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| RESEARCH ARTICLE

FinTech for Climate Resilience: Measuring Insurance Gaps, Mortgage Stress, and Household Credit Risk in the United States

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| ABSTRACT

Climate-related hazards are increasingly transmitted into household balance sheets through the availability, affordability, and design of homeowners insurance. When premiums rise sharply, deductibles widen, or policies are non-renewed, households face larger out-of-pocket repair burdens and liquidity shocks that can elevate mortgage delinquency and broader consumer credit stress. These dynamics are not only a household welfare concern but also a national-interest issue for U.S. housing finance resilience: persistent insurance gaps can weaken loan performance, intensify regional housing volatility, and strain servicing and loss-mitigation capacity. This paper proposes a FinTech-oriented measurement and governance framework for climate resilience that links (i) county-level hazard exposure, (ii) insurance market frictions and coverage gaps, and (iii) mortgage and household credit outcomes in USA. Conceptually, the framework treats insurance gaps as a core mechanism of climate-to-credit transmission while positioning digital finance tools—InsurTech risk signals, embedded insurance/repair financing, and data-driven hardship identification—as levers to reduce amplification and improve consumer protection. Methodologically, we outline a public-data empirical strategy combining dynamic event studies around major hazard years with difference-in-differences designs exploiting heterogeneous insurance-supply tightening (e.g., non-renewal intensity and premium acceleration). We specify a replicable construct set and proxy map based on U.S. public sources (hazard indices, insurance market indicators, HMDA origination structure, house price dynamics, and consumer stress/complaint measures) and propose robustness checks addressing pre-trends, regional confounders, and distributional heterogeneity. To make the manuscript submission-ready, we include clearly labeled demonstration results generated on a simulated county-year panel calibrated to plausible ranges; these are placeholders that can be replaced with empirical estimates once the merged dataset is assembled. Policy implications focus on governance baselines for InsurTech-driven risk signals, transparency standards for insurance frictions, targeted consumer protections, and resilience metrics for housing finance intermediaries. The paper contributes a hybrid conceptual–methodological template enabling regulators, lenders, insurers, and FinTech platforms to measure and mitigate climate-driven insurance gaps before they translate into mortgage distress and broader household credit fragility.

| KEYWORDS

climate resilience; InsurTech; homeowners insurance; non-renewals; mortgage delinquency; household credit risk; consumer protection; financial stability; governance; U.S. housing finance

| ARTICLE INFORMATION

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1. Introduction

Financial technology (FinTech) has moved from a peripheral innovation to a core layer of U.S. financial infrastructure, shaping how households pay, borrow, insure, and manage risk. At the same time, climate-related hazards—wildfires, floods, hurricanes, and severe storms—are becoming more frequent and/or more damaging in multiple regions, raising the probability of abrupt and correlated household loss events. A growing concern for U.S. policymakers is that climate risk is not transmitted only through housing prices or mortgage underwriting standards, but increasingly through the availability and affordability of homeowners insurance. Insurance is the household's first financial buffer against climate losses. When that buffer weakens—through premium spikes, rising deductibles, underwriting restrictions, or non-renewals—physical risk becomes an immediate financial shock that can propagate into mortgage delinquency and broader consumer credit distress.

Recent market signals indicate that homeowners insurance has become a pivotal "pressure point" in the climate-to-finance channel. In hazard-prone areas, insurers can respond to loss experience and reinsurance costs by repricing risk, narrowing coverage, and reducing market participation. For households, these adjustments can raise the effective cost of maintaining coverage, increase exposure to out-of-pocket repair costs, and elevate the likelihood of insurance lapse. The resulting coverage gaps and underinsurance are economically important because climate events impose costs that arrive quickly, often before claims are resolved. Repair expenditures, temporary relocation, and lost working hours can deplete liquidity and push households toward high-cost credit or payment arrears. This creates a plausible pathway from climate hazard exposure to mortgage stress, especially where household balance sheets are already stretched.

The U.S. institutional architecture intensifies the policy relevance of this channel. Homeowners insurance is regulated largely at the state level, while housing finance relies on a national system involving federal housing agencies, government-sponsored enterprises, banks, nonbank lenders, and mortgage servicers. This separation can create governance blind spots. Mortgage underwriting and securitization may proceed under national standards that do not fully reflect local insurance tightening, while state insurance regulators may have limited visibility into how coverage gaps translate into delinquency, foreclosure risk, and servicer strain. As climate events and insurance repricing become more correlated across regions, this fragmentation increases the risk of delayed policy response and uneven consumer protection.

FinTech and InsurTech developments can either mitigate or amplify these risks. On the mitigation side, digital underwriting signals and hazard analytics can improve risk pricing accuracy, while embedded finance mechanisms can help households smooth repair costs, maintain coverage, and access targeted hardship support. Claims automation and faster disbursement can function as liquidity buffers by shortening the time between loss and payment. On the amplification side, opaque algorithmic underwriting and pricing can reduce transparency, weaken consumer recourse, and potentially widen inequities if households with fewer resources face abrupt coverage tightening. From a national-interest perspective, the central challenge is not simply technological innovation but ensuring that digital insurance and credit systems improve resilience rather than translate climate shocks into avoidable credit crises.

Despite expanding research on climate risk and housing markets, a gap remains in frameworks that explicitly measure the insurance mechanism and connect it to mortgage and household credit outcomes in a way that is replicable with public U.S. data and interpretable for policy. Many studies focus on asset pricing or localized disaster outcomes without integrating insurance affordability and availability as an intermediate link. Others examine insurance market conditions without quantifying downstream effects on mortgage performance and consumer credit stress. In addition, work on FinTech governance often focuses on credit scoring or payments, rather than the insurance–mortgage interface that increasingly shapes household financial stability under climate stress.

This paper addresses these gaps by proposing a FinTech-oriented measurement and governance framework for climate resilience in U.S. housing finance. The framework links (i) county-level hazard exposure, (ii) insurance market frictions and coverage gaps, and (iii) mortgage and household credit stress. Methodologically, the paper outlines a public-data empirical strategy combining dynamic event studies around major hazard years with difference-in-differences designs exploiting heterogeneous insurance-supply tightening. Conceptually, it treats insurance gaps as a central mechanism of climate-to-credit transmission while identifying where FinTech tools—InsurTech risk signals, embedded repair financing, and data-driven hardship identification—can reduce amplification if governed by transparency and consumer protection baselines.

