |
| ASI Preferred | 3% | 1% | AIR |
| Heritage | 2% | --- | AIR |
| Southern Oak | 2% | 1% | AIR |
| Truck Insurance | 2% | --- | RMS |
| American Strategic | 2% | 2% | AIR |
| Homeowners Choice | 2% | 2% | RMS |
| Castle Key Insurance | 1% | 3% | AIR |
| St. John’s | --- | 4% | AIR |
| | **68%** | **49%** | |

# Modeled hurricane risk from 7 catastrophe models, 2006–2023

## Standardized disclosures from model vendors

- Designed for comparability across models and over time
- Reporting
  - ZIP-level AALs per dollar of value
    - Standardized 1989 masonry home
    - AALs scale linearly with reconstruction cost
  - Annual aggregate exceedance curve
    - Combined losses on all Florida homes

## Modeled expected losses (AAL) over time

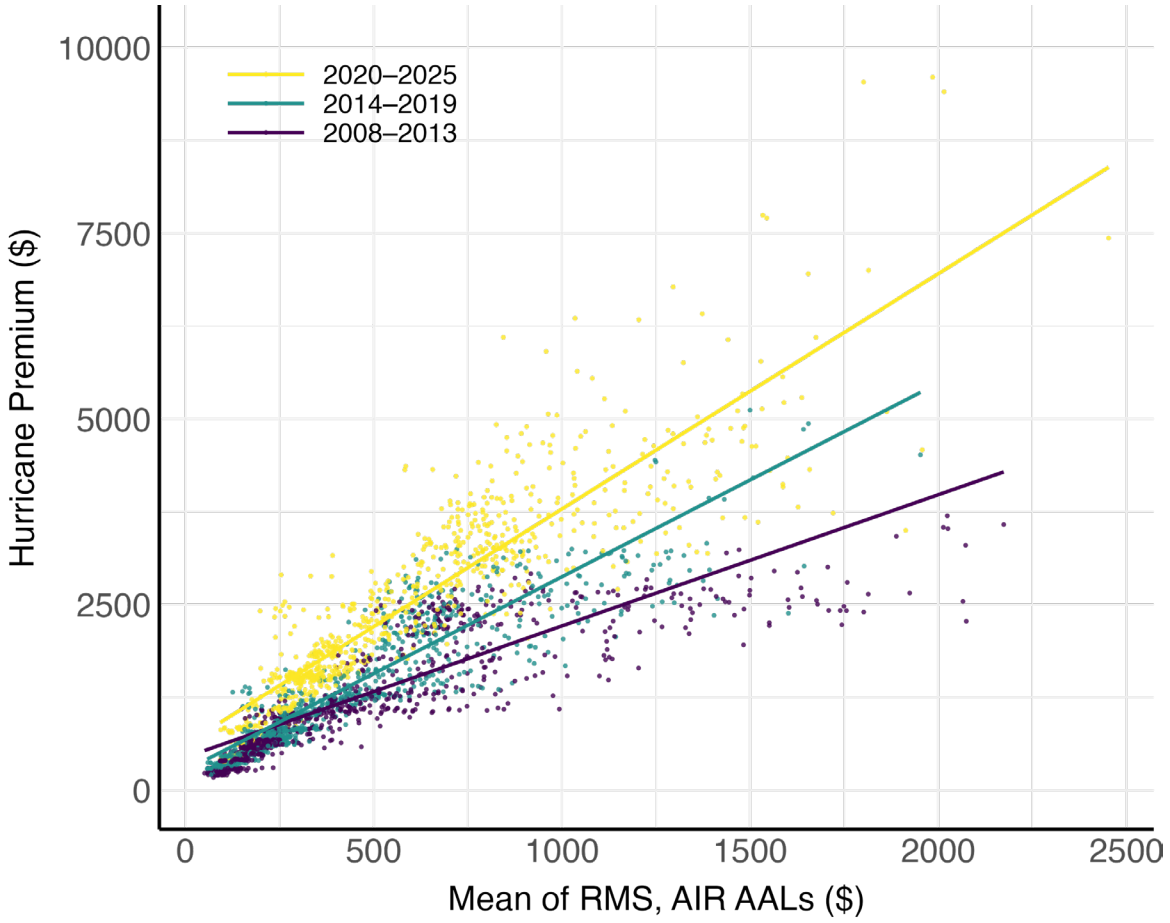



Median ZIP-level AAL increase, 2006–2023:

