Capital Costs, Reinsurance, and the Price of Climate Risk

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Wisconsin	Iowa	Wisconsin	Minnesota & NBER	NYU Stern

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  - $>$ **$15 per $1** for 1-in-250+ layers
- Little causal evidence on **why** — risk? capital? market power?

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  - **Structural model:** household welfare about **$95 per hh-year**

Literature

Setting and Data

The Collateral Reform

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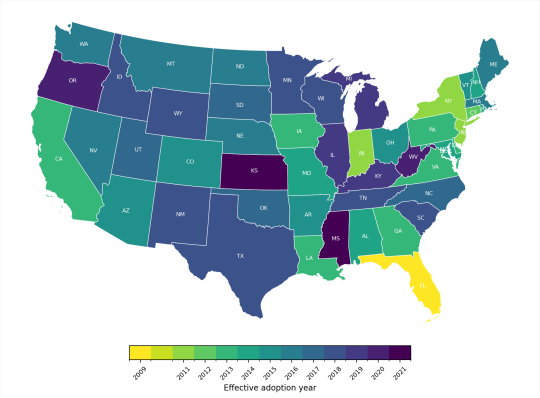
- Saves $\approx$ **8–10¢ per $1 ceded**
- Rule set by the insurer's **domicile state**, not where it sells
  - States adopted from **2009** (FL) to **2021** (KS)
  - Compare a **NY** and a **TX** insurer, both selling in **FL**
  - 2011–2017: only the NY insurer has the cheaper collateral rule

Capital-cost math

States Adopted the Reform from 2009 to 2021



Year of state adoption of collateral reform.

New Contract-Level Data: Reinsurance Is Expensive in the Tail

Layer	Limit	Attachment	Total Expected Premium	Expected Loss	Margin
Layer 5	150,000,000	2,500,000,000	4,286,585	406,474	3,880,111
Layer 4	350,000,000	2,150,000,000	14,052,103	1,302,582	12,749,521
Layer 3	250,000,000	1,900,000,000	13,190,319	1,261,863	11,928,456
Layer 2	700,000,000	1,200,000,000	56,500,821	6,387,326	50,113,495
Layer 1	500,000,000	700,000,000	64,121,928	13,385,134	50,736,794

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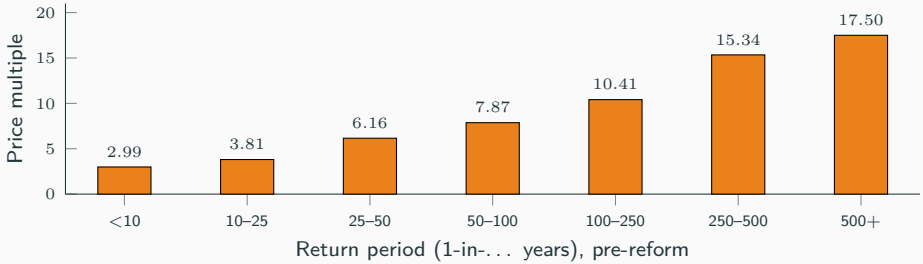


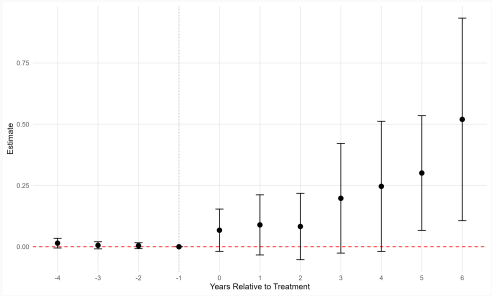
Other Data and Methods

- **Treatment:** Reform adoption dates — hand-collected, state-by-state
- **Reinsurance prices** (FL OIR rate filings, 2004–25): **3,576** priced private XoL layers, **109** insurers
- **Reinsurance quantities** (NAIC Schedule F, 2004–24): insurer–reinsurer *pair*; premium ceded, collateral, recoverables; **domestic/foreign, affiliated/unaffiliated**
- **FL homeowners** (QUASR, 2010–20, 67 counties): insurer–county–quarter; policies, premiums, TIV, **wind / non-wind**
- **Estimation:** TWFE event study via **BJS imputation** (Borusyak et al., 2024) — already-treated units don't contaminate controls
- **Ratios** (ceded/DPW, recovered/ceded): **slope-DiD**

