# Natural Disasters, Property Insurance, and Housing Markets

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**Abstract**

We study how local climate risk affects house prices and location choices through insurance and migration channels in spatial equilibrium. We develop a dynamic spatial housing model in which households choose location, tenure, and property insurance coverage in the presence of heterogeneous climate risk across regions. Insurance decisions and spatial mobility interact to determine equilibrium house prices and population distributions across regions. The model generates realistic patterns of insurance demand, including underinsurance and strong heterogeneity across wealth, age, and regional risk exposure. Counterfactual increases in local climate risk induce selective migration out of exposed regions, leading to lower house prices in equilibrium as higher insurance costs are capitalized into asset values. Our results underscore the importance of jointly modeling climate risk, property insurance, and spatial sorting when evaluating the housing market impacts of climate change.

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# 1 Introduction

Natural disasters have become an increasingly important component in shaping housing markets, both through the physical destruction of housing capital and changes in expected housing costs. In the United States, natural disasters have caused $2.9 trillion in damages from 1980 to 2024, with more than half of that total coming since 2015.[1] Beyond realized destruction that affect local housing stocks *ex post*, climate risk potentially affects housing markets *ex ante* by altering local amenities, expected housing quality, expected costs and homeownership tenure. Climate risk can also give rise to migrations and pricing differentials across geographies that generate spillovers impacting the *entire* housing market including beyond affected areas. As a result, climate risk can have significant influence on housing prices even in periods and in areas without realized climate shocks.

How does local climate risk affect housing prices and household location choices on the entire housing market? Housing is typically the largest asset on household balance sheets and a key form of collateral in the economy. Climate risk, an inherently spatial phenomenon that exhibist substational regional heterogeneity, can be partially insured against with property insurance. Altogether, housing prices and population distributions reflect the aggregation of household location, tenure, and insurance decisions. We demonstrate that understanding these joint decisions is central to assessing how climate risk is capitalized into house prices and how households adapt over space.

While some components of climate risk are correlated at the national or continental levels, exposure is largely determined locally. As a result, differences in climate risk translate into differences in housing markets across geographic regions. When households are mobile, these differences generate spatial reallocation in addition to purely local price changes. Changes in the composition of local homeowners alters the marginal buyer, which feeds back into equilibrium housing prices. Therefore, understanding how climate risk affects housing markets requires an equilibrium model in which prices and population distributions adjust jointly across space.

[1] Source: https://www.ncei.noaa.gov/access/billions/time-series/US/cost

In this paper, we develop such a dynamic spatial equilibrium housing model. Households choose location, tenure, and property insurance coverage in the presence of heterogeneous local climate risk. In the United States, property insurance is effectively mandatory for most homeowners through mortgage underwriting standards, making insurance costs a large and recurring component of total housing costs. Households respond to differences in climate risk through a number of channels: adjusting insurance coverage, changing tenure between owner and tenure, and relocating across regions. These responses interact in equilibrium, jointly determining regional house prices and the spatial allocation of households. A non-spatial framework would miss these feedback effects and fail to fully characterize the impact of climate risk on housing markets.

We contribute a structural spatial model to a growing literature documenting how climate risk affects insurance coverage choices, migration patterns, and house prices. These reduced-form estimates are an important step in documenting the impact of climate risk on housing markets, but reflect the combined effects of risk exposure, insurance costs, and endogenous household sorting. Our structural framework allows us to disentangle these channels and assess how local shocks propagate across housing markets in general equilibrium. Existing models that abstract from spatial mobility or insurance decisions cannot capture how household responses reshape housing demand across regions. Our framework fills this gap by jointly modeling climate risk, property insurance contracts, and endogenous spatial sorting in equilibrium.

The model generates realistic property insurance demand across households and regions. When presented with a menu of insurance premiums and coverage, demand is highly non-linear in household liquidity, age, and background climate risk. Under-insurance is prevalent at both tails of the wealth distribution. Liquidity constrained households cannot afford insurance and are exposed directly to climate risk, while wealthier households can partially self-insure and avoid directly buying full coverage. Increased climate risk weakens this pattern by reducing sensitivity of insurance demand to household liquidity and increasing average insurance coverage.

We calibrate the model reflect a high-risk region, Florida, and model the rest of the United States as a low-risk region. We use the model as a laboratory to

study three counterfactual experiments that together map out how insurance costs, physical climate risk, and insurance rate regulation shape housing markets and spatial allocation.

In our first experiment, we raise the insurer's cost-of-capital coefficient by 10%, increasing insurance premia uniformly across all coverage levels in both regions. This captures, for example, rising reinsurance costs or tighter regulatory capital requirements. The equilibrium response operates through a selection margin. The population share of the high-risk region contracts as marginal households relocate, yet among those who remain, homeownership rises and average net worth and consumption increase. House prices in the high-risk region rise by 0.7, reflecting a compositional shift toward wealthier incumbent homeowners. Insurance coverage declines in both regions as premia rise while expected climate and non-climate losses remain unchanged.

In our second experiment, we increase the annual probability of a climate disaster in the high-risk region by 10%, which mechanically generates higher insurance premia in that region. Homeownership in Florida falls by 0.70 p.p. and house prices decline by 2.40%, reflecting both reduced within-region housing demand and outward migration. Relative to the first experiment, migration is more pronounced, as this shock falls disproportionately on the high-risk region. Average net worth falls by 7.75% as incumbent homeowners bear higher expected climate costs.

Our final experiment examines cross-subsidization under rate regulation. We suppose a regulator caps insurance premia in the high-risk region at 90% of their unregulated level, with the national insurer offsetting the revenue shortfall through a compensating markup in the low-risk region. The equilibrium effects are striking. The high-risk population share more than doubles, from from 9% to 20%, as artificially suppressed premia attract a large inflow of lower-income renter households into Florida, driving homeownership there down by 31 p.p. In the low-risk region, the compensating markup depresses house prices by 2.6% as housing demand shifts toward Florida, and average net worth of remaining households decreases by 3.4%. The experiment illustrates how rate regulation, intended to make housing more affordable in high-risk areas, can instead generate substantial unintended consequences through spatial reallocation and cross-regional subsidization.

Taken together, the three experiments underscore a key policy insight: the equilibrium effects of rising insurance costs depend critically on their source, as different drivers trigger distinct sorting responses that can amplify or partially offset the direct price effect.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 describes the calibration. Section 4 documents insurance demand patterns in the model. Section 5 presents the three counterfactual experiments: a rise in insurance capital costs, an increase in climate risk, and the introduction of cross-subsidization through rate regulation. Section 6 concludes.

## 1.1 Related Literature

This paper studies how natural disaster risk and property insurance interact to shape modern housing markets. We study how natural disaster risk, which is mostly local, affects aggregate housing markets when property insurance is available and, in turn, how property insurance itself affects the spatial location of households, hence local housing markets, in the presence of climate risk. We contribute to three main strands of the literature.

**Natural Disasters and Housing Markets** First, our work complements the growing literature on natural disasters and housing markets, which is mostly empirical. There is increasing evidence that natural disaster risk affects financial markets in general and housing markets in particular (see, e.g., the surveys by Giglio *et al.* (2021b), who document how climate risk is priced across asset classes and emphasize the role of expectations), and that it has become a first-order consideration for investors and policymakers (Stroebel & Wurgler, 2021).

Existing work using cross-sectional variation across exposed areas to identify the effects of climate risk suggests that exposure varies strongly with geography as well as with housing stock and household types. For example, Bernstein *et al.* (2019) estimate price discounts for sea-level-rise exposure in coastal housing markets in a local and partial-equilibrium empirical design. Baldauf *et al.* (2020) show that climate risk is capitalized into house prices only where beliefs about climate change are stronger (including systematic heterogeneity in beliefs) and Bakkensen & Lint (2022) estimate a dynamic housing-market

framework in which heterogeneous flood-risk beliefs generate sorting and can rationalize mixed evidence on flood-risk capitalization. This directly motivates our equilibrium approach to joint price and location adjustments. Keys & Mulder (2020) document dynamic changes in both housing outcomes and mortgage lending in response to sea-level-rise exposure, which closely relates to our analysis of mortgages and the market-wide consequences of local risk through reallocation. The estimated effects depend on households' preferences for housing services, expectations about future climate risk, and beliefs that differ across demographic and political groups. Financial resources play a key role: income and wealth affect both the ability to insure and to absorb losses, while credit constraints and mortgage contract terms shape households' responses to risk and realized shocks.

Most of these studies identify local average treatment effects by comparing more- and less-exposed areas. We contribute by considering the spillovers across housing markets that arise when households relocate in response to climate risk and endogenous house price adjustments. Existing empirical work also studies different types of climate risk but cannot compare their economic effects on the housing market as a whole. While hurricanes, wildfires, and severe storms act primarily as housing-capital depreciation shocks, extreme heat and sea level rise risk mostly operate through productivity and amenities (Bilal & Rossi-Hansberg, 2025). Our setting allows us to disentangle the effects of *ex ante* climate risk from those of realized climate shocks, including how insurance premia and coverage choices mediate the mapping from risk into housing demand and prices.

**Macroeconomic Models with Climate Risk** Second, our paper adds spatial heterogeneity and detailed property insurance markets to the recent literature on macroeconomic and asset pricing models of climate risk.

Spatial heterogeneity is a first-order feature of the data since climate risk exposure is mostly local. Giglio *et al.* (2021a) develop a benchmark asset-pricing framework for housing valuation with climate risk and carefully model the stochastic process for climate damages, but they study a single location and abstract from housing as both a consumption and an investment good. Compared to Van der Straten (2025), who studies climate change and adaptation in

a macro-finance model with housing, we add property insurance and explicitly model mobility across housing markets as key adjustment margins for heterogeneous households in response to climate change. Our novel setting bridges an important gap in the literature on macro-finance models of climate risk: the lack of an equilibrium housing/asset-pricing model with heterogeneous locations and different exposures that can generate aggregate spillovers from local shocks through migration, insurance costs, and endogenous sorting.