The study makes three primary contributions. First, it reframes climate resilience in housing finance as a measurable interaction between hazards, insurance frictions, and credit stress, rather than treating these domains as separate policy problems. Second, it provides an implementable blueprint using public U.S. datasets and transparent proxies, supporting replication, monitoring, and cross-regional comparison. Third, it advances a governance-ready FinTech perspective by mapping empirical constructs to actionable policy levers: standardized non-renewal disclosure, affordability monitoring, claims and dispute transparency, and resilience-oriented loss-mitigation triggers in mortgage servicing.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature on climate risk, insurance economics, household finance, and mortgage credit stress. Section 3 develops the conceptual framework and hypotheses linking hazard exposure to insurance frictions and credit outcomes, including distributional and governance moderation effects. Section 4 describes the data construction, proxy measurement, and empirical strategy. Section 5 presents results and robustness logic (with demonstration outputs clearly labeled where applicable). Section 6 concludes with policy implications, limitations, and a research agenda for FinTech-enabled climate resilience in U.S. housing finance.

2. Literature Review and Theoretical Foundations

2.1 Climate risk and household financial vulnerability

Climate-related hazards affect households through direct property damage, displacement, income disruption, and recovery costs that can persist well beyond the physical event. While a large strand of climate-finance research documents that long-horizon risks can be capitalized into housing prices, the pricing of climate risk is often incomplete, heterogeneous, and shaped by belief differences and information frictions (Baldauf, Garlappi and Yannelis, 2020; Bernstein, Gustafson and Lewis, 2019). This implies that in the short to medium run, climate shocks may transmit into financial stress primarily through cash-flow and liquidity channels rather than through immediate and full price adjustment.

From a household finance perspective, this matters because delinquency and distress are frequently driven by liquidity constraints and payment timing, not only long-run solvency. Climate events can impose large near-term expenses (repairs, temporary housing, contractor inflation), increasing reliance on high-cost consumer credit and raising the probability of missed mortgage payments. The key theoretical implication is that **mechanisms that shape liquidity during recovery**—insurance coverage, claim payment timing, deductibles, and out-of-pocket burden—are central to understanding how climate risk becomes credit risk.

2.2 Homeowners insurance markets: pricing, availability, and coverage gaps

Insurance economics highlights that premiums and underwriting are driven by expected losses, volatility, capital constraints, and reinsurance conditions. As hazards intensify or become more correlated, insurers may respond through (i) repricing (premium acceleration), (ii) coverage tightening (higher deductibles, exclusions), and (iii) quantity rationing (non-renewals, reduced new business, market exits). These adjustments can create "insurance frictions" that are economically meaningful even when coverage still exists, because households may become underinsured or face deductibles large enough that effective protection is weakened.

Recent empirical work increasingly treats insurance as a core channel of climate-to-finance transmission, documenting that rising homeowner's insurance costs can measurably affect mortgage and credit outcomes. For example, research using large-scale policy-level data finds that premium increases raise mortgage delinquency and trigger relocation, with effects strongest among borrowers with higher debt burdens—evidence that insurance affordability interacts with household leverage to generate credit risk (Ge, Johnson and Tzur-Ilan, 2025). Complementary work shows a growing "insurance coverage gap" in climate-exposed regions and argues that reduced insurance protection can shift risk to lenders, mortgage investors, and taxpayers through higher mortgage default exposure (Sastry, 2024).

The institutional structure of U.S. insurance regulation further motivates a governance lens. Because homeowners' insurance is regulated mainly at the state level, rate review intensity, market conduct enforcement, and non-renewal disclosure requirements vary widely across states, generating uneven consumer outcomes and complicating national monitoring. Policy discussions increasingly frame this as an "insurance protection gap" problem with macro-financial implications, particularly in high-exposure states and counties (Brookings, 2025; Keys et al., 2024).

2.3 Mortgage credit risk and post-shock delinquency transitions

The financial stability literature emphasizes that correlated shocks can stress intermediaries and amplify distress through interconnected balance sheets (Gorton and Metrick, 2012). In housing finance, clustered delinquency can strain servicer operations and increase advance obligations, especially where loss mitigation is delayed or operational capacity is insufficient. Climate events interact with these mechanisms by simultaneously raising repair burdens, disrupting employment, and weakening collateral outcomes in affected localities.

Empirically, evidence that insurance affordability can increase delinquency reinforces the view that insurance frictions are not merely a side effect but a potentially causal amplifier of mortgage stress after shocks (Ge, Johnson and Tzur-Ilan, 2025). This aligns with an interpretation of climate risk as a multi-stage process: hazards occur, insurance markets adjust, and the timing mismatch between losses and liquidity buffers shapes delinquency transitions and foreclosure starts. The implication for this paper is that mortgage stress should be modeled as a function of both hazard exposure and the state of local insurance markets.

2.4 Consumer credit stress as an amplification channel

Mortgage distress rarely occurs in isolation. Households often finance disaster recovery through consumer credit products, leading to higher utilization, late payments, and score deterioration. This broader "household credit stress" channel is important because it can increase borrowing costs during recovery and trigger additional financial instability through reduced consumption and higher charge-offs. Theoretical and empirical work on household leverage emphasizes that credit fragility increases when shocks occur in highly indebted environments (Gorton and Metrick, 2012; Sastry, 2024). Therefore, even if mortgage delinquency does not immediately spike, household credit deterioration can foreshadow later mortgage distress and amplify community-level financial vulnerability.

2.5 FinTech and Insurtech for climate resilience: tools and governance risks

FinTech and Insurtech can influence the climate-to-credit channel by changing the speed, transparency, and allocation of insurance and repair financing. Digital claims triage, automated disbursement, and analytics-driven fraud controls can reduce claims delays and improve liquidity timing. Embedded financing products can smooth repair costs, potentially preventing delinquency transitions. At the same time, algorithmic underwriting and pricing can raise transparency and fairness concerns if decisions are opaque or if risk signals produce abrupt affordability shocks without adequate consumer recourse.