Summary stats Estimator details

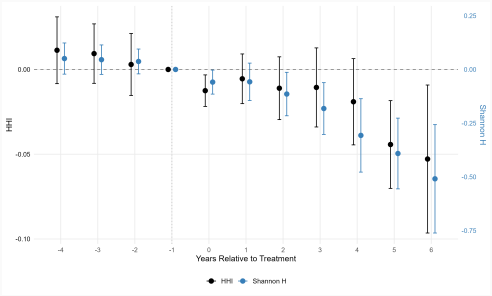
Effects on the Reinsurance Market

Reinsurance: More Use, More Competition



How much do insurers buy from foreign reinsurers?

More: up 25%

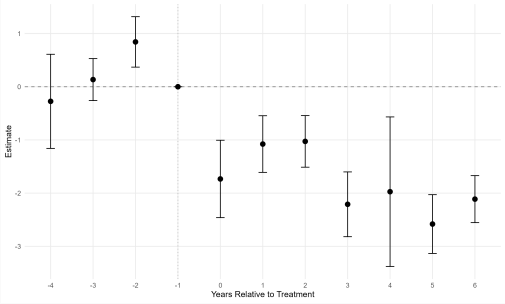


How concentrated are insurers' reinsurance purchases?

Less concentrated

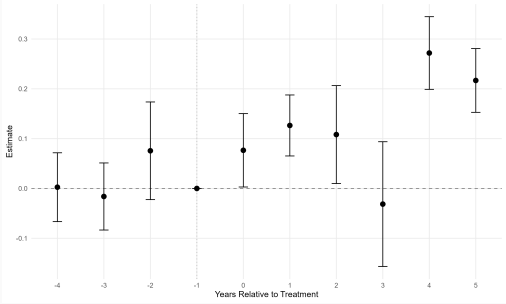
Number of reinsurers | Affiliate routing

Reinsurance: Lower Prices, More Tail Coverage



How much do insurers pay per $1 of expected loss?

Less: down 31% Hurricane Exposure ↑



How many insurers buy cover for 1-in-500-year losses?

More: 11% → 22%

The Trade-off: Counterparty Exposure

- Collateral is a cost in every year, but it protects only in the rare bad year when a reinsurer fails.

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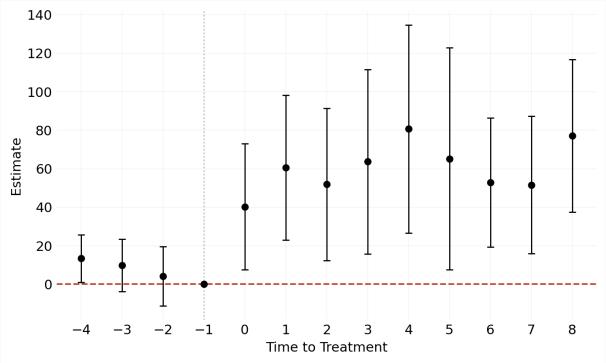
- Net effect: +$58k per insurer-year (about $87M a year in total).



Expected loss from reinsurer impairment

Effects on Florida Homeowners Insurance

Empirical Strategy: Wind vs. Non-Wind

So far the reform reshaped the *reinsurance* market. Does it reach homeowners?