We carefully model property insurance suppliers who offer a menu of coverage and premium options to homeowners. Sastry *et al.* (2025b) study how insurer fragility and climate-related losses interact with mortgage markets and show that insurance market disruptions can transmit to mortgages. We build a structural equilibrium model in which the kink between insurance and mortgage choices arise endogenously through location, tenure, and coverage decisions. Relatedly, Ge *et al.* (2026) estimate the effect of rising homeowners-insurance premiums on mortgage and credit outcomes and show that rising premia spur relocation, which is a migration channel captured in our model. Keys & Mulder (2025) show in large-scale escrow-based premium data that the repricing of catastrophic risk increases premium pass-through and reduced home values in high-exposure areas, which our model also captures in equilibrium. Similarly, Wylie *et al.* (2025) report that insurers can pass disaster costs to policyholders not only through premiums but also through non-price contract dimensions (e.g., claim rejections), including spillovers to unaffected areas.

Gropper & Kuhnen (2025) study how wealth affects insurance choices in the context of life insurance (coverage and deductibles) and document that wealthier households purchase more coverage, which we use to discipline the heterogeneity in coverage and the extent to which insurance can attenuate or amplify housing market responses to risk. The theoretical foundations for this wealth-insurance gradient are developed by Rampini & Viswanathan (2022), who show in a dynamic model with collateral constraints that insurance is globally increasing in household net worth: households must finance premia upfront and, when collateral is scarce, are unable to obtain full coverage, generating precautionary underinsurance that is most severe for wealth-constrained households and amplified in equilibrium by collateral scarcity. In our life-cycle setup, where retired households optimally decumulate wealth, this gradient

need not be globally monotone: sufficiently wealthy retirees with declining asset positions may reduce coverage, attenuating or reversing the positive wealth-insurance relationship at the top of the distribution."

For property insurance and its pricing of climate risk, we build on the analysis of rate regulation and cross-subsidies in Oh *et al.* (forthcoming) to motivate our treatment of insurance pricing as shaped by both risk and institutional features rather than actuarially fair pricing alone. Our treatment of insurance pricing builds on the capital-frictions framework of Koijen & Yogo (2015) and Koijen & Yogo (2016), who show that insurance premia include a capital wedge arising from regulatory and financial frictions. We extend this logic to property insurance markets, where capital requirements are tied to catastrophe tail risk and reinsurance costs, generating nonlinear pricing in coverage. Relatedly, Sastry *et al.* (2025a) document an "insurance protection gap," and demand elasticities using microdata on homeowners insurance, which we seek to explain in a model in which insurance interacts with mobility and housing prices in equilibrium. Finally, Eastman *et al.* (2024) estimate the effect of homeowner insurance price increases on housing prices using regulatory variation in Florida, which offers an empirical benchmark for the magnitude of the insurance-price capitalization channel we quantify in a structural model.

In terms of modeling, our work most closely relates to Bilal & Rossi-Hansberg (2025), who analyze how various U.S. regions respond to anticipated climate change in a high-dimensional spatial quantitative model. While they focus on the macroeconomic consequences of climate risk, we analyze its implications for housing and mortgages—households' largest assets and liabilities—in the presence of property insurance. We add to this literature by calibrating a structural model with housing, property insurance, and spatial sorting. Our equilibrium model with endogenous location and insurance choices, and price adjustments, allows us to quantify the respective importance of the various channels documented in isolation in the data—out-migration following risk reassessments or disasters, premium growth (including from reinsurance repricing), insurer exit/market distress and contract non-price adjustments, and changes in mortgage outcomes and constraints—and to trace how these channels interact once households reallocate across regions and marginal buyers change endogenously.

Three ingredients in our model are key to accurately capturing the spatial equilibrium consequences of climate risk. First, the model features heterogeneous local exposure to climate shocks across geographic areas, with climate risk following a state-of-the-art specification used in quantitative macroeconomic models (Bilal & Rossi-Hansberg, 2025). We solve the model at an annual frequency to capture migration, insurance adjustment, and housing market dynamics, which substantially increases the dimensionality of the state space. To address this challenge, we introduce a new recursive formulation of the discrete choice problem governing household location and tenure decisions.

Second, we introduce Epstein–Zin preferences that allow for a separation between risk aversion and intertemporal substitution, and capture households' preference for early resolution of uncertainty. This feature is essential to match how natural disaster risk is priced into housing markets even in the absence of realized shocks.

Third, we introduce a nested CES aggregator between non-durable consumption and housing services within households' Epstein–Zin preferences. This structure captures the trade-offs households face between consumption and housing quality in the presence of climate risk, especially when households can insure housing services at the cost of higher premia and reduced non-durable consumption. Together, these ingredients allow us to provide a unified quantitative framework that links climate risk, property insurance, household sorting, and housing prices in a spatial general equilibrium setting.

**Models of Spatial Housing and Mortgage Markets** Finally, our work contributes to the literature on spatial housing and mortgage market models by analyzing how regional heterogeneity shapes aggregate responses to shocks. Beraja *et al.* (2019) study how regional heterogeneity in the distribution of borrowers' home equity shapes the entire economy's response to monetary policy shocks. Hurst *et al.* (2016) show that mortgage-market institutions can generate large redistribution across U.S. regions and result in substantial cross-subsidization across housing and mortgage markets. Guren *et al.* (2020) show that cross- regional estimates mix partial-equilibrium responses with local general-equilibrium effects in response to area-specific shocks, and propose a method to recover partial-equilibrium effects in various settings. Our spatial macro-

finance model complements their work by allowing us to separate the effects of local from those of aggregate shocks. Mabille (2023) uses a related model with regional heterogeneity but without climate risk and insurance and shows that an aggregate shock, in that case to credit conditions, can generate heterogeneous local housing responses even when local shocks are identical, underscoring the importance of decomposing the various types of shocks. Fonseca *et al.* (2025) extend this setting into a spatial housing ladder model to study the dynamic impact of mortgage lock-in, but they also abstract from climate risk and property insurance, which are two major features of modern housing markets.

# 2 Model

This section presents a dynamic spatial housing model with climate risk and property insurance. We first describe locations and their risk exposure before detailing households' tenure and location choice problems, insurance companies, and finally housing supply. We then define the recursive competitive equilibrium that jointly determines household allocations, insurance outcomes, and house prices in each region.

## 2.1 Locations

There are $N_\ell$ locations in the model indexed by $\ell \in \{1, 2, ..., N_\ell\}$. Each location has amenities for owners, $\Xi_{\ell O}$, and amenities for renters, $\Xi_{\ell R}$.

### 2.1.1 Property Damage and Climate Risk

Properties are subject to two sources of damage each period. First, all properties in every region experience baseline property damage $d_{\text{base}}$ drawn i.i.d. from a Beta distribution scaled to the interval $[0, \bar{d}]$:

$$d_{\text{base}} \sim \text{Beta}(\alpha_{\text{base}}, \beta_{\text{base}}) \text{ on } [0, \bar{d}].$$

This baseline damage captures routine depreciation events such as minor weather damage, wear-and-tear, and other property risks unrelated to major climate disasters.

Second, properties in each region $\ell$ face a climate disaster shock. Each period, there is a region-specific probability $p_\ell$ that a climate disaster occurs, destroying an additional fraction $\chi_\ell$ of the housing stock. Climate disaster shocks are i.i.d. over time and across regions.

Total property damage in region $\ell$ in a given period is the sum of baseline damage and the climate disaster component:

$$d_{\text{total},\ell} = d_{\text{base}} + \chi_\ell \cdot \mathbb{1}_{\text{disaster},\ell},$$

where $\mathbb{1}_{\text{disaster},\ell} = 1$ with probability $p_\ell$ and $0$ otherwise. Effective housing quality evolves according to the household's insurance coverage $\phi'$ and the realized total damage:

$$\omega' = [1 - (1 - \phi') \cdot d_{\text{total},\ell}]\, \omega.$$

Full insurance coverage, $\phi' = 1$, fully protects against both sources of damage and maintains housing quality. Partial coverage exposes the household to uninsured losses from both layers.

#### 2.1.1.1 Household-Specific Exposure and Insurance

In a more general version of the model, the climate disaster component may include a household-specific exposure factor, $\lambda_i$, so that $\chi_{i,\ell} = \lambda_i \chi_\ell$. This captures heterogeneity in household behavior with respect to climate risk mitigation. For example, within a region exposed to wildfire risk, households may vary in their propensity to trim tree branches and lessen their exposure. The factor $\lambda_i$ may be public or private information, which is important for adverse selection in insurance pricing. When $\lambda_i$ is endogenously chosen by the household, insurers must also consider the impacts of moral hazard. In the benchmark version of the model, $\lambda_i = 1$ for all households, is publicly observable and exogenous, and thus insurance markets are efficient.

## 2.2 Households

Households make location and tenure decisions in each period. We define generic location-specific value functions that are used by both homeowners and renters in evaluating their options of whether to move or remain in their current location/tenure. In other words, these are unconditional value functions which

depend generically on household wealth, income, and age, but not on their current location/tenure. In what follows, we assume there are $N_\ell = 2$ locations, denoted by the household's current location, $\ell$, and the other location, $\ell'$.

### 2.2.1 Preferences and Income

Households have Epstein-Zin preferences that separate risk aversion from the elasticity of intertemporal substitution:

$$V_t(S) = \left( u_t^{1-\rho} + \beta \left( \mathbf{E}_t \left[ V_{t+1}(S')^{1-\gamma} \right] \right)^{\frac{1-\rho}{1-\gamma}} \right)^{\frac{1}{1-\rho}},$$

where $\gamma$ is the coefficient of relative risk aversion, $1/\rho$ is the elasticity of intertemporal substitution $\beta$ is the subjective discount factor and $S_t$ is the state space that we describe below. The flow utility function is a CES aggregator of consumption $c$ and effective housing services:

$$u_t(c, \tilde{h}, \Xi_{\ell\tau}) = \left( (1-\alpha) c^\epsilon + \alpha \tilde{h}^\epsilon \right)^{1/\epsilon} + \Xi_{\ell\tau},$$

where $\alpha$ governs the preference for housing services, $\epsilon$ determines the elasticity of substitution between consumption and housing, and $\Xi_{\ell\tau}$ is an amenity shifter specific to location $\ell$ and tenure $\tau \in \{O, R\}$. The substitutability between consumption and housing is important for the insurance channel: when a climate shock lowers housing quality, households can partially smooth utility by substituting toward consumption.