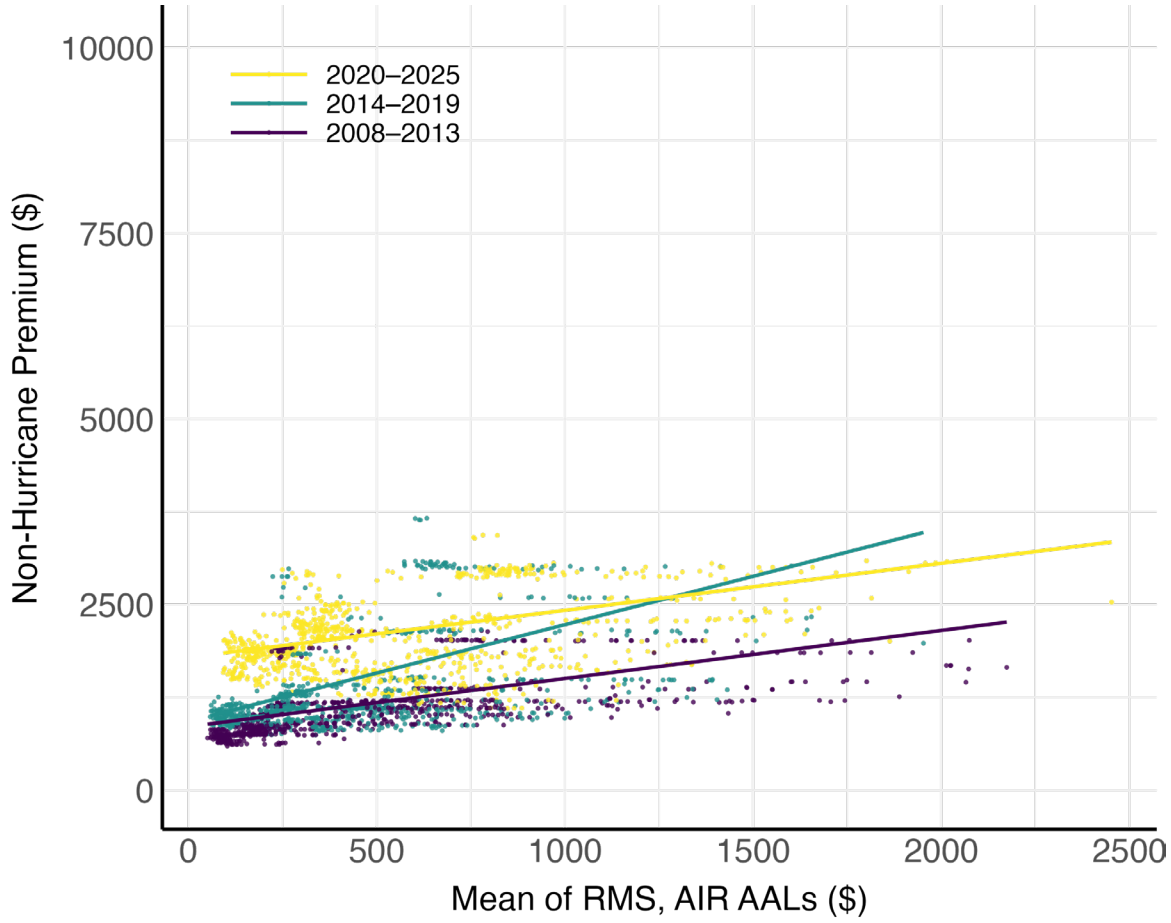
- Approximately 50% in the leading models