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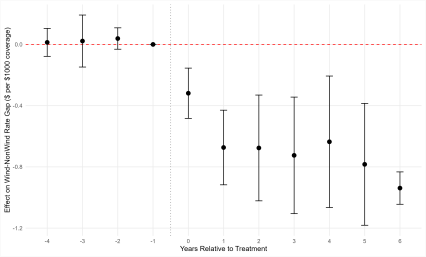
Study **Florida**, the most cat-exposed state, where **wind is priced separately**.

- Reinsurance most relevant for **catastrophes** $\Rightarrow$
- **Triple difference:** treated domicile $\times$ post $\times$ (**wind** $-$ **non-wind**), within the same insurer $\times$ county $\times$ quarter

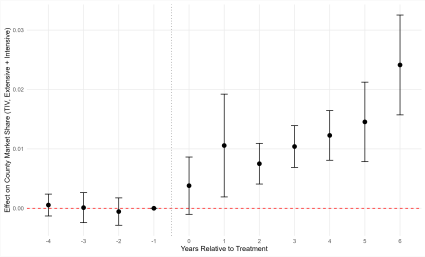
$$\Delta^{r}_{ict} = r^{\text{wind}}_{ict} - r^{\text{nonwind}}_{ict} \qquad (r = \text{premium rate per \$1,000 of exposure})$$

Wind Premiums Fall, Coverage Expands



What do homeowners pay for wind cover?

Less: −$0.50 per $1,000 (10–16%)



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More: +1 pp on average, +2 pp by year 6

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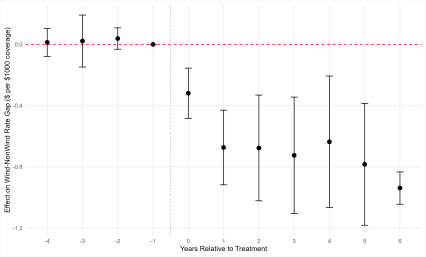

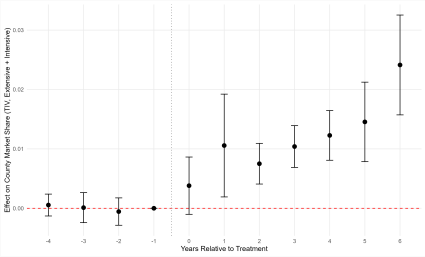

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Direct price effect: non-wind **placebo** flat(ter), robust to **incumbents** & portfolio **composition**; plus new **entry** into unserved counties

Placebo | Incumbents | Composition | Entry

Structural Model and Welfare

From Reduced Form to Structural

What the reduced form shows

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- **Homeowners:** wind premiums fall 10–16%; treated insurers gain market share

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- **Incidence:** who gets the gains: reinsurers, insurers or homeowners?
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Today: a model of the homeowners market, which speaks to the insurer–homeowner split.

Structural Model: Setup

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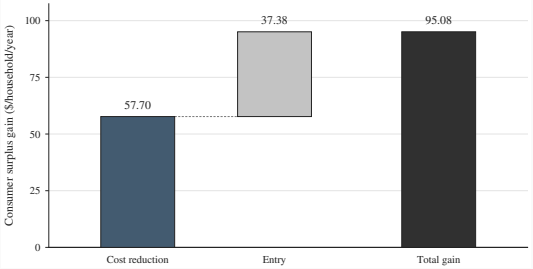
- **Instruments:** rival-product exposure and lagged cost shifters outside Florida; demand and supply estimated jointly. Identification
- **Taken as given:** the set of products offered, and the reinsurance market, which enters only through the reform.

Structural Model: Results

- Marginal cost falls 9.6% for treated insurers.
- Own-price demand elasticity $-4.3 \Rightarrow$ markup $\approx$ 29% of premium. NAIC benchmark: $\approx$ 27%
- Pass-through ≈ 1: savings reach homeowners, not markups.
- Gain of \$95 per household per year.
- \$58 from lower costs, \$37 from additional entry.