Households receive idiosyncratic income that varies over the life cycle. Log income for household $i$ of age $t$ in location $\ell$ is:

$$\log Y_{i,t,\ell} = \alpha_i + g(t) + z_{i,t,\ell},$$

where $\alpha_i$ is a household fixed effect, $g(t)$ is a deterministic age profile, and $z_{i,t,\ell}$ is a persistent stochastic component following an AR(1) process:

$$z_{i,t,\ell} = \rho_z z_{i,t-1,\ell} + \varepsilon_{i,t}, \quad \varepsilon_{i,t} \overset{iid}{\sim} \mathcal{N}(0, \sigma_\varepsilon^2).$$

Retired households receive a deterministic income that is a fraction of their pre-retirement earnings.

### 2.2.2 Generic Location-Specific Value Functions

Within each location, households can either be homeowners or renters. We define three location-specific value functions for households: the value from living in an owner-occupied home in the location, the value from purchasing a new home in the location, and the value from renting in the location. In the next section, these three value functions will be used to build up the rest of the household's decision tree.

#### 2.2.2.1 Inactive Homeowner: Living in Location

A homeowner living in location $\ell$ has state variables cash-on-hand $X$, mortgage balance $M$, effective housing quality $\omega$, and the persistent component $z$ of the (log) income process. Letting $S = \{X, M, \omega, z\}$, an inactive homeowner $\tilde{O}$ in region $\ell$ chooses consumption and property insurance to maximize the value function:

$$V_t^{\ell\tilde{O}}(S) = \max_{c_t^{\ell\tilde{O}}(S), \phi'^{\ell\tilde{O}}(S)} u(c_t^{\ell\tilde{O}}(S), \omega h_\ell, \Xi_{\ell O}) + \beta E V_{t+1}^{\ell O}(X', M', \omega', z'),$$

subject to the budget constraint:

$$c_t^{\ell\tilde{O}}(S) + p_\ell(\phi'^{\ell\tilde{O}}(S)) p_{h,\ell} \omega h_\ell + (1 - \lambda + r_M) M + \frac{s}{1+r} = X.$$

The total insurance expenditure, $p_\ell(\phi'^{\ell\tilde{O}}(S)) p_{h,\ell} \omega h_\ell$, is the product of the per-unit price $p_\ell(\phi)$, which depends on the chosen coverage level, and the effective home value $p_{h,\ell}\omega h_\ell$. The continuation value function, $V_{t+1}^\ell$, will be defined below. Rearranging the budget constraint implies that saving is equal to the income from cash-on-hand minus expenditures:

$$s = (1+r)(X - c_t^{\ell\tilde{O}}(S) - p_\ell(\phi'^{\ell\tilde{O}}(S)) p_{h,\ell} \omega h_\ell - (1 - \lambda + r_M) M).$$

Future cash-on-hand combines saving with exogenous income:

$$X' = Y' + s = Y' + (1+r)(X - c_t^{\ell\tilde{O}}(S) - p_\ell(\phi'^{\ell\tilde{O}}(S)) p_{h,\ell} \omega h_\ell - (1 - \lambda + r_M) M),$$

where $Y'$ is a combination of deterministic and stochastic components of income, including $z'$. Mortgage balances decrease by the principal payment:

$$M' = M - (1 - \lambda) M = \lambda M.$$

Finally, effective housing quality evolves according to the endogenous insurance choice and the realized total property damage:

$$\omega' = [1 - (1 - \phi_t'^{\ell\tilde{O}}(S)) \cdot d_{\text{total},\ell}]\omega.$$

#### 2.2.2.2 Active Homeowner: Purchase New Home

We next define a generic value function, $V^{\cdot,\ell O}$, for a household $O$ that purchases a new home in location $\ell$, regardless of it's current location or homeownership status (e.g., currently a renter or currently a homeowner that will sell its existing home and purchase another, whether within or across locations). The only relevant state variables are the current cash-on-hand $X$ and the persistent component $z$ of its income process.

The generic household's choice variable is the size of the mortgage used to finance the new home cost, $p_{h,\ell}h_\ell$. The new LTV $\theta_{LTV}^{\cdot,\ell O}$ is chosen subject to an exogenous LTV limit $\bar{\theta}_{LTV}$ and a payment-to-income ratio $\bar{\theta}_{PTI}$, measured as:

$$\frac{(1 - \lambda + r_M)\theta_{LTV}^{\cdot,\ell O} p_{h,\ell}h_\ell}{\tilde{Y}} \leq \bar{\theta}_{PTI},$$

with $\tilde{Y} = \exp(\alpha_i + g(t) + z)$. Combining these implies that the maximum loan size is bounded above by the tighter of the two constraints:

$$\theta_{LTV}^{\cdot,\ell O} \leq \min\left\{\bar{\theta}_{LTV}, \left(\frac{(1 - \lambda + r_M)p_{h,\ell}h_\ell}{\tilde{Y}}\right)^{-1} \bar{\theta}_{PTI}\right\}.$$

For a given LTV, the required mortgage is $\theta_{LTV,t}^{\cdot,\ell O} p_{h,\ell}h_\ell$, and the required downpayment is $(1 - \theta_{LTV}^{\cdot,\ell O})p_{h,\ell}h_\ell$, Further, the household pays variable and fixed buying fees, $f_{b,\ell}$ and $F_{b,\ell}$. In total, the household's available cash-on-hand net of these fees defined as:

$$\tilde{X}^{\cdot,\ell O} = X - (1 - \theta_{LTV}^{\cdot,\ell O} + f_{b,\ell})p_{h,\ell}h_\ell - F_{b,\ell}.$$

Altogether, the problem of purchasing a new home is equivalent to the problem of choosing an LTV and then remaining inactive in that home:

$$V_t^{\cdot,\ell O}(X, z) = \max_{\theta_{LTV,t}^{\cdot,\ell O}(X,z)} V_t^{\ell\tilde{O}}(\tilde{X}^{\cdot,\ell O}, \tilde{M}^{\cdot,\ell O}, 1, z),$$

with $\tilde{M}^{\cdot,\ell O} = \theta_{LTV,t}^{\cdot,\ell O}(X, z)p_{h,\ell}h_\ell$ and the effective housing quality for the new home is one.

#### 2.2.2.3 Renter: Living in Location

The renter $\tilde{R}$ living in location $\ell$ has state variables cash-on-hand $X$ and the persistent component $z$ of the income process. The renter chooses consumption and the rental size to maximize the value function

$$V_t^{\ell\tilde{R}}(X,z) = \max_{c_t^{\ell\tilde{R}}(X,z), h_t^{\ell\tilde{R}}(X,z)} u(c_t^{\ell\tilde{R}}(X,z), h_t^{\ell\tilde{R}}(X,z)\cdot h_\ell, \Xi_{\ell R}) + \beta E V_{t+1}^{\ell R}(X',z'),$$

with $h_t^{\ell\tilde{R}}(X,z) \in [\underline{h}^R, \bar{h}^R]$ and subject to the budget constraint:

$$c_t^{\ell\tilde{R}}(X,z) + p_{r,\ell} h_t^{\ell\tilde{R}}(X,z) h_\ell + \frac{s}{1+r} = X.$$

The location-specific rental rate, $p_{r,\ell}$, is the user cost of capital:

$$p_{r,\ell} = (r + \omega_{r,\ell} p_\ell(1) + \phi^{R,\ell}) p_{h,\ell},$$

where $\omega_{r,\ell}$ is the pass-through from landlords to tenants on the full coverage insurance price, $p_\ell(1)$, and $\phi^{R,\ell}$ is an additional rent premium. Future cash-on-hand combines future income and net savings after the household's choices for consumption and rental housing:

$$X' = Y' + (1+r)(X - c_t^{\ell\tilde{R}}(X,z) - p_{r,\ell} h_t^{\ell\tilde{R}}(X,z)).$$

## 2.3 Spatial and Tenure Decisions

We now turn to the household's joint discrete decision of where to live and whether to own or rent. Using the location-specific values for ownership and renting from the last section, we model the decision of a homeowner and renter currently living in location $\ell$.

### 2.3.1 Homeowner

Consider a household entering the period as a homeowner. This household faces a menu of choices regarding homeownership. First, it can choose to remain in the same home, meaning it is inactive in the housing market. Alternatively, it sells its home and faces two options in each location: buy a new home or rent. So with $N_\ell$ locations, the homeowner has $2N_\ell + 1$ options to consider.