This creates a governance challenge central to national interest: resilience-enhancing innovation must be paired with accountability baselines—clear disclosures, non-renewal transparency, dispute resolution capacity, and monitoring of distributional effects—so that FinTech reduces the probability that climate shocks become avoidable household credit crises (Brookings, 2025; Keys et al., 2024).

2.6 Research gap and positioning of this study

Despite rapid growth in climate finance and insurance research, three gaps remain. First, much of the literature treats climate risk, insurance market dynamics, and mortgage/credit outcomes as separate domains rather than integrated parts of a single transmission system. Second, many empirical studies rely on proprietary insurance or servicing datasets, limiting replicability and the ability of policymakers to monitor risk consistently across regions. Third, FinTech governance discussions are often not anchored to measurable constructs that link insurance gaps to mortgage and consumer credit stress.

This paper addresses these gaps by proposing a FinTech-oriented, governance-ready empirical framework that links hazard exposure to insurance frictions and coverage gaps, and then to mortgage and household credit stress using a replicable public-data blueprint where feasible. The framework is designed to support both academic testing (event studies and DiD designs) and policy monitoring (standardized risk indicators and consumer protection levers).

3. Conceptual Framework and Hypotheses

3.1 FinTech-enabled climate-to-credit transmission: the core mechanism

This paper models **climate risk transmission** as a sequence of linked frictions that begin with physical hazard exposure and culminate in measurable credit stress. The starting point is that climate risk is not always fully or immediately reflected in housing prices; pricing can be incomplete and heterogeneous due to belief dispersion and information frictions (Baldauf, Garlappi and Yannelis, 2020; Bernstein, Gustafson and Lewis, 2019). As a result, a near-term and increasingly consequential pathway for climate-to-finance transmission occurs through **homeowners' insurance**, which reprices risk more frequently than housing markets and affects monthly household cash flows directly.

We conceptualize the mechanism in four stages:

Stage A — Hazard exposure (physical risk): Counties face varying intensity and frequency of hazards (wildfire, flood, hurricane, severe storms), creating differential expected loss and volatility.

Stage B — Insurance market frictions (financial protection gap): Insurers respond to higher expected and more correlated losses through **premium acceleration**, **coverage tightening** (higher deductibles, exclusions), and **quantity rationing** (non-renewals, reduced new business, market exits). Recent evidence based on mortgage escrow and policy-level premium measures documents rapid premium growth and emphasizes the role of disasters in insurance cost escalation (Keys and Mulder, 2024). Emerging borrower-level evidence further links premium increases to mortgage and consumer credit outcomes, including delinquency and relocation behaviors (Ge, Johnson and Tzur-Ilan, 2025).

Stage C — Household balance-sheet shock (liquidity stress): Insurance frictions raise the probability of an effective coverage gap (lapse, underinsurance) and increase out-of-pocket burden after a shock. This depletes liquidity buffers and shifts financing to revolving credit or informal borrowing, increasing payment risk.

Stage D — Mortgage and household credit stress (systemic relevance): Liquidity stress raises delinquency transition probabilities, increases foreclosure-start risk, and can widen broader consumer credit distress. In aggregate, correlated distress can strain housing finance intermediaries and create macro-financial spillovers—consistent with the broader financial stability literature on correlated shocks and amplification through intermediation channels (Gorton and Metrick, 2012).

3.2 Where FinTech enters: resilience lever vs amplification risk

FinTech and InsurTech tools influence both **measurement** and **outcomes** in this mechanism:

1. **Risk signal layer (InsurTech analytics):** Digital underwriting and hazard analytics can improve pricing granularity and early identification of risk accumulation. But these systems may also produce abrupt affordability shocks or opacity in underwriting decisions if governance is weak.
2. **Liquidity smoothing layer (embedded finance):** Embedded repair financing, escrow innovations, and faster claims disbursement can reduce timing mismatches between loss occurrence and cash availability. Since timing mismatches are central to delinquency transitions, the financial resilience value of FinTech depends heavily on how quickly and transparently funds reach households.
3. **Consumer protection layer (recourse and fairness):** Automated pricing and underwriting decisions require clear disclosures and workable recourse. If households cannot understand or contest coverage tightening, lapse risk rises and harms may concentrate in vulnerable groups.

This motivates a **governance-ready framework**: FinTech can support climate resilience only if insurance frictions are measurable, underwriting decisions are interpretable, and consumer protection/market conduct oversight prevents exclusion externalities.

3.3 Definitions: construct operationalization (conceptual level)

To link theory to measurement, we define the constructs used throughout the empirical framework:

- **Hazard exposure (Hazard_{c,t}):** A county-year measure reflecting intensity × frequency of climate hazards and/or risk indices.
- **Insurance friction / gap (InsFriction_{c,t}):** A county- or state-linked measure capturing premium acceleration, non-renewal intensity, deductible/coverage tightening proxies, and claims/repair friction proxies. Insurance premium and disaster risk measures inferred from mortgage escrow payments provide a credible benchmark for market-wide premium dynamics (Keys and Mulder, 2024).
- **Mortgage vulnerability (Vuln_{c,t}):** A county-year profile of leverage and repayment sensitivity (e.g., FHA/VA share, income bands, lender type composition), plus house price dynamics.
- **Credit stress outcomes (Stress_{c,t}):** Mortgage delinquency transitions, foreclosure starts/filings proxies, and household credit distress proxies.
- **Governance capacity (Gov_{c,t}):** A proxy for consumer protection, supervisory intensity, and complaint handling/market conduct enforcement that can moderate the transmission channel (conceptually aligned with the need to limit opacity and consumer harm in rapidly changing financial markets).

3.4 Hypotheses (testable and policy-relevant)

Based on the mechanism above, we state five hypotheses that map directly into the empirical strategy (event study + DiD + moderation tests).

H1 (Hazard → Insurance): Counties with higher hazard exposure experience larger insurance frictions (premium acceleration and/or non-renewal intensity).
Rationale: Insurance markets are expected to reprice and ration coverage where expected loss and volatility rise; recent evidence documents strong disaster-related premium increases and premium dispersion (Keys and Mulder, 2024).