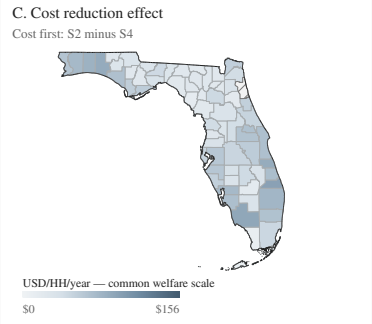
Consumer welfare: dollars per household per year

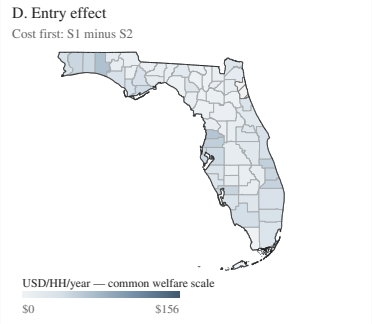
Parameter estimates Counterfactual design

Consumer Gains: Two Channels and Their Incidence

Total ≈**$95/hh/yr** (∼$0.47B/yr)

= lower costs **$58** + additional products **$37**





Cost: largest in coastal, high-premium counties

Additional products: follow local market structure, not risk alone

Next Steps

Next: model the full vertical chain — reinsurers ↔ insurers ↔ households

Planned counterfactuals

- **Capital requirements**
  - Optimal collateral regimes: cost vs recoveries
- **Market structure**
  - Maximal diversification: the whole state or country in one portfolio
  - Public reinsurance: cheaper (tail?) public option
- **Bargaining**
  - Insurer bargaining power (e.g. access to cat bonds)
  - Single-payer style: small Florida insurers pay what diversified nationals pay
- **Climate**
  - Simulate tail thickness under future climate scenarios

Your feedback is particularly useful here!

Conclusion

- **Capital costs make reinsurance expensive.** Cutting collateral $\rightarrow$ price $\downarrow$ 31%.
- **Tail concentrated:** More reinsurance, more reinsurers, deeper cover.
- **Homeowner savings:** Wind premiums fall \$0.50 per \$1,000 (10–16%); households gain \$95 a year (\$58 lower costs + \$37 additional products).
- **Next:** a model of the full vertical chain: reinsurers $\leftrightarrow$ insurers $\leftrightarrow$ households
- **Counterfactuals:** capital rules, market structures and climate.

Thank You

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Appendix: Why Is Tail Risk Expensive? Three Explanations

- **1. Rising risk:** losses are growing; premiums follow

  Keys & Mulder 2024; Oh et al. 2026; Boomhower et al. 2024; Sastry et al. 2024; Solomon 2026

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- **2. Market power, scarce capacity:** few reinsurers, slow capital, high prices

  Gron 1994; Winter 1994; Froot 2001; Koijen & Yogo 2016; Cole et al. 2010; Anand et al. 2026

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- **3. Cost of capital:** capital held against the tail is priced in (theory)

  Froot & Stein 1998; Froot 2007; Zanjani 2002; Koijen & Yogo 2015

  - *We add:* quasi-experimental **capital-cost pass-through**, reinsurer $\rightarrow$ homeowner

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  Example: \$100M layer, 1-in-100 $\Rightarrow$ expected loss \$1M

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  Example: \$1M + \$5M = \$6M, a multiple of 6
- The reform cuts collateral, which lowers r: the biggest price cut is where p is small

	Multiple $1 + r/p$	
Layer	$r = 5\%$	$r = 10\%$
1-in-10	1.5	2.0
1-in-50	3.5	6.0
1-in-100	**6.0**	11.0
1-in-250	13.5	26.0