We first consider the several options faced by a homeowner $O$ in location $\ell$. First, the homeowner may remain inactive ($\tilde{O}$), opting to live in the same home in the same location. Second, the homeowner may move to a new home, either as a renter or homeowner, in any location, including its current location. Let $L = \{\ell_1, \ell_2, \ldots, \ell_{N_\ell}\}$ denote the set of all locations, including the current location $\ell \in L$. The household's envelope value function is given by the maximum over all options:

$$V_t^{\ell O}(S) = \max\{V_t^{\ell\tilde{O}}(S), V_t^{\ell O,\ell_1}(S), V_t^{\ell O,\ell_2}(S), \ldots, V_t^{\ell O,\ell_{N_\ell}}(S)\}.$$

The first option is to be inactive in housing markets and remain in both the same location and house. The other options entail moving to a different home. Consider a location $\ell' \in L$, which we refer to as another location but may be the same as the current location. The function $V_t^{\ell O,\ell'}$ denotes the value of moving from being a homeowner $O$ in location $\ell$ to location $\ell'$. Within location $\ell'$, the household further decides to purchase a home or become a renter:

$$V_t^{\ell O,\ell'}(S) = \max\{V_t^{\ell O,\ell' O}(S), V_t^{\ell O,\ell' R}(S)\}.$$

In both cases, the household sells its current home in $\ell$ for $p_{h,\ell}\omega$, subject to fixed and proportional selling fees $F_{s,\ell}$ and $f_{s,\ell}$. Net of mortgage prepayment, total proceeds from the home sale are given by $(1-f_{s,\ell})p_{h,\ell}\omega h_\ell - F_{s,\ell} - M$, where $M$ is the current mortgage balance. We therefore define new cash-on-hand for the household leaving homeownership in location $\ell$ as:

$$\tilde{X}^{\ell O,\cdot} = X + (1 - f_{s,\ell})p_{h,\ell}\omega h_\ell - F_{s,\ell} - M.$$

#### 2.3.1.1 Stay in Current Home

The first option $V_t^{\ell\tilde{O}}(S)$ defined above is the value of the homeowner living in the current location. This is the choice to be inactive in housing markets and remain in both the same home and location.

#### 2.3.1.2 Owner in New Home

The homeowner in location $\ell$ considers purchasing a new home in $\ell'$. Moving entails a utility cost $\Psi(\ell O, \ell' O)$ and a financial cost $\psi(\ell O, \ell' O)$. This general

formulation allows for the case where $\ell' = \ell$, i.e., the homeowner moves to a different house in the same location.

Using the new definition of cash-on-hand with net home proceeds and the generic home purchase value function defined above, we can write the problem of a homeowner in location $\ell$ purchasing a new home in location $\ell'$ as:

$$V^{\ell O,\ell' O}(S) = V^{\cdot,\ell' O}(\tilde{X}^{\ell O,\cdot} - \psi(\ell O, \ell' O), z) - \Psi(\ell O, \ell' O).$$

To see this, recall that cash-on-hand in the generic purchase value function for location $\ell'$ is defined as:

$$\tilde{X}^{\cdot,\ell' O} = X - (1 - \theta_{LTV}^{\cdot,\ell' O} + f_{b,\ell'}) p_{h,\ell'} h'_{\ell} - F_{b,\ell'}.$$

Then, using the cash-on-hand net of proceeds from a home sale in location $\ell$ and subtracting the financial cost of moving, we can define:

$$\begin{aligned} X^{\ell O,\ell' O} &\equiv \tilde{X}^{\cdot,\ell' O} | \tilde{X}^{\ell O,\cdot} - \psi(\ell O, \ell' O) \\ &= X + (1 - f_{s,\ell}) p_{h,\ell} \omega h_{\ell} - F_{s,\ell} - M - (1 - \theta_{LTV}^{\cdot,\ell' O} + f_{b,\ell'}) p_{h,\ell'} h'_{\ell} - F_{b,\ell'} - \psi(\ell O, \ell' O). \end{aligned}$$

Altogether, cash-on-hand is initial cash holdings plus proceeds from the current home sale, less outlays for the new home sale and moving costs.

#### 2.3.1.3 Become a Renter

When the homeowner in location $\ell$ considers becoming a renter in $\ell'$, moving entails a utility cost of $\Psi(\ell O, \ell' R)$ and a financial cost of $\psi(\ell O, \ell' R)$.

Using the value function of a renter living in location $\ell'$, the value from becoming a renter is given by:

$$V_t^{\ell O,\ell' R}(S) = V_t^{\ell' \tilde{R}}(\tilde{X}^{\ell O,\cdot} - \psi(\ell O, \ell' R), z) - \Psi(\ell O, \ell' R).$$

## 2.4 Renter

Consider instead a household entering the period as a renter. A renter will have the option to remain a renter or to buy a home. These options are present in every location, including the current location, and thus the renter has $N_{\ell}$ options to consider.

A renter in location $\ell$ considers moving to a new home in every location, including the one in which they currently rent:

$$V_t^{\ell R} = \max\{V_t^{\ell R,\ell_1}, V_t^{\ell R,\ell_2}, \ldots, V_t^{\ell R,\ell_{N_\ell}}\}.$$

Unlike the homeowner, there is no explicit option to remain inactive in the current home, as the renter can simply choose to rent the same or a different unit in the same location.

As above, consider a location $\ell' \in L$, which we refer to as another location but may be the same as the current location. The function $V_t^{\ell R,\ell'}$ denotes the value of a renter moving from location $\ell$ to location $\ell'$. Within location $\ell'$, the household further decides to purchase or rent a home:

$$V_t^{\ell R,\ell'}(S) = \max\{V_t^{\ell R,\ell' O}(S), V_t^{\ell R,\ell' R}(S)\}.$$

When $\ell = \ell'$, the renter considers remaining a renter in the same location or becoming a homeowner in the same location.

### 2.4.1 Homeownership

The renter in location $\ell$ considers purchasing a new home in $\ell'$. Moving from renting in $\ell$ to owning a home in $\ell'$ incurs a utility cost of $\Psi(\ell R, \ell' O)$ and a real cost of $\psi(\ell R, \ell' O)$. We can then use the generic purchase value function in $\ell'$ to write the renter's problem as:

$$V_t^{\ell R,\ell' O}(X, z) = V^{\cdot,\ell' O}(X - \psi(\ell R, \ell' O), z) - \Psi(\ell R, \ell' O).$$

### 2.4.2 Renting

When the renter in location $\ell$ considers renting in $\ell'$, moving entails a utility cost of $\Psi(\ell R, \ell' R)$ and a financial cost of $\psi(\ell R, \ell' R)$. Using the value function of a renter living in location $\ell'$, the value from a renter in $\ell$ renting in $\ell'$ is given by:

$$V_t^{\ell R,\ell' R}(X, z) = V_t^{\ell' \tilde{R}}(X - \psi(\ell R, \ell' R), z) - \Psi(\ell R, \ell' R).$$

## 2.5 Insurance Companies

### 2.5.1 Private Insurance Company

A representative national insurance company supplies insurance contracts in each location. The per-unit price of insurance in location $\ell$ for a household choosing coverage $\phi$ is:

$$p_\ell(\phi) = \frac{1 + \kappa(\phi)}{1 - \mu} \cdot p_{A,\ell},$$

where $p_{A,\ell}$ is the actuarially fair value of insurance, $\mu \geq 0$ defines a constant markup, and $\kappa(\phi)$ is a coverage-dependent capital charge. The actuarially fair price reflects both layers of the property damage process:

$$p_{A,\ell} = E[d_{\text{base}}] + p_\ell \cdot \chi_\ell,$$

where $E[d_{\text{base}}] = \bar{d} \cdot \alpha_{\text{base}}/(\alpha_{\text{base}} + \beta_{\text{base}})$ is the expected baseline property damage. This implies that even regions with no climate disaster risk ($p_\ell = 0$) have positive insurance costs reflecting baseline property damage. The coverage-dependent capital charge is:

$$\kappa(\phi) = c \cdot \phi^\eta,$$

with $c > 0$ and $\eta > 1$. The formulation nests actuarially fair pricing ($c = 0$, $\mu = 0$) as a special case.

This reduced-form specification is motivated by the framework developed in Koijen & Yogo (2015) and Koijen & Yogo (2016), in which insurance premia reflect actuarial losses, competitive structure, and a capital wedge arising from regulatory and financial frictions. Under NAIC risk-based capital (RBC) standards, insurers must hold capital reserves proportional to their underwritten exposure. The parameter $c$ reflects the cost of regulatory capital that insurers must hold per unit of coverage-weighted exposure, including cost-of-capital spread, the opportunity costs of holding reserves, frictional costs such as taxes, and origination costs. These costs are passed through to policyholders as a loading above the actuarily fair price.

Primary insurers typically transfer catastrophe exposure through layered reinsurance structures ("reinsurance towers"), with higher layers priced at increasing rates (Froot, 2001). We capture this institutional feature in reduced

form through the curvature parameter $\eta$, which governs how capital and reinsurance costs scale with coverage. As insured limits rise, insurers must obtain additional protection in higher layers and hold more capital against tail exposure. Values $\eta > 1$ allow marginal costs to rise with coverage, consistent with capital requirements, concentration penalties in regulatory and rating-agency models, and the pricing structure of layered reinsurance contracts.

## 2.6 Housing Supply

In each region, the supply of owner-occupied housing is measured in square feet and depreciates at a constant rate $\delta_\ell$. Total supply in the current period also includes new construction funded by exogenous, perfectly competitive developers:

$$H^{\ell}_{S,t} = (1-\delta)H^{\ell}_{S,t-1} + I^{\ell}_{S,t}. \tag{1}$$

We assume that new housing construction in $\ell$ is supplied according to a reduced-form function of the house price, which captures developers' incentives to build:

$$I^{\ell}_{S,t} = \overline{I}^{\ell}_{S} \times p^{\rho_\ell}_{h,\ell}, \tag{2}$$

where $\overline{I}^{h}_{S}$ is a vertical supply curve shifter and $\rho_h$ is the price elasticity of housing supply, which both differ between combinations of housing statuses and location $h$. The lower $\overline{I}^{h}_{S}$, the higher the house price required to construct a given level of housing. The lower $\rho_h$, the larger the price change required to induce a given change in construction. The supply function can be micro founded using the optimization problem of perfectly competitive developers.

## 2.7 Equilibrium

A dynamic spatial recursive competitive equilibrium describes how the economy in steady state responds to unanticipated local shocks. Given exogenous time paths for unanticipated local climate shocks $\{\chi^{\ell}_{t}\}$, an equilibrium consists of the following sequences for locations $\ell \in L$:

(i) prices for owner-occupied and rental housing $\{p_{h,\ell,,t}, p_{r,\ell,t}\}$;

(ii) value functions for homeowners and renters $\{V^{\ell O}_{t}, V^{\ell R}_{t}\}$;

(iii) policy functions describing non-durable consumption, rental housing services, and homeowner insurance $\{c_t^{h,h'}, h_t^{h,h'}, \theta_{LTV,t}^{h,h'}, \phi_t^{'h,h'}\}$ for each possible household transition $h, h' \in \{O, R\} \times L$ between owner-occupied or rental housing, $O$ or $R$, in location $\ell$.