# Hurricane risk and premiums – graphical evidence

## Hurricane Premium vs Mean of RMS, AIR




## Non-Hurricane Premium vs Mean of RMS, AIR



# Hurricane risk and premiums – regression evidence

**Setting**

- Insurer $i$, Rating territory $j$, Year $t$
- Sample weights: implied number of customers (= market share × population)

**Leveraging the full panel, 2008–2025 filings**

$$y_{ijt} = \beta \times AAL_{jt} + \gamma_{it} + \varepsilon_{ijt}$$

**Natural experiment leveraging the 2019 model review cycle, 2021–2023 rate filings**

$$y_{ijt} = \beta \times AAL_{jt} + \gamma_{it} + \psi_{ij} + \varepsilon_{ijt}$$

# Regression results – natural experiment

| | **Hurricane Premium** |
|---|---|
| RMS, AIR AAL | 3.90*** (0.393) |
| Company-Year FE | ✓ |
| Company-Territory FE | ✓ |
| Observations | 8,907 |
| Dependent variable mean (wtd.) | 2,283.70 |
| $R^2$ | 0.98 |

- Variation: Within territory, from model update
- Includes 2021–2023 rate filings only

↑ $1 expected loss → ↑ $3.90 premiums

# Regression results – full panel

| | Hurricane Premium | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Constant | 131.20* (73.4) | | | |
| RMS, AIR AAL | 3.21*** (0.176) | 3.43*** (0.087) | | |
| RMS, AIR AAL × 2008–2013 | | | 2.42*** (0.148) | 2.78*** (0.158) |
| RMS, AIR AAL × 2014–2019 | | | 3.41*** (0.057) | 3.15*** (0.056) |
| RMS, AIR AAL × 2020–2025 | | | 4.17*** (0.154) | 3.65*** (0.144) |
| Company-Year FE | | ✓ | ✓ | ✓ |
| Panel | Unbalanced | Unbalanced | Unbalanced | Balanced |
| Observations | 67,859 | 67,859 | 67,859 | 42,988 |
| Dependent variable mean (wtd.) | 1,955.80 | 1,955.80 | 1,955.80 | 1,855.90 |
| $R^2$ | 0.43 | 0.77 | 0.79 | 0.79 |

# Mechanisms

## Profits?

*Returns on Florida operations, 2008–2024*

| | Pre-tax profits (% of premiums) |
|---|---|
| Florida domestic insurers | 9.7 |
| Diversified insurers | 11.9 |