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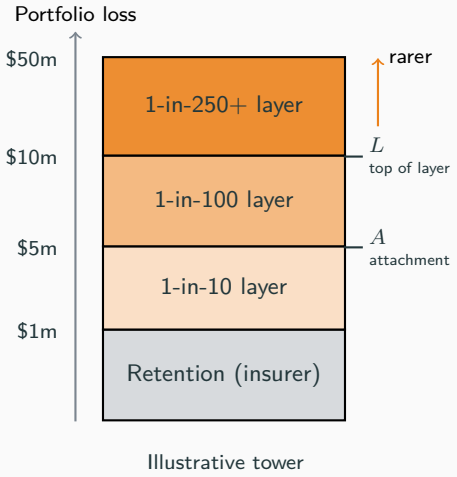

Cat bonds

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Appendix: Catastrophe Bonds vs. Reinsurance

Dimension	Catastrophe bond (ILS)	Traditional reinsurance
Quantity	**$0.85bn** modeled EL, $4.5bn prem. 369 priced layers, 17 carriers	**$15.9bn** modeled EL, $49.9bn prem. 4,280 priced layers, 124 carriers
Price	Premium/EL, mean **6.99**	Premium/EL, mean **5.52**
Median size	Limit **$652m**, **$100m** placed Premium **$9.2m**	Limit **$40m**, **$31m** placed Premium **$4.0m** (**17%** under $1m)
Median layer	Attaches at **$1.37bn**; **1-in-62** yrs	Attaches at **$50m**; **1-in-37** yrs
Terms & transparency	**Standard** multi-year note, one trigger **Fixed spread**; spreads **public** (Artemis)	**Bespoke** terms, **12-month** re-cut **No public price** (bilateral, broker-placed)
Market size	**$63.9bn** outstanding $\approx$ **8%** of the $785bn total	**$649bn** capital $785bn total incl. $136bn alternative

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Appendix: Summary Statistics

		Pre-treatment		Post-treatment	
Outcome	**Unit**	**Mean**	**SD**	**Mean**	**SD**
Panel A. National reinsurance: insurer–year, 2004–24					
Direct premiums written	$M	5,460.96	9,350.58	4,900.16	10,517.07
Premium ceded to reinsurance	$M	1,645.74	2,843.00	2,482.37	4,137.98
Number of reinsurers		56.50	91.29	62.92	103.80
Panel B. Florida homeowners: insurer–county–quarter, 2009–24 ($N = 249{,}445$)					
Policies in force		2,541.65	2,321.34	16,737.07	27,488.29
Total direct premium written	$M	9.09	11.20	52.05	102.44
Avg. premium per policy	$	4,129.77	4,294.15	2,940.88	2,508.55
Total insured exposure	$M	2,505.24	3,468.73	6,776.41	9,882.66
Wind share of DPW		0.91	0.16	0.97	0.10

Statistics are DPW-weighted within each period. Pre and post are relative to the reform adoption date of the insurer's domicile state.

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Appendix: Estimation — BJS Imputation

Event time $\mathrm{RelTime}_{it} = t - t^{\text{adopt}}_{s(i)}$; reference $\tau = -1$. Schedule F uses DPW weights and domicile-state clusters. Florida filing estimates are unweighted.

Levels — imputation event study (Gardner 2022; Borusyak, Jaravel & Spiess 2024). Naïve TWFE is biased under staggered adoption:

$$Y_{it} = \alpha_i + \lambda_t + \sum_{\tau \neq -1} \gamma_\tau \, \mathbf{1}\{\mathrm{RelTime}_{it} = \tau\} + \varepsilon_{it}$$

Instead: (i) fit $Y_{it} = \alpha_i + \lambda_t + \varepsilon_{it}$ on untreated obs ($D_{it} = 0$); (ii) impute $\hat{Y}_{it}(0)$, regress residual $Y_{it} - \hat{Y}_{it}(0)$ on D_{it} (or event-time dummies) $\Rightarrow$ ATT.