(iv) a law of motion for the cross-sectional distribution of households $\lambda_t$ across locations, housing statuses, and individual states,

such that households optimize given prices, the law of motion for the distribution of households is consistent with their individual choices market and prices, and house prices are such that housing markets clear.

### 2.7.1 Insurance Companies

Let $\Omega_t^{\ell h}$ denotes the set of households with combination of housing status $h \in \{O, R\}$ and location $\ell \in L$ at date $t$, and let $\mathcal{M}_t^{\ell h} = \int_{\Omega_t^{\ell h}} di$ denote the mass of such households. In spatial equilibrium, this set depends on the entire vector of house prices and rents in all possible housing combinations because of endogenous sorting.

#### 2.7.1.1 Private Insurance Companies

In each location, the private insurer receives revenues from contracts purchased in the current period and makes insurance payments for contracts purchased in the previous period:

$$\pi_\ell = p_\ell \left( \mathcal{M}_{t+1}^{\ell R} + \int_{\Omega_{t+1}^{\ell O}} \phi_i' \omega_i di \right) - \chi_\ell \left( \mathcal{M}_t^{\ell R} + \int_{\Omega_t^{\ell O}} \phi_i \omega_i di \right).$$

where $\mathcal{M}^{\ell R}$ represents rental properties, all of which have mandated full insurance, while across the distribution of homeowners, $\Omega^{\ell h, \phi}$, the level of coverage is an endogenous choice. Total profit for the private insurer is the sum of profits across all locations:

$$\Pi = \sum_{\ell \in \mathcal{L}} \pi_\ell.$$

#### 2.7.2 Housing markets.

Market-clearing for owner-occupied housing in each of the $N_\ell$ housing markets is given is given by:

$$\int_{\Omega_t^{\ell O}} \omega_i h_\ell di = H_{S,t}^\ell, \tag{3}$$

where housing demand depends on the effective stock of housing and $H_{S,t}^\ell$ is the supply of housing in region $\ell$. Rental units are perfectly elastically supplied at the rental price defined above as a function of house prices.

# 3 Calibration

## 3.1 Parameters

We organize the model parameters into three parts in Table 1. The first set of parameters are common to macroeconomic and asset pricing models with housing (Panel A). The last two sets of parameters are unique to our housing market model with climate risk and insurance. They are related to climate risk and insurance (Panel B), and geographic heterogeneity (Panel C). A subset of the parameters are calibrated externally, while the remaining parameters are chosen to match empirical targets in the data, as indicated in the last column of the table. One model period corresponds to one year and targets are in annual terms.

**Preferences, income, mortgages and housing.** The utility function is Epstein-Zin with a subjective discount factor of 0.95, a coefficient of risk aversion $\gamma$ = 5 and elasticity of intertemporal substitution of 0.5. These are standard values in the asset pricing literature. We set the preference for housing coefficient to 0.4 as in Favilukis *et al.* (2023). The income parameters are from Kaplan & Violante (2022). We set the maximum LTV and PTI limits at mortgage origination to those of Greenwald (2018). We set rental premiums to match average price-to-rent ratios in the two regions. We give more details when we describe Table 2.

**Regional heterogeneity.** In our baseline calibration, we consider Florida as a coastal state with high climate risk and the rest of the U.S. as a second low-risk

region. As described in Table 2 , the model's endogenous choices are disciplined by several sets of parameters to generate rich geographic heterogeneity between low- and high- climate risk exposure areas. We calibrate age-dependent amenity shifters to target 10% population share in the U.S. and the utility cost of moving to match the average migration rate between Florida and the rest of the U.S. We set homeowner-specific amenities to target average homeownership rates over the lifecycle. Finally, the housing supply levels are calibrated to match average home prices in each region and the elasticities estimation follow Baum-Snow & Han (2024).

**Property damage, climate risk and insurance.** We model two layers of property damage against which households can purchase insurance. Baseline property damage is drawn each period from a Beta distribution on $[0, \bar{d}]$ with $\bar{d} = 0.05$, $\alpha_{\text{base}} = 1$, and $\beta_{\text{base}} = 12.08$, implying an expected baseline damage of approximately 0.38% of home value per year. On top of this, climate disaster risk is characterized by the annual probability of a climate shock and the conditional loss given a shock. Climate risk can take many forms, including severe storms, heatwaves, floods, or wildfires. We calibrate the probability of a climate disaster in the high-risk region to be 8%, following Bilal & Rossi-Hansberg (2025) estimates of probability of a 1-in-50 year storm following a 1 degree increase in temperature relative to 1920. We calibrate the conditional loss following a climate disaster to be 17% of the house value, following Bilal & Rossi-Hansberg (2025) estimate of capital depreciation following a large storm. In the baseline calibration, the rest of the U.S. has zero climate disaster probability ($p_\ell = 0$), but properties in this region still face baseline property damage risk.

We set insurance coverage choices to range from $\underline{\phi} = 30\%$ (severely underinsured) to $\bar{\phi} = 100\%$ (full coverage). We calibrate the insurance supply parameters to jointly to match the average U.S. insurance premium paid by homeowners and the empirical distribution of coverage demand. These two objects naturally depend on one another since average premiums are determined by the product of coverage demanded times the insurance cost of give coverage. Importantly, we calibrate a convex price schedule with rising marginal costs, consistent with regulatory requirements around holding concentrated geographic risk in a given region. We assume that renters' landlords fully pass on insurance costs to the rental price of housing.

## 3.2 Baseline Results

Similar to the parameters, we report the model results into three parts in Table 2. The first part is common to other models and describes key housing moments (Panel A). The last two parts are unique to our housing market model with climate risk and insurance. They center on climate risk and insurance (Panel B), and geographic heterogeneity (Panel C).

The data moments for income, population shares, and homeownership rates are drawn from the American Community Survey (ACS). We construct a panel of U.S. metropolitan statistical areas (MSAs) at the MSA–year level and use the most recent year available, 2024. We then aggregate these measures for Florida and for the rest of the United States (excluding Florida) by grouping all Florida MSAs and all non-Florida MSAs, respectively, and weighting each variable by population. Average house prices and rents are from Zillow Home Value Index and Zillow Rent Index respectively. Zillow reports these statistics at the MSA level, that we merge with our ACS panel.

Migration data are also drawn from the American Community Survey and are directly available at the state level. To construct gross migration rates between the two regions, we compute a population-weighted average of migration flows from Florida to the rest of the United States and from the rest of the United States to Florida. Specifically, flows are weighted by the population of the destination region, so that migration into larger areas receives greater weight. This measure captures the relative attractiveness of each region and can be interpreted as an average in-migration rate weighted by destination population.

Table 2 reports a detailed comparison between data moments and their model counterparts across the three groups of targets (aggregate, climate risk and insurance and geographic heterogeneity). Average income in the data is \$82.7 thousand, similar to the model value of \$87.2 thousand. The model matches housing affordability reasonably well: the average house price–to–income ratio is 6.06 in the data versus 5.76 in the model, and the rent–to–income ratio is 0.25 in the data compared with 0.24 in the model.

The model implies substantial heterogeneity in climate-shock losses across regions. Conditional losses from a climate shock are modest in low-exposure

areas (-3.9%) but much larger in high-exposure areas (-24.3%). Average insurance coverage in the data is 70% (Sastry *et al.*, 2025a), while the model generates a slightly lower average coverage rate of 59%.

The average annual moving rate between areas is 2.2% in the data and 2.0% in the model. Population shares are concentrated in low-exposure areas ("rest of the U.S.", with 93% in the data and 90% percent in the model, leaving 7% percent and 10% percent, respectively, in high-exposure areas. The model closely matches housing prices by exposure: average house prices are $512 thousand in low-exposure areas and $407 thousand in high-exposure areas in both the data and the model. Rents are also similar, with low-exposure monthly rents of $1,740 per month in the data versus $1,742 in the model, and high-exposure rents of $1,917 in the data compared with $2,055 in the model.

Finally, Figure 1 plots income (Panel A) and wealth (Panel B) over the life-cycle. Wealth is total household net-worth, meaning that it include home equity. More importantly, Panel C plots average homeownership rate over the life-cycle both in the model and in the data.

# 4 Demand for Property Insurance

We begin by examining the determinants of insurance demand in our model. Figure 2 plots the unconditional distribution of coverage endogenously chosen by homeowners. The vast majority of households do not hold full insurance, implying that a natural disaster would not be fully covered by their insurer. Insurance demand peaks around 70% coverage and there is a significant mass of households severely underinsured. To understand why some households hold nearly-full coverage while others are several uninsured, figures 3 and 4 illustrate how liquidity, age, and climate risk shape insurance demand.

Panels A and B of Figure 3 plot insurance coverage as a function of liquid wealth, where households in each region are sorted into twenty bins. Two patterns emerge. First, coverage is increasing in liquid wealth, but in a non-linear fashion: liquidity-constrained households exhibit steeper demand responses than their wealthier counterparts, while unconstrained households continue to increase coverage but at a diminishing rate. Second, coverage is uniformly

lower in high-risk regions across the liquid wealth distribution, consistent with higher premiums reducing the value of insurance. A second-order compositional effect reinforces this pattern: wealthier households, who can self-insure, sort into high-risk regions, mechanically depressing average coverage. The figure also reveals endogenous precautionary savings behavior: households in high climate risk regions hold substantially higher liquid wealth on average than those in low-risk regions. These aggregate patterns, however, mask important heterogeneity at the tails of the cash-on-hand distribution, which we examine in the next figure.