**Source:** Own calculations based on NAIC data

Insurer profits are insufficient to explain loads

## Costs of managing tail risks?

*Two channels*

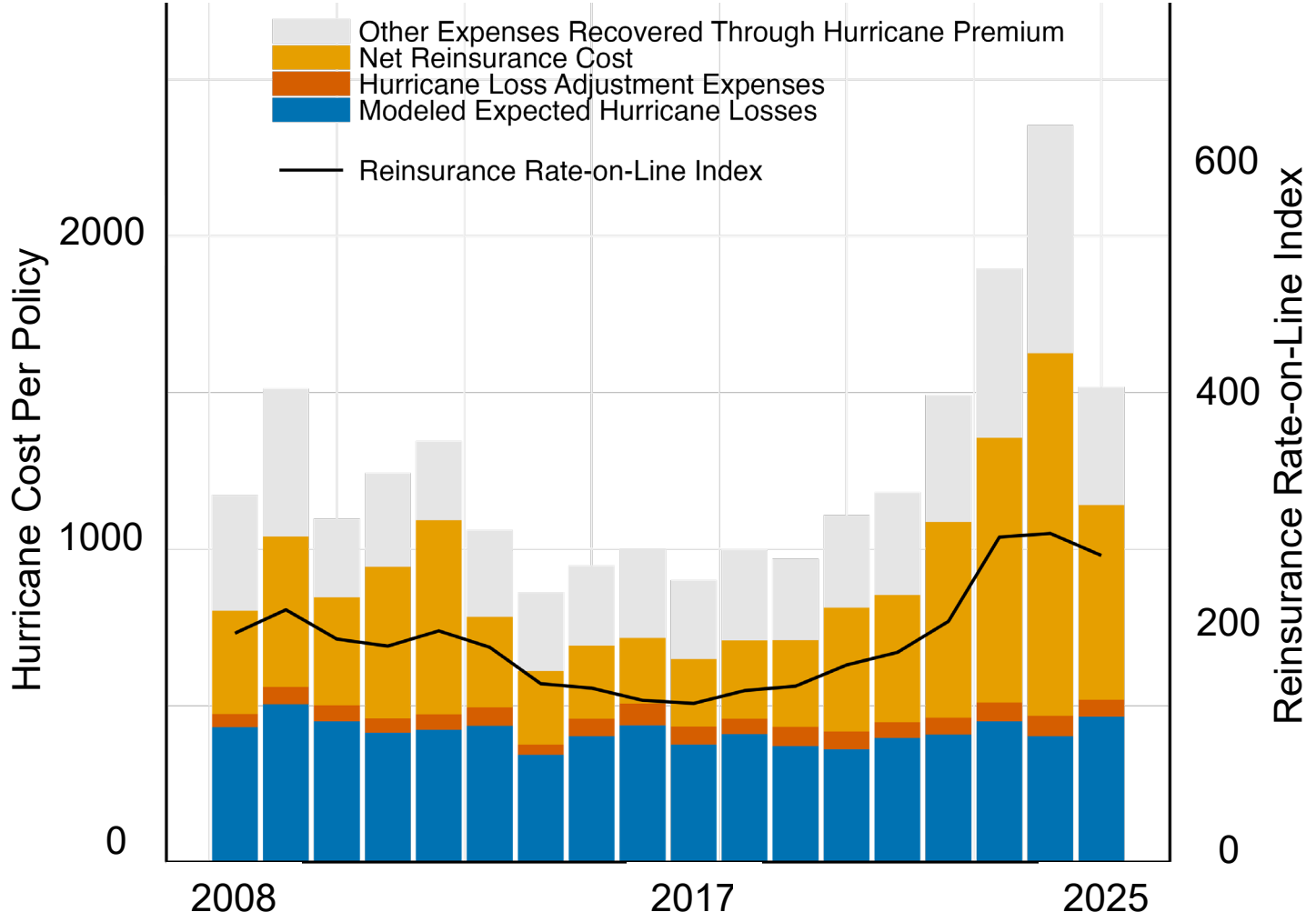
I. Reinsurance prices

II. Market structure

# Costs of managing tail risks (I) – reinsurance prices

**Additional data**

- Aggregate data on hurricane cost per policy by insurer (left y-axis)
- Guy Carpenter U.S. Property Rate-on-Line Index (right y-axis)