Ratio outcomes — slope-DiD (Y = numerator, e.g. ceded; X = denominator, e.g. DPW):

(i) $Y_{it} = \beta_0 X_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \quad (D_{it} = 0);$ (ii) $Y_{it} - \hat{Y}_{it}(0) = \sum_{\tau} \gamma_\tau \, X_{it} \, \mathbf{1}\{\mathrm{RelTime}_{it} = \tau\} + \nu_{it}$

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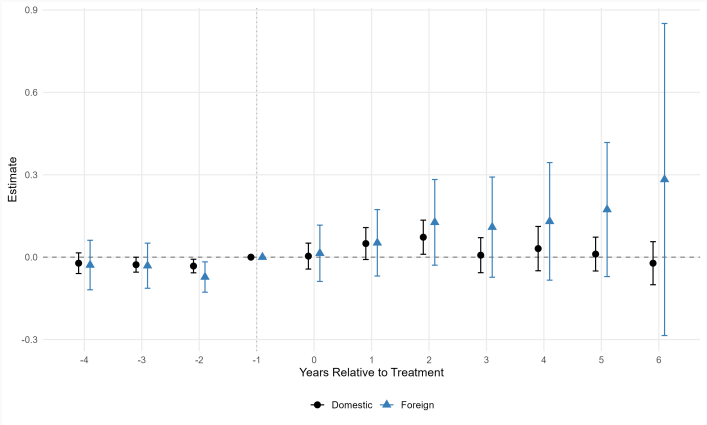
Appendix: Number of Reinsurers — Domestic vs. Foreign



Log number of reinsurers per insurer. By $\tau = 5$: about **50% more foreign** reinsurers; no change in domestic.

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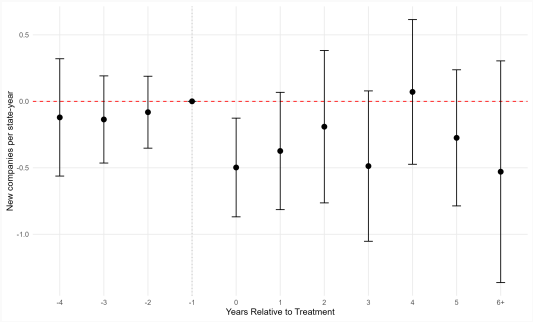
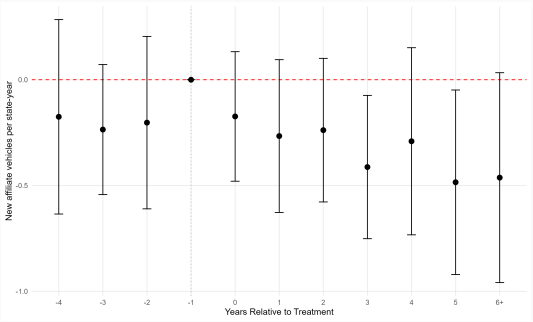
Appendix: No Affiliate Entry into Early-Adopting States



New insurers per state-year



New affiliated reinsurance vehicles per state-year

Concern: groups set up affiliates in early-adopting states before their own state adopts. Neither count rises after a state adopts.

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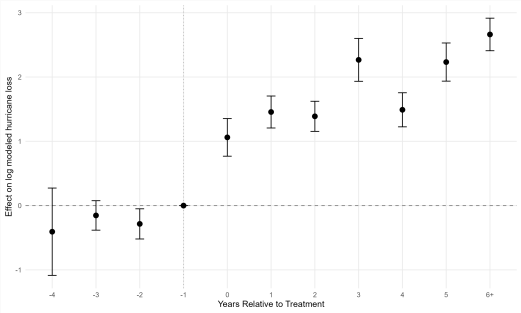
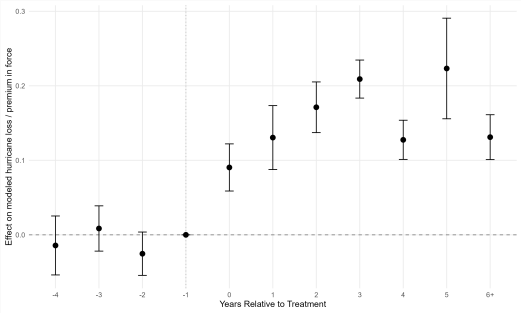
Appendix: Insurers' Hurricane Exposure