The bottom panels plot insurance coverage against age. In both regions, coverage follows a hump-shaped profile over the life cycle, rising from young to middle age before declining. This pattern mirrors the life-cycle trajectory of wealth accumulation: as net worth rises, households demand more insurance, but as they age further, demand declines. Intuitively, insurance serves partly as a savings vehicle, and older households with no bequest motive have limited incentive to insure. Notably, the peak of insurance demand occurs at a later age in high-risk regions than in low-risk regions. This reflects the fact that the marginal value of insurance declines once a household has sufficient liquid wealth to self-insure against a loss, and this threshold is reached later in the life cycle in high-risk regions due to the higher cost of insurance there.

Figure 4 examines the tails of the liquid wealth distribution. The top panels restrict to homeowners in the bottom quintile of cash-on-hand, while the bottom panels restrict to the top quintile. Among liquidity-constrained households, coverage is low, reflecting the fact that purchasing insurance constitutes a transfer of resources from the present to the future. Within this group, however, an important distinction emerges across regions: in the low-risk region, coverage rises steeply with liquid wealth even among the poorest households, whereas in the high-risk region demand is nearly flat, reflecting the substantially higher cost of insurance.

The bottom panels reveal a different pattern at the top of the wealth distribution. Coverage is largely flat across the liquid wealth distribution for wealthy households, with a notable exception at the very top: the wealthiest households demand significantly less insurance than average because these households have sufficient resources to self-insure. As a result, the marginal value of

insurance falls sharply once liquid wealth crosses this self-insurance threshold. This pattern is especially pronounced in high-risk regions, where the incentive to substitute away from costly formal insurance and toward self-insurance is strongest.

# 5 Applications

We use the calibrated model to study three counterfactual experiments each focusing on a different section of the economy: insurance pricing, climate risk, and cross-subsidization under rate regulation. In each experiment, we modify relevant parameters and hold all other parameters fixed at their calibrated values. Each experiment highlights a distinct channel through which climate risk and insurance markets interact with housing markets and spatial allocation.

## 5.1 Insurance Pricing

Our first counterfactual examines how changes in insurance costs affect housing markets and spatial allocation. We increase the insurer cost-of-capital coefficient $c$ by 10 percent. This raises insurance premia at all coverage levels and in all locations proportionally, reflecting, for example, an increase in insurer capital requirements or reinsurance costs.

Table 3 and Figure 5 compare the new equilibrium to the baseline economy. The spatial effects are non-trivial: the population share of Florida declines by 0.05 percentage points, an overall population decline of 0.5% and migration falls slightly ($-0.07$ pp). Within Florida, however, the composition of households shifts. Homeownership rises by 0.86 pp reflecting two effects: first marginal renters, who face full insurance pass-through from landlords, find it relatively more attractive to own and choose their own coverage level and second on average the households that do not move from Florida are wealthier. In particular net worth rises on average by 2.49% and consumption by 2.17%. Effects in the rest of the US are negligible. These compositional shifts are reflected in equilibrium house prices: Florida prices rise by 0.67% as the concentration of wealthier homeowners bids up housing values, while prices in the rest of the US are essentially unchanged ($-0.02\%$).

Figure 5(b) illustrates changes in the distribution of insurance coverage. In the US, the distribution is largely unchanged, with a slight compression toward intermediate coverage levels as higher prices discourage the highest coverage choices. In Florida, the CDF shifts to the right: the share of homeowners choosing low coverage declines, and average coverage increases. This is consistent with the compositional shift toward wealthier homeowners who can afford and choose to maintain higher coverage despite the price increase.

In sum, a 10% increase in the cost-of-capital coefficient produces some spatial reallocation and generates compositional effects within the high-risk region, as higher insurance costs push marginal renters out and concentrate wealthier homeowners.

## 5.2 Climate Risk

Our second counterfactual examines how an increase in climate risk propagates through housing markets when households can insure and relocate endogenously. We increase the probability of a climate disaster shock by 10 percent in the high-risk region while holding all other parameters fixed. The likelihood of a climate shock in Florida increases from 8.0% to 8.8%.

The increase in disaster probability mechanically raises the actuarially fair price of insurance in the high-risk region. As insurance markets are competitive in the benchmark environment, higher expected losses are fully passed through into higher premia. Households respond by adjusting both their insurance coverage, their housing and location tenure decisions.

Table 3 and Figure 6 compare the new equilibrium to the baseline. The higher expected losses raise actuarially fair insurance premia, increasing the cost of homeownership in Florida. Homeownership in the high-risk region falls by 0.72 percentage points as marginal homeowners shift to renting, and average net worth declines by 7.75%, reflecting the higher expected damage costs borne by incumbent homeowners. Average consumption in Florida falls by 4.57% as households devote more resources to insurance or bear larger uninsured losses. The population share of Florida declines by 0.11 percentage points, as some households migrate toward the low-risk region, pushing migration rates up by 0.27 percentage points. In the rest of the US, net worth rises modestly (+0.63%)

and consumption increases (+1.06%) as the region absorbs a small inflow. These channels are reflected in equilibrium house prices: Florida house prices decline by 2.40%, capturing both the capitalization of higher expected climate losses and the reduction in housing demand from outmigration. In the rest of the US, house prices are essentially unchanged (+0.11%).

Figure 6(b) illustrates changes in the distribution of insurance coverage. In the low-risk region, the distribution is essentially unchanged, as neither risk nor prices are directly affected. In Florida, the CDF shifts slightly to the left: the share of homeowners at low coverage levels increases, as higher insurance premia lead some households to reduce coverage. Unlike the insurance pricing counterfactual, there is no offsetting compositional shift toward wealthier homeowners, since homeownership falls rather than rises.

Altogether, a 10% increase in climate disaster probability generates a meaningful house price decline in the affected region ($-2.40\%$) and substantially reduces household wealth and consumption there, but produces only limited spatial reallocation. The welfare cost is borne primarily by incumbent Florida homeowners through lower asset values and higher insurance costs, rather than through large-scale migration.

## 5.3 Cross-Subsidization under Rate Regulation

Our third counterfactual examines cross-subsidization in insurance markets under rate regulation. We suppose that a regulator caps the insurer's price schedule in the high-risk region at a fraction $\lambda \in (0, 1]$ of the baseline schedule:

$$p_r(\phi) = \lambda \cdot p_r^{\text{base}}(\phi).$$

The national insurer compensates by raising a markup $\mu_u > 0$ in the unregulated region to maintain revenue neutrality:

$$p_u(\phi) = \frac{1 + c \cdot \phi^{\eta}}{1 - \mu_u} \cdot p_{A,u}.$$

This setting also approximates the cumulative effect of annual rate-increase caps. In many jurisdictions, insurance regulators cap the annual rate increase that insurers can impose on policyholders. If actuarially fair prices are rising faster than the cap allows, as is the case when climate risk is increasing, then

over time a gap opens between the regulated price and the actuarially fair price. After several years of binding rate caps, the insurer's price schedule in the regulated region is a fraction $\lambda < 1$ of what it would be in an unregulated market.

We set $\lambda = 0.90$, so that Florida insurance prices are 10% below their unregulated baseline. Table 3 and Figure 7 compare the new equilibrium to the baseline. With insurance subsidized by households in the rest of the US, Florida attracts a large inflow of households, more than doubling its population share from 9.9% to 20.3% (+10.4 pp). The migration rate rises by 0.72 percentage points. In particular, lower-income renter households flee to Florida, collapsing the homeownership rate by 31.0 percentage points to 33.7%. Average net worth in Florida rises sharply (+23.9%) because the remaining homeowners are disproportionately wealthy, while average consumption falls by 15.1% as lower-income renters now make up the bulk of the population. In the rest of the US, the compensating markup raises insurance costs and reduces net worth by 3.4%, and homeownership rises by 5.7 percentage points because of the outmigration of renters to Florida. House prices in Florida rise by 6.0% as the large population inflow bids up housing values, while house prices in the rest of the US fall by 2.6% as demand shifts away.

Figure 7(b) illustrates the effects on insurance coverage. The compensating markup in the rest of the US shifts the CDF sharply to the left, with roughly 80% of homeowners now choosing minimum coverage. In Florida, subsidized prices shift the CDF to the right, compressing the lower tail and raising average coverage as cheaper insurance induces homeowners to insure more fully.

Overall, the cross-subsidization counterfactual generates large equilibrium effects. A 10% reduction in regulated insurance prices produces substantial spatial reallocation, a significant contraction in homeownership in the subsidized region, and meaningful wealth redistribution, underscoring the potential for insurance rate regulation to propagate through general equilibrium channels with considerable force. We note, however, that while the direction of these effects is economically correct, their magnitudes are implausibly large. This likely reflects the absence of a public insurer of last resort: in many markets, households can obtain publicly-funded low-coverage insurance, which serves as an outside option that attenuates the equilibrium response to private market price changes. We are currently developing this important extension of the model,

which we expect to substantially moderate the estimated magnitudes in this counterfactual.

# 6 Conclusion

This paper studies how climate risk affects housing markets through the joint interaction of property insurance, tenure choice, and spatial mobility. We develop a dynamic spatial equilibrium model in which households choose where to live, whether to own or rent, and how much property insurance to purchase in the presence of heterogeneous local disaster risk. By embedding insurance and migration decisions into a housing market equilibrium, the framework shows how local climate risk is transmitted not only through expected property losses, but also through insurance premia, endogenous sorting, and changes in the composition of marginal buyers across regions.

Our calibration delivers realistic patterns of household insurance demand and regional housing outcomes. In particular, the model generates substantial heterogeneity in coverage choices, including widespread underinsurance, and matches key moments on house prices, rents, migration, and homeownership across high- and low-risk areas. These features are important for understanding how climate risk is capitalized into house prices. When climate risk rises, higher expected losses increase insurance costs, reduce the attractiveness of homeownership in exposed regions, and lower house prices as some households switch tenure or migrate away. At the same time, the model shows that equilibrium responses are shaped by selection: changes in insurance costs and disaster exposure alter the composition of households who remain in or enter risky locations.