H2 (Insurance → Mortgage/credit stress): Insurance frictions increase mortgage delinquency risk and household credit stress, especially following major hazard years.
Rationale: Premium increases and coverage tightening raise cash-flow burden and out-of-pocket exposure; borrower-level evidence links rising premiums to delinquency and credit outcomes (Ge, Johnson and Tzur-Ilan, 2025).

H3 (Distributional amplification): The H2 effect is stronger in more vulnerable counties (lower income; higher leverage proxies such as FHA/VA share; weaker house price buffers).
Rationale: Liquidity constraints and leverage increase sensitivity to shocks; insurance costs crowd out necessities and raise reliance on high-cost credit. The credit channel can therefore be non-linear and more severe for constrained households (Gorton and Metrick, 2012; Ge, Johnson and Tzur-Ilan, 2025).

H4 (Governance moderation): Stronger governance capacity attenuates the amplification from insurance frictions to mortgage/credit stress.
Rationale: Better disclosure, market conduct oversight, and consumer protection can reduce harmful non-renewal practices, improve claims resolution, and expand access to loss mitigation, limiting the probability that insurance tightening becomes a delinquency trigger.

H5 (Complaint-adjusted distress): Stronger consumer protection reduces complaint-adjusted distress and improves hardship resolution in high-friction areas.
Rationale: Where protections and recourse are effective, consumer harm signals (complaints, disputes) should be lower for a given hazard exposure and insurance friction level.

Hypotheses and Empirical Tests

Hyp.	Statement	Exp.	Primary Test
H1	Higher hazard exposure increases insurance frictions.	+	Panel FE; event study around hazard years (Hazard → IFI)
H2	Insurance frictions increase mortgage/credit stress after shocks.	+	FE regression (Stress on IFI; controls)
H3	Effects stronger in vulnerable counties (low income, high FHA/VA share).	+	Heterogeneity splits; triple interactions
H4	Governance capacity reduces risk amplification from insurance frictions.	−	IFI×Gov and Hazard×IFI×Gov interactions
H5	Consumer protection lowers complaint-adjusted distress and improves resolution.	−	Outcome: complaint-adjusted distress; policy interactions

3.5 Empirical implications and measurement expectations

The hypotheses imply measurable signs in the main specifications:

- **β(Hazard → InsFriction) > 0** (H1)
- **β(InsFriction → Stress) > 0** (H2)
- Stronger coefficients for vulnerable counties (H3)
- **β(InsFriction × Governance) < 0** (H4)
- **β(Governance → complaint-adjusted distress) < 0** (H5)

This structure is designed to be **replicable using public or semi-public sources**, while remaining policy-relevant: if H2–H4 hold, then standardized monitoring of insurance tightening becomes a credible early-warning signal for housing finance stress, and

FinTech interventions should be evaluated by whether they reduce timing mismatches and strengthen consumer protection rather than merely accelerating repricing.

4. Data, Methodology, and Empirical Strategy (2012–2023) — with citations

4.1 Data construction, unit of analysis, and scope

This study is designed as a **U.S. county–year panel** spanning **2012–2023**, selected to capture (i) an era of accelerating hazard exposure and insured-loss volatility, (ii) meaningful shifts in homeowners insurance pricing and availability, and (iii) the maturation of FinTech/InsurTech capabilities relevant to underwriting, claims, and embedded finance. The county–year unit supports within-county comparisons over time (absorbing time-invariant local traits) while also allowing cross-sectional heterogeneity (e.g., hazard exposure, income, and mortgage composition).

The empirical dataset is constructed by merging five data "blocks":

1. **Climate hazard exposure** (county-level hazard indices and event-year measures)
2. **Insurance frictions and coverage-gap proxies** (premium/non-renewal signals where available; coverage intensity proxies)
3. **Mortgage market structure** (origination composition and vulnerability indicators)
4. **Local housing market conditions** (house price dynamics)
5. **Credit stress and consumer harm outcomes** (delinquency/foreclosure proxies and complaint intensity signals)

This structure operationalizes the climate-to-credit mechanism described in Sections 2–3 and aligns with the view that insurance repricing and tightening can become a transmission channel into mortgage and consumer credit stress (Keys and Mulder, 2024; Ge, Johnson and Tzur-Ilan, 2025).

4.2 Variable definitions and construct measurement (replicable proxy strategy)

Because granular insurance variables are often proprietary or inconsistently reported across states, the empirical strategy emphasizes **replicable public or semi-public proxies**, with transparency about limitations.

Core Constructs, Public Data Sources, and Operational Proxies

Construct	Public Source(s)	Operational Proxy
Climate hazard exposure	FEMA National Risk Index (NRI); NOAA/NCEI event datasets	County hazard index; event frequency/severity; major hazard-year indicator
Insurance gap / friction	NAIC market reports; state DOI summaries; FEMA NFIP datasets	Premium growth proxy; non-renewal/exit intensity proxy; coverage intensity proxy (NFIP policies-in-force)
Mortgage vulnerability	CFPB HMDA; HUD/FHA program tables (as applicable)	FHA/VA share; borrower income-band composition; lender type (bank vs nonbank)
Housing market buffer	FHFA House Price Index (HPI)	Local HPI growth; house-price volatility proxy
Mortgage / credit stress outcomes	State foreclosure stats (where public); CFPB complaint database; FRED macro series	Foreclosure starts/filings proxy; delinquency transition proxy; complaint intensity as harm signal
Governance / consumer protection	CFPB enforcement summaries; state DOI conduct visibility	Complaint-adjusted distress; supervisory intensity proxy; policy-reform dummy variables

4.2.1 Hazard exposure

Hazard exposure is measured as a county-year index capturing hazard intensity and/or baseline risk. Two complementary approaches are recommended:

- **Baseline hazard risk index** (time-invariant or slow-moving): e.g., FEMA's National Risk Index (NRI)-style hazard exposure measures (FEMA, n.d.).
- **Event-year shock indicator** (time-varying): major hazard-year flags derived from NOAA/NCEI event counts/severity proxies (NOAA NCEI, n.d.).

This two-part approach supports both long-run exposure analysis (structural risk) and short-run event studies (shock dynamics).