Log modeled hurricane loss



Modeled loss / premium

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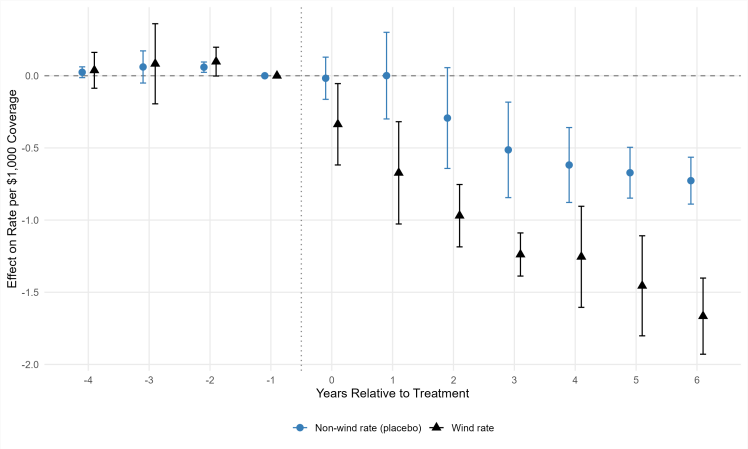
Appendix: Placebo — Non-Wind Rate



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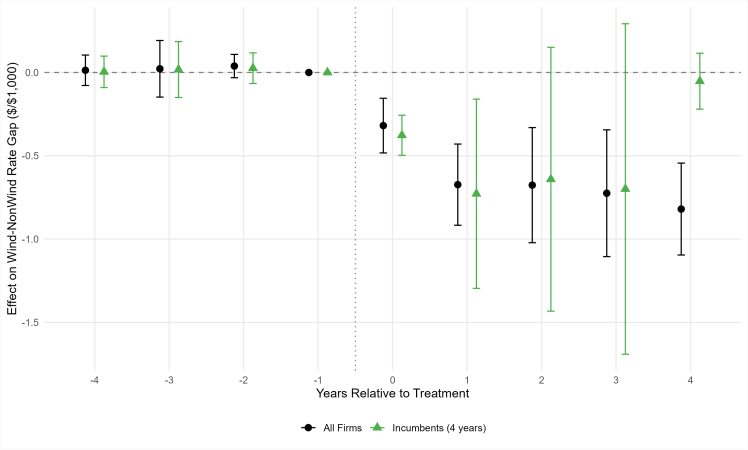
Appendix: Incumbents Only



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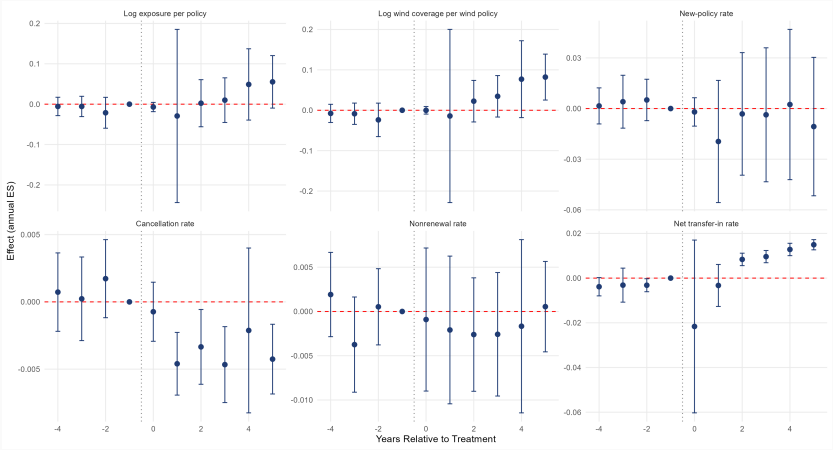
Appendix: Portfolio Composition Unchanged