Our counterfactual exercises highlight that the housing-market effects of climate risk depend critically on the insurance environment. Increases in insurer costs or local disaster probabilities generate lower welfare and lower house prices in exposed regions, with relatively modest but non-negligible spatial reallocation. By contrast, insurance rate regulation that compresses premia in risky areas can induce large cross-regional redistribution and substantial distortions in location choices, house prices, and homeownership patterns. These results underscore that insurance markets are not a passive backdrop to climate

adaptation; they are a central mechanism through which climate risk is priced, shared, and propagated across space.

Taken together, our findings imply that evaluating the consequences of climate change for household balance sheets and housing markets requires a framework that jointly models climate risk, insurance, and spatial equilibrium. Approaches that abstract from either endogenous insurance demand or household mobility risk missing important general-equilibrium feedback effects and may mismeasure both the incidence and capitalization of climate risk.

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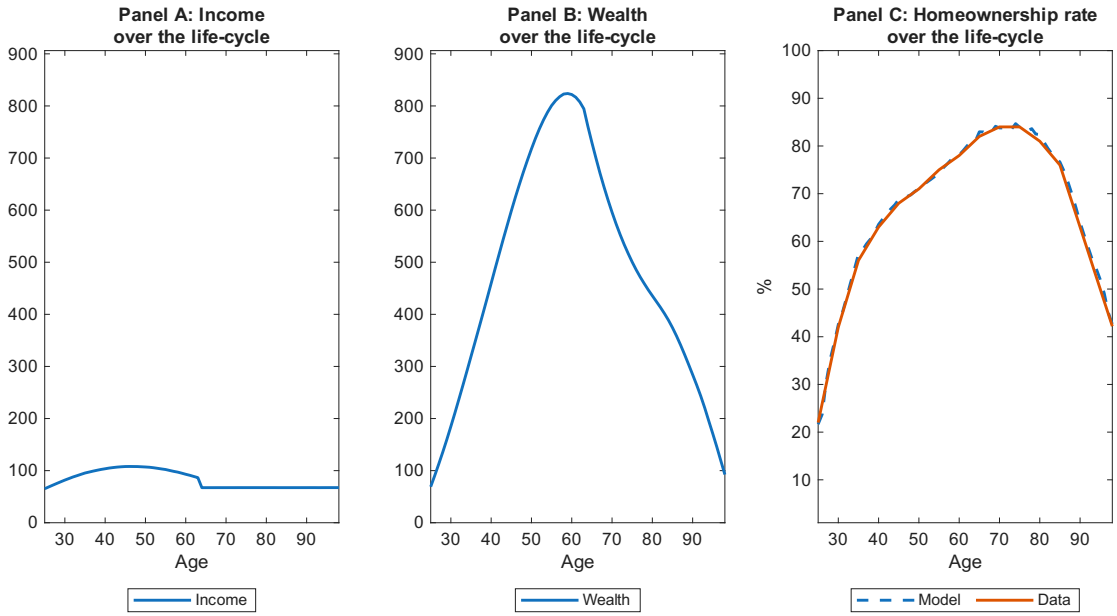
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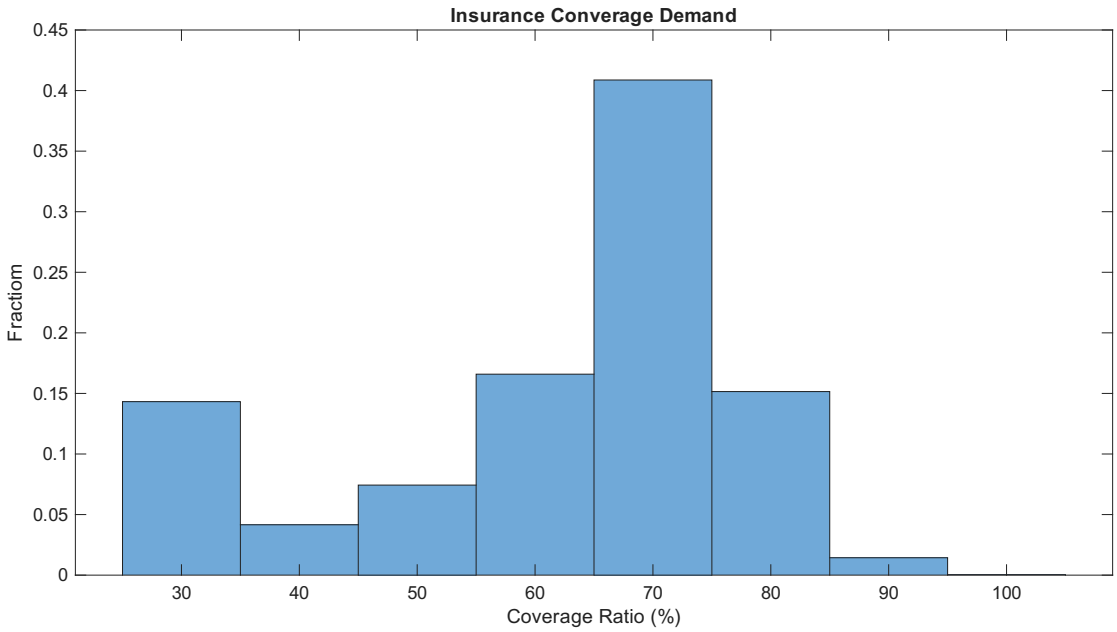
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**Figure 1:** Life-cycle profiles of income, wealth, and homeownership



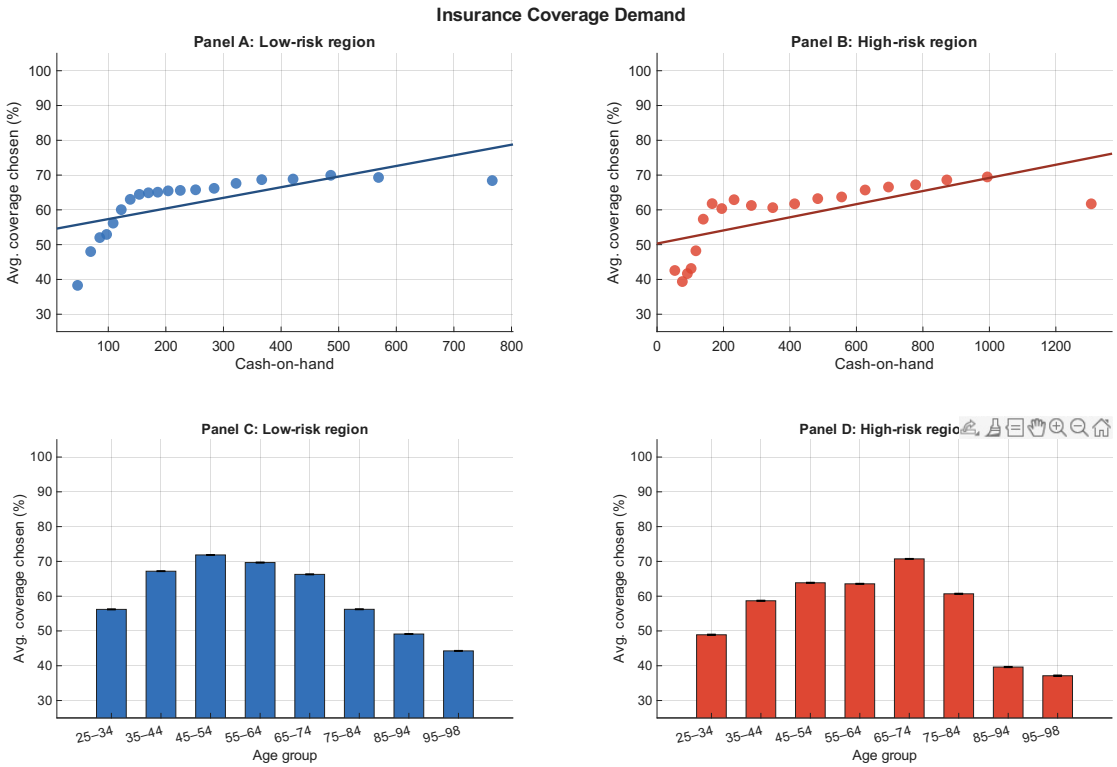

*Notes: This figures plots average income over the life-cycle (Panel A), average wealth over the life-cycle (Panel B) and homeownership rate over the life-cycle (Panel C).*