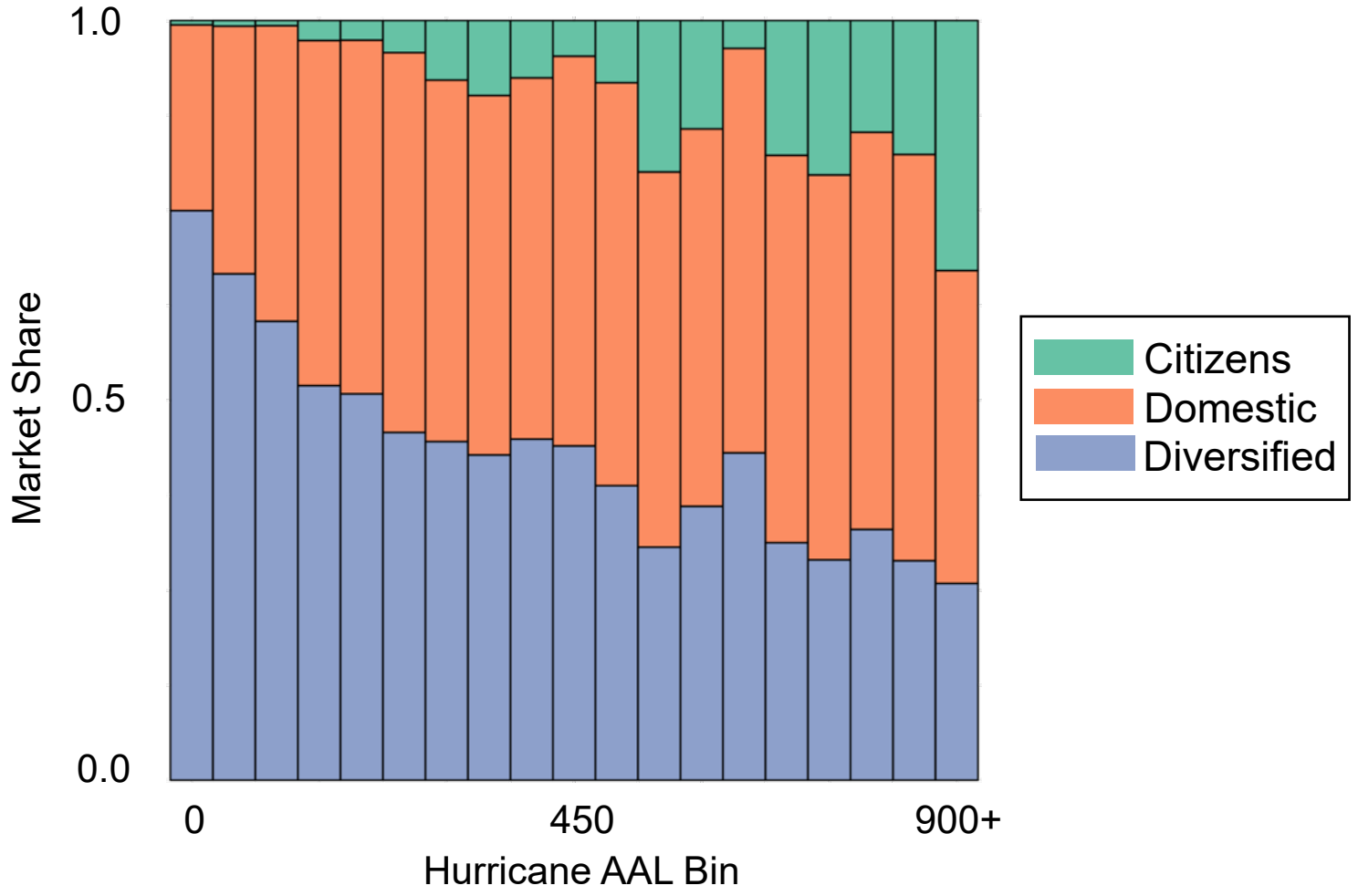



Hurricane premiums co-move with the reinsurance cycle.

# Costs of managing tail risks (II) – market structure

**Additional data**

- County-level market share data on Florida home insurers




National insurers (“Diversified”) limit their market share in high-risk areas

# Market structure – regression results, 2020–2025

| | Hurricane Premium | | |
|---|---|---|---|
| | Florida Domestics | Diversified Comp. | Citizens |
| | (1) | (2) | (3) |
| RMS, AIR AAL | 4.96*** (0.137) | 3.93*** (0.179) | 2.73*** (0.496) |
| Company-Year FE | ✓ | ✓ | ✓ |
| Observations | 6,183 | 14,736 | 495 |
| Dependent variable mean (wtd.) | 3,186.10 | 2,728.10 | 1,447.20 |
| $R^2$ | 0.79 | 0.81 | 0.66 |

Florida Domestics charge more per dollar of AAL than other insurer types

# Conclusion

**How has hurricane risk been priced into home insurance?**

- Modeled expected loss ↑ 50% across models
- Pass-through: ↑ $1 modeled expected loss → ↑ $4 hurricane premiums
- Insurers charge a large, growing load above expected loss

**Implications**

- Costs of managing tail risks → Central to premium rise in hurricane areas
- Owners of hurricane-exposed homes face a price signal well above expected loss
- Tail costs increasingly salient for other climate perils (wildfire, severe thunderstorms, …)?

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