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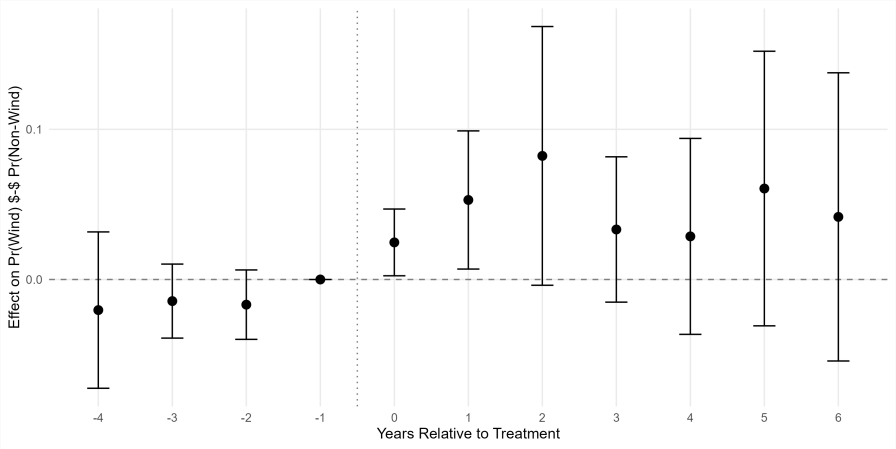
Appendix: Extensive Margin — Entry (Wind – Non-Wind)



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Appendix: Instruments and Identification

Instrument	What it is	Identifies	Valid when
BLP: rival counts	Number of rival wind products in the county-quarter	$\bar{\alpha}$, σ_0	Insurers do not enter a county in response to unobserved shocks to wind-insurance demand there
Differentiation	Number of rivals priced close to the product	σ_α	Rivals' cost-driven price positions are unrelated to demand for this insurer's product
Out-of-state losses	The insurer's unexpected losses outside Florida, recentered for its footprint	$\bar{\alpha}$	Florida homeowners respond to an insurer's losses elsewhere only through its premium

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Appendix: Parameter Estimates

Parameter	Estimate	Standard error
Fixed component of price sensitivity, β_p	1.242	0.159
Dispersion of price RC (log scale), σ_p	0.858	0.047
$\log(\text{exposure/policy})$	0.383	0.027
Citizens indicator	0.349	0.009
Post Model Law 785	-0.101	0.004
Reform intensity	0.033	0.008
County AAL	0.083	0.003
Reform intensity $\times$ AAL	0.002	0.002

Own-price elasticity: mean -4.31, median -3.45. Own-cost pass-through: 1.065. 152,507 observations, 2,935 markets, 131 firms.

NAIC benchmark, Florida homeowners 2010–2020: premium less losses, defense costs, commissions and taxes is 27% of premium. Reinsurance costs are not netted out, so this is an upper bound on the comparable margin.

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Appendix: Welfare Counterfactuals

	Restricted product set (excludes post-adoption additions)	Full observed product set
No-reform costs	**S4**: no-reform world	S3
Reform costs	S2	**S1**: observed world

- **Cost channel:** S4 $\rightarrow$ S2. Costs fall, products held fixed, all insurers reprice
- **Product channel:** S2 $\rightarrow$ S1. Additional products restored, all insurers reprice again
- **Measure:** change in expected consumer surplus (log-sum formula), in dollars per owner-occupied household per year, including households that choose the outside option
- **Limit:** observed product additions are an input; the model does not predict entry

Cost \$57.70; additional products \$37.38; total \$95.08.

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References

Borusyak, Kirill, Xavier Jaravel, and Jann Spiess, "Revisiting Event-Study Designs: Robust and Efficient Estimation," *Review of Economic Studies*, 2024, *91* (6), 3253–3285.