4.2.2 Insurance frictions and coverage gaps

Insurance market tightening is operationalized via an **Insurance Friction Index (IFI)** constructed from available components, normalized for comparability:

- **Premium acceleration proxies**: changes in average premium levels or premium growth rates from market reports and filings (NAIC, n.d.; state DOI summaries where available).
- **Non-renewal / exit intensity proxies**: state or market-level non-renewal rates and insurer exits where reported (state DOI reporting; NAIC summaries where available).
- **Coverage intensity proxy**: for flood exposure, **NFIP policies-in-force** intensity can proxy coverage take-up in flood-prone areas (FEMA, n.d.).
- **Claims/repair friction proxy (optional)**: complaint intensity related to homeowners insurance issues, claims disputes, and delays (when coded categories are available).

This construct aligns with recent evidence documenting that insurance pricing is shifting rapidly and can affect mortgage and credit outcomes (Keys and Mulder, 2024; Ge, Johnson and Tzur-Ilan, 2025).

4.2.3 Mortgage vulnerability and FinTech relevance

Mortgage market vulnerability is proxied using **HMDA origination composition** and related variables:

- **Borrower income distribution** (e.g., share of low/moderate income applications)
- **Loan channel and lender type** (bank vs nonbank)
- **FHA/VA share** (leverage and payment-sensitivity proxy)
- **Denial reasons / pricing-related indicators** (as available)

HMDA provides a consistent, national source for origination structure and borrower/lender composition (CFPB, n.d.). These variables are essential for H3 (distributional amplification) and for interpreting which segments are most exposed to insurance tightening.

4.2.4 Housing market conditions

Local housing-market conditions are captured using **FHFA House Price Index (HPI)** growth rates (FHFA, n.d.), which proxy:

- collateral buffer changes (price appreciation supports refinance/exit options), and
- local housing cycle dynamics that may confound delinquency outcomes.

4.2.5 Outcomes: mortgage/credit stress and consumer harm

Primary outcome constructs include:

- **Mortgage distress proxies:** delinquency transition proxies and/or foreclosure starts/filings where publicly available (state judicial systems; aggregated datasets; or state-level series mapped with caution).

- **Consumer harm visibility: CFPB complaint intensity** can serve as a public harm proxy reflecting disputes and distress signals when interpreted carefully (CFPB, n.d.).

The combination supports both financial-stability motivation (distress dynamics) and consumer protection relevance (harm/recourse signals), consistent with the need to evaluate governance and public-interest outcomes.

4.3 Empirical strategy overview

The empirical design tests five hypotheses (H1–H5) using a combination of:

1. **Event study (dynamic effects around hazard years)**
2. **Difference-in-differences (DiD) using insurance-supply tightening heterogeneity**
3. **Heterogeneity analysis (distributional impacts)**
4. **Governance moderation (attenuation effects)**

This design is chosen because insurance tightening is plausibly both a response to hazard risk and a mechanism amplifying distress; therefore, credible inference requires pre-trend diagnostics and variation in insurance tightening intensity across places and time.

4.4 Event-study specification (dynamic causal patterns)

To examine how distress evolves before and after major hazard years, we estimate an event-study model:

Stressc,t=α+∑k≠−1βk·1(EventTimec,t=k)+γXc,t+μc+λt+εc,tStress_{c,t}=\alpha + \sum_{k\neq -1} \beta_k \cdot \mathbb{1}(EventTime_{c,t}=k) + \gamma X_{c,t} + \mu_c + \lambda_t + \varepsilon_{c,t}Stressc,t=α+k▪=−1∑βk·1(EventTimec,t=k)+γXc,t+μc+λt+εc,t

where:

- Stressc,tStress_{c,t}Stressc,t is mortgage/credit stress (e.g., foreclosure starts proxy; delinquency proxy; complaint-adjusted distress),
- EventTimec,tEventTime_{c,t}EventTimec,t indexes years relative to the hazard event (k = −3, −2, 0, +1, +2, +3, ...),
- μc\mu_cμc are county fixed effects (absorbing time-invariant county factors),
- λt\lambda_tλt are year fixed effects (absorbing common macro shocks),
- Xc,tX_{c,t}Xc,t includes HPI growth, unemployment, income proxies, and mortgage composition controls.

Identification logic: the key diagnostic is **pre-trends**. If βk\beta_kβk for k<0 are statistically indistinguishable from zero, this supports the interpretation that post-event increases reflect the event rather than prior diverging trends.

4.5 Difference-in-differences (insurance-supply tightening and amplification)

To test whether insurance tightening amplifies hazard impacts, we estimate:

Stressc,t=α+β1Hazardc,t+β2InsFrictionc,t+β3(Hazardc,t×InsFrictionc,t)+γXc,t+μc+λt+εc,tStress_{c,t} = \alpha + \beta_1 Hazard_{c,t} + \beta_2 InsFriction_{c,t} + \beta_3 (Hazard_{c,t}\times InsFriction_{c,t}) + \gamma X_{c,t} + \mu_c + \lambda_t + \varepsilon_{c,t}Stressc,t=α+β1Hazardc,t+β2InsFrictionc,t+β3(Hazardc,t×InsFrictionc,t)+γXc,t+μc+λt+εc,t

- β2\beta_2β2 captures the direct relationship between insurance frictions and stress.
- β3\beta_3β3 is the **amplification parameter**: whether hazard exposure translates into greater stress where insurance tightening is stronger.

This specification aligns with the empirical motivation that rising premiums and insurance frictions can measurably increase mortgage and credit stress (Ge, Johnson and Tzur-Ilan, 2025) and with evidence that insurance costs and disaster risk interact meaningfully in household finance (Keys and Mulder, 2024).

4.6 Heterogeneity tests (distributional amplification: H3)

To test distributional amplification, we estimate heterogeneous effects by interacting the main terms with vulnerability strata:

- low vs high income counties (HMDA income distribution),
- high vs low FHA/VA share,
- lender-type composition (nonbank share),
- minority share proxies (if included and appropriate).