**Figure 2:** Insurance coverage demand



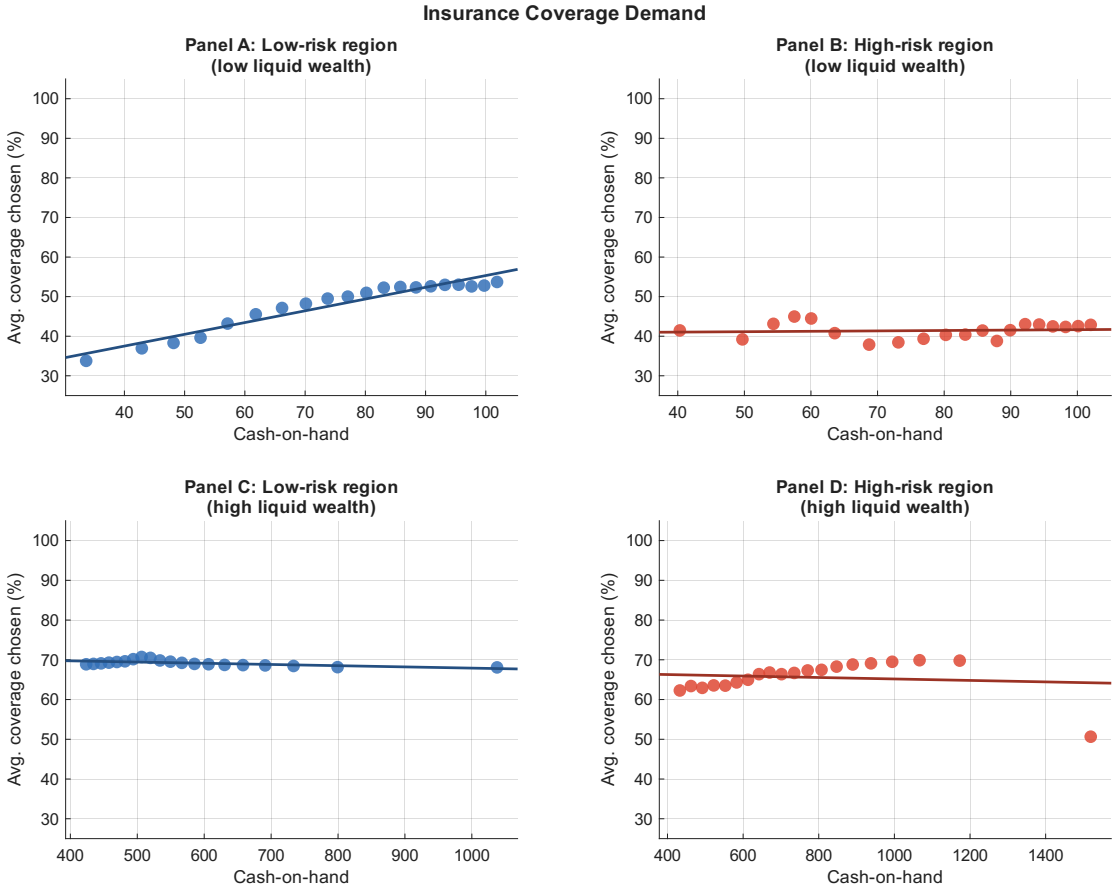

*Notes: The figure shows the distribution of endogenous insurance coverage demand in the model.*

**Figure 3:** Insurance demand by liquid wealth and age



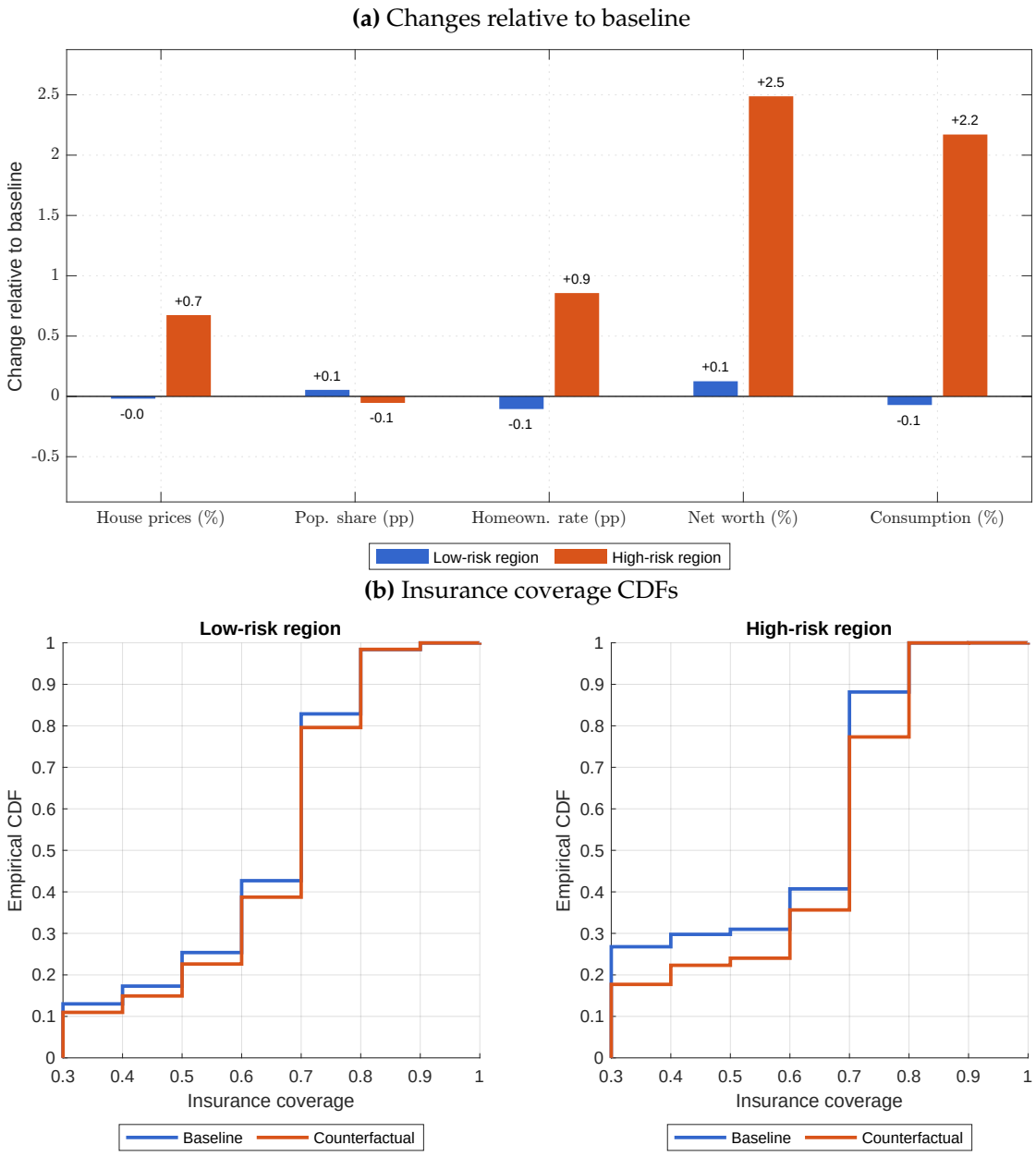

*Notes: This figure plots binscatter relationships between insurance coverage and cash-on-hand (top panels) and age (bottom panels) for homeowners, separately for the low climate risk and high climate risk regions. Each point represents the mean of insurance coverage within bins of the x-axis variable.*

**Figure 4:** Insurance demand: extremes of liquid wealth distribution



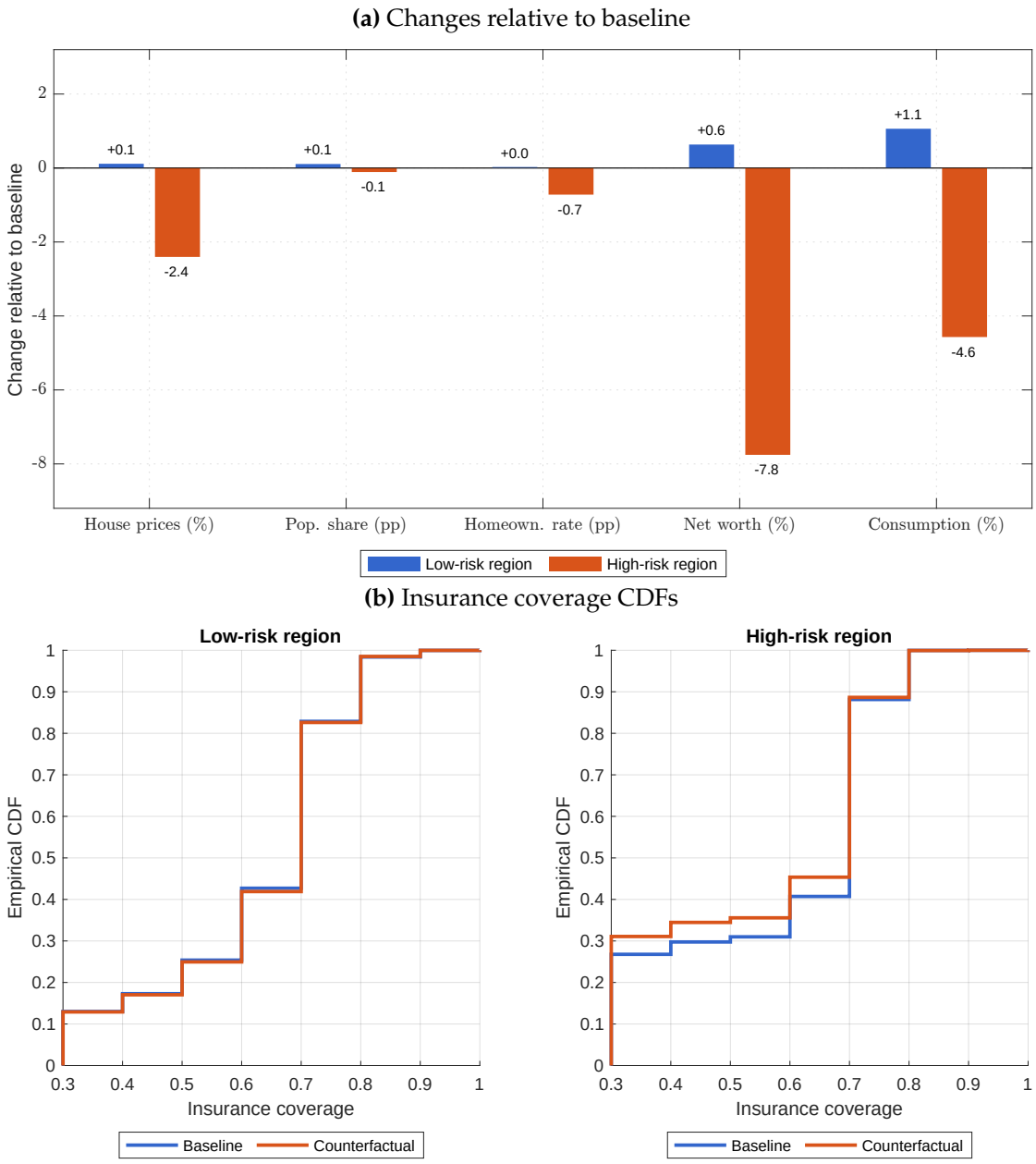

*Notes: This figure plots binscatter relationships between insurance coverage and cash-on-hand for homeowners in the bottom and top liquid-wealth deciles, separately by climate risk region.*

**Figure 5:** Insurance pricing counterfactual: equilibrium changes and insurance coverage