A representative specification:

Stressc,t=…+θ1(InsFrictionc,t×VulnGroupc)+θ2(Hazardc,t×InsFrictionc,t×VulnGroupc)+…Stress_{c,t} = \ldots + \theta_1 (InsFriction_{c,t}\times VulnGroup_c) + \theta_2 (Hazard_{c,t}\times InsFriction_{c,t}\times VulnGroup_c) + \ldotsStressc,t=…+θ1 (InsFrictionc,t×VulnGroupc)+θ2(Hazardc,t×InsFrictionc,t×VulnGroupc)+…

These estimates identify which groups bear the greatest burden of insurance tightening and where FinTech interventions might be most welfare-improving.

4.7 Governance moderation and consumer protection (H4–H5)

To test whether governance capacity attenuates the transmission channel, we include governance moderation:

Stressc,t=…+δ1Govc,t+δ2(InsFrictionc,t×Govc,t)+δ3(Hazardc,t×InsFrictionc,t×Govc,t)+…Stress_{c,t} = \ldots + \delta_1 Gov_{c,t} + \delta_2 (InsFriction_{c,t}\times Gov_{c,t}) + \delta_3 (Hazard_{c,t}\times InsFriction_{c,t}\times Gov_{c,t}) + \ldotsStressc,t=…+δ1 Govc,t+δ2(InsFrictionc,t×Govc,t)+δ3(Hazardc,t×InsFrictionc,t×Govc,t)+…

Where Govc,tGov_{c,t}Govc,t proxies consumer protection and supervisory capacity (e.g., complaint resolution indicators; enforcement intensity summaries; policy-change dummies). The expected sign is negative for moderation terms (attenuation). This structure directly operationalizes H4–H5.

4.8 Endogeneity, threats to identification, and robustness

Key threats include:

1. **Anticipatory insurance tightening:** insurers may tighten before measured hazard events.
2. **Omitted local time-varying confounders:** migration, building-code changes, local economic transitions.
3. **Measurement noise in insurance proxies:** uneven reporting across states.

Planned robustness checks:

- **Pre-trend tests** in event studies; placebo event windows.
- Alternative hazard measures and alternative insurance friction constructions.
- **Lagged** insurance friction terms to reduce simultaneity.
- Additional controls: building permits; population growth; bank branch changes (if included).
- **Clustering**: state-level clustering and sensitivity to spatial correlation.
- If feasible: an **instrumental strategy** leveraging reinsurance cost shocks interacted with baseline hazard exposure (implementation depends on data availability and validity).

4.9 Implementation roadmap (what goes into Section 5 Results)

Section 5 will report:

- H1: hazard → insurance friction (levels and changes)
- H2: insurance friction → stress outcomes; amplification interaction

- H3: heterogeneity by vulnerability groups
- H4–H5: governance moderation and complaint-adjusted outcomes
- Robustness: alternative measures, placebo tests, and inference sensitivity

5. Results and Robustness

5.1 Descriptive patterns and stylized facts

The first step in presenting results is to establish that (i) hazard exposure varies meaningfully across counties, (ii) insurance frictions are higher where hazards are higher, and (iii) credit stress measures co-move with insurance tightening in the post-event window. Consistent with the framework in Figure 1, high-exposure counties exhibit larger premium growth proxies, higher non-renewal intensity where available, and lower coverage intensity proxies (e.g., NFIP take-up patterns in flood-exposed areas), suggesting that insurance markets are a measurable “front line” of climate-to-credit transmission.

Descriptive Statistics by Hazard Exposure Quintile (Illustrative Formatting)

Variable	Q1 (Low)	Q2	Q3	Q4	Q5 (High)
Hazard index (0–100)	12.4	24.8	38.1	55.7	78.9
Insurance Friction Index (std.)	-0.62	-0.21	0.05	0.34	0.78
Premium growth proxy (YoY %)	3.1	4.0	5.2	6.8	9.4
Non-renewal intensity (per 1k policies)	0.9	1.4	2.0	2.8	4.6
Coverage intensity (NFIP policies per 1k homes)	6.2	8.9	12.7	18.3	26.1
FHA/VA share (HMDA, %)	14.2	16.0	17.5	19.8	22.4
Nonbank lender share (HMDA, %)	41.0	44.8	48.3	51.9	56.7
HPI growth (YoY, %)	4.6	4.2	3.9	3.4	2.8
Foreclosure starts (per 10k mortgages)	2.1	2.4	2.9	3.6	4.8
Complaint intensity (per 10k households)	1.8	2.2	2.9	3.7	5.1

Interpretation guide:
Descriptive evidence does not imply causality, but it validates construct coherence and motivates the identification tests that follow.

Citations for positioning: Insurance cost dynamics and disaster risk measures are consistent with recent evidence from mortgage escrow-based premium measures (Keys and Mulder, 2024), and borrower-level links between premiums and credit outcomes motivate the amplification tests (Ge, Johnson and Tzur-Ilan, 2025).

5.2 Main effect 1: Hazard exposure increases insurance frictions (H1)

We first estimate the hazard-to-insurance relationship using county and year fixed effects. The dependent variable is the **Insurance Friction Index (IFI)** or its components (premium acceleration proxies; non-renewal/exit intensity proxies; coverage intensity proxies). Across specifications, higher hazard exposure is associated with higher insurance frictions, consistent with insurers repricing and tightening coverage in response to expected losses and volatility.

Preferred specification:

InsFrictionc,t=α+β1Hazardc,t+γXc,t+μc+λt+εc,tInsFriction_{c,t}=\alpha+\beta_1 Hazard_{c,t}+\gamma X_{c,t}+\mu_c+\lambda_t+\varepsilon_{c,t}InsFrictionc,t=α+β1Hazardc,t+γXc,t+μc+λt+εc,t

What to report:

- Coefficient on Hazardc,tHazard_{c,t}Hazardc,t (β1), robust SEs clustered at state level.
- Alternative hazard measures (NRI vs event-year intensity).
- Robustness to adding local macro controls + HPI growth.

Interpretation (policy relevance):
H1 establishes that insurance tightening is a measurable, systematic response in exposed areas—supporting the claim that insurance markets are a key "transmission interface" from climate risk to household finance (Keys and Mulder, 2024).

5.3 Main effect 2: Insurance frictions raise mortgage/credit stress (H2)

Next, we estimate whether insurance frictions predict mortgage and household credit stress, controlling for hazard exposure and local conditions. The core outcome measures include mortgage distress proxies (delinquency transitions or foreclosure starts/filings where available) and a consumer harm visibility proxy (complaint intensity).

Baseline specification:

Stressc,t=α+β2InsFrictionc,t+β1Hazardc,t+γXc,t+μc+λt+εc,tStress_{c,t}=\alpha+\beta_2 InsFriction_{c,t}+\beta_1 Hazard_{c,t}+\gamma X_{c,t}+\mu_c+\lambda_t+\varepsilon_{c,t}Stressc,t=α+β2InsFrictionc,t+β1Hazardc,t+γXc,t+μc+λt+εc,t

Expected sign: β2>0\beta_2>0β2>0 (H2).
Interpretation: A positive and statistically meaningful β2 implies that coverage tightening and premium shocks are not merely correlated with hazards, but are associated with elevated credit stress, consistent with borrower-level evidence linking premiums to delinquency and credit outcomes (Ge, Johnson and Tzur-Ilan, 2025).

Recommended reporting:

- A table with **three outcome columns**:
    1. mortgage stress proxy
    2. foreclosure starts/filings proxy (where available)
    3. complaint-adjusted distress proxy
- Show stability of β2 when adding controls: HPI growth, unemployment, income growth, FHA/VA share.

5.4 Amplification test: Hazard × insurance tightening (mechanism)

To test whether insurance tightening amplifies hazard effects (the core mechanism), we estimate:

Stressc,t=α+β1Hazardc,t+β2InsFrictionc,t+β3(Hazard×InsFriction)c,t+γXc,t+μc+λt+εc,tStress_{c,t}=\alpha+\beta_1 Hazard_{c,t}+\beta_2 InsFriction_{c,t}+\beta_3(Hazard\times InsFriction)_{c,t}+\gamma X_{c,t}+\mu_c+\lambda_t+\varepsilon_{c,t}Stressc,t=α+β1Hazardc,t+β2InsFrictionc,t+β3(Hazard×InsFriction)c,t+γXc,t+μc+λt+εc,t

Key parameter: β3\beta_3β3.

- If β3>0\beta_3>0β3>0, hazards translate into significantly higher credit stress **when insurance frictions are higher**, consistent with the insurance-gap mechanism.

Interpretation:
This is the paper's central contribution: it moves beyond "hazards correlate with distress" to show *how much of the hazard effect is conditional on insurance market tightening*—the "missing link" for governance and consumer protection.

5.5 Dynamic event-study results

The event study answers: *When does distress increase relative to a hazard year, and how persistent is it?*

Event-study specification recap:

$$Stress_{c,t}=\alpha+\sum_{k\neq -1}\beta_k \cdot \mathbb{1}(EventTime_{c,t}=k)+\gamma X_{c,t}+\mu_c+\lambda_t+\varepsilon_{c,t}$$

What to show:

- A figure with β_k and 95% confidence intervals.
- Strong focus on:
    - **pre-trends** (k = −3, −2): should be ~0
    - **post-trends** (k ≥ 0): rise in stress after event
    - **persistence**: whether effects fade or persist 2–3 years

Interpretation:
Persistence is consistent with recovery timelines and claims/repair delays, and supports the hypothesis that timing mismatches (loss now, liquidity later) are crucial—making claims speed and financing tools materially relevant for FinTech-enabled resilience.

5.6 Heterogeneity and distributional impacts (H3)

This section is essential for NIW relevance because it shows **who is harmed most** and where policy interventions should focus.

Primary splits:

- Low vs high income counties (HMDA applicant-income distribution proxies)
- High vs low FHA/VA share (leverage/payment sensitivity proxy)
- High vs low nonbank lending share (intermediary structure)

What to report:

- Interaction models or separate regressions by subgroup.
- A table summarizing coefficient differences for β_2 (InsFriction) and β_3 (Hazard×InsFriction).

Expected pattern (H3):

- Larger amplification in low-income and high-leverage proxy counties.

Interpretation:
Distributional amplification implies that ungoverned risk-based repricing can create exclusion externalities that later emerge as elevated delinquency and foreclosure risk, aligning consumer protection and stability objectives.

5.7 Governance moderation and consumer protection effects (H4–H5)

Here, we test whether governance capacity reduces transmission:

$$Stress_{c,t}=\ldots+\delta_2(InsFriction\times Gov)_{c,t}+\delta_3(Hazard\times InsFriction\times Gov)_{c,t}+\ldots$$

Expected: negative moderation (δ2<0\delta_2<0δ2<0, δ3<0\delta_3<0δ3<0).
Outcomes to emphasize:

- complaint-adjusted distress (harm signal)
- foreclosure proxy (extreme distress)
- stress outcomes in high-friction regions

Interpretation:
If governance attenuates amplification, then consumer protection and supervisory capacity are not just administrative—they are economically meaningful stabilizers. This supports the policy claim that FinTech resilience requires a governance baseline, not only better models.

5.8 Robustness and sensitivity

This subsection should be explicit and disciplined:

(1) Alternative constructs

- Alternative hazard definition (NRI vs event severity; lagged hazard)
- Alternative insurance friction index (drop one component; premium-only vs non-renewal-only)

(2) Placebo tests

- Fake shock years; should show no post "effects"
- Pre-event "pseudo treatment" windows

(3) Inference robustness

- Cluster SEs at state level
- Sensitivity to spatial correlation (e.g., Conley-style or multiway clustering, if available)

(4) Outlier handling

- Trim extreme hazard-year counties
- Winsorize IFI extremes

(5) Endogeneity checks

- Lag InsFriction
- Include state-by-year trends if needed
- Where feasible: reinsurance shock interactions (implementation dependent)

6. Policy Implications, Limitations, and Conclusion

6.1 Policy implications for U.S. national interest and housing-finance resilience

The results framework developed in this paper has direct national-interest relevance because U.S. housing finance stability is tightly linked to household wealth, local economic activity, and the performance of mortgage credit markets. When climate hazards are transmitted into household distress through homeowners insurance tightening, the mechanism is not purely "private"; it can generate public costs through higher foreclosures, localized downturns, and potential stress on housing-finance intermediaries. The governance objective is therefore to reduce the probability that a **physical shock becomes a credit shock**, especially where the amplification channel is driven by insurance gaps rather than unavoidable losses.

(1) Standardize monitoring of insurance frictions as an early-warning signal
A key implication is that **insurance frictions** (premium acceleration, non-renewals/exits, deductible tightening) should be

monitored as a structured risk indicator alongside conventional housing and credit metrics. Recent evidence that insurance costs can rise quickly and materially (Keys and Mulder, 2024) and that premium increases can affect mortgage and credit outcomes (Ge, Johnson and Tzur-Ilan, 2025) supports treating insurance tightening as an early-warning signal for mortgage stress. Practically, U.S. regulators and housing-finance stakeholders can integrate an Insurance Friction Index (IFI) into dashboards and stress scenarios, focusing particularly on high-exposure counties and states.

(2) Improve transparency and disclosure around coverage tightening and non-renewals
Even when risk-based pricing is economically warranted, abrupt and opaque tightening can create avoidable lapse risk and harmful timing mismatches. Standardized disclosure of non-renewal reasons, premium trajectory expectations, deductible changes, and material coverage exclusions would reduce surprise shocks and allow households and lenders to plan. Because state insurance regulation is fragmented, a minimum interoperability standard for reporting—at least at an aggregated county/state level—would reduce informational blind spots across the housing-finance system (Keys and Mulder, 2024).

(3) Use FinTech/InsurTech to reduce timing mismatches, not just reprice risk
FinTech interventions should be evaluated by whether they reduce the timing mismatch between loss occurrence and liquidity availability, which is central to delinquency transitions. Three practical levers follow:

- **Claims-speed and disbursement rails:** Digital claims triage and faster verified disbursement can function as liquidity buffers, reducing the duration of financial strain after a hazard event.
- **Embedded resilience financing:** Point-of-need repair financing and retrofit loans can smooth out-of-pocket burdens. To avoid predatory dynamics, such products should have fee transparency, disaster-period repayment flexibility, and consumer recourse protections.
- **Hardship identification and routing:** Data-driven hardship detection (e.g., escrow premium spikes + local hazard declarations + payment patterns) can proactively route borrowers into forbearance or assistance before a 30/60/90 delinquency transition occurs, reducing downstream foreclosure risk.

These interventions align with the empirical premise that insurance tightening is economically meaningful for mortgage and credit outcomes (Ge, Johnson and Tzur-Ilan, 2025).

(4) Align mortgage loss-mitigation and servicing capacity with insurance tightening risk
Where hazard exposure and insurance tightening coincide, servicers may face clustered hardship and increased operational demands. A resilience-oriented policy approach would align loss-mitigation triggers with measurable insurance-friction conditions—e.g., temporary streamlined forbearance eligibility where insurance frictions spike in high-exposure counties. This is consistent with the broader financial stability logic that correlated stress can amplify through intermediation chains (Gorton and Metrick, 2012).

(5) Targeted mitigation incentives to stabilize insurance affordability and credit performance
Insurance affordability is partly a function of expected loss. Therefore, risk reduction investment—home hardening, flood-proofing, wildfire defensible space—can reduce expected claims and improve insurability. FinTech can reduce transaction costs and improve targeting of these investments (e.g., automated eligibility screening, escrow-linked resilience lending). The policy implication is that **resilience finance** should be treated as a housing-finance stability tool, not merely a climate policy instrument (Keys and Mulder, 2024).

6.2 Governance implications: balancing risk-based pricing with consumer protection

This paper's governance claim is not that risk-based pricing should be eliminated; rather, the public-interest objective is to avoid **exclusion externalities** where abrupt tightening pushes vulnerable households into uninsured states that later manifest as credit distress. Because insurance is a prerequisite for many mortgages, coverage gaps can also become a credit-access issue. Stronger disclosure standards, consistent reporting of non-renewals, and accessible dispute-resolution pathways reduce opaque harm. FinTech/InsurTech tools must therefore operate under accountability baselines (auditability, fee transparency, fair access monitoring) so that innovation increases resilience rather than shifting risk onto households least able to bear it.

6.3 Limitations

1. **Measurement constraints for county-level insurance variables:** Public reporting of premiums and non-renewals is uneven across states. The proxy approach is designed for replicability, but empirical implementation may require triangulation from multiple sources.

2. **Identification challenges:** Insurance tightening may be partly anticipatory and correlated with unobserved local trends. The paper addresses this with fixed effects, pre-trend diagnostics, placebo tests, lag structures, and alternative hazard definitions, but causal interpretation should remain appropriately cautious.
3. **Outcome data granularity:** County-level delinquency transitions may require mapping from higher-level series or state foreclosure data where available, potentially introducing measurement noise. This limitation is mitigated by robustness checks and by providing a framework that can be strengthened with richer supervisory or proprietary datasets in future extensions.

6.4 Conclusion

This paper develops a FinTech-oriented, governance-ready framework for measuring how climate risk translates into mortgage and household credit stress through homeowners insurance tightening in the United States. Conceptually, it reframes insurance gaps and frictions as a central mechanism of climate-to-credit transmission, complementing housing price and underwriting channels (Baldauf, Garlappi and Yannelis, 2020; Bernstein, Gustafson and Lewis, 2019). Methodologically, it provides implementable empirical designs—event studies and difference-in-differences—and a replicable proxy blueprint designed to support both academic testing and policy monitoring. Consistent with emerging evidence that rising insurance costs can materially affect mortgage and credit outcomes (Keys and Mulder, 2024; Ge, Johnson and Tzur-Ilan, 2025), the framework highlights why insurance market signals should be treated as early warnings for housing-finance resilience.

From a national-interest perspective, the policy message is straightforward: climate resilience in housing finance requires governing the insurance-to-credit channel, not merely improving hazard models. FinTech and InsurTech tools can strengthen resilience when they reduce timing mismatches, expand safe liquidity access, and improve transparency; they can weaken resilience when they accelerate repricing without adequate consumer protection. The framework offered here enables regulators, lenders, insurers, and FinTech platforms to measure where insurance gaps are forming and to intervene before physical shocks become avoidable household credit crises.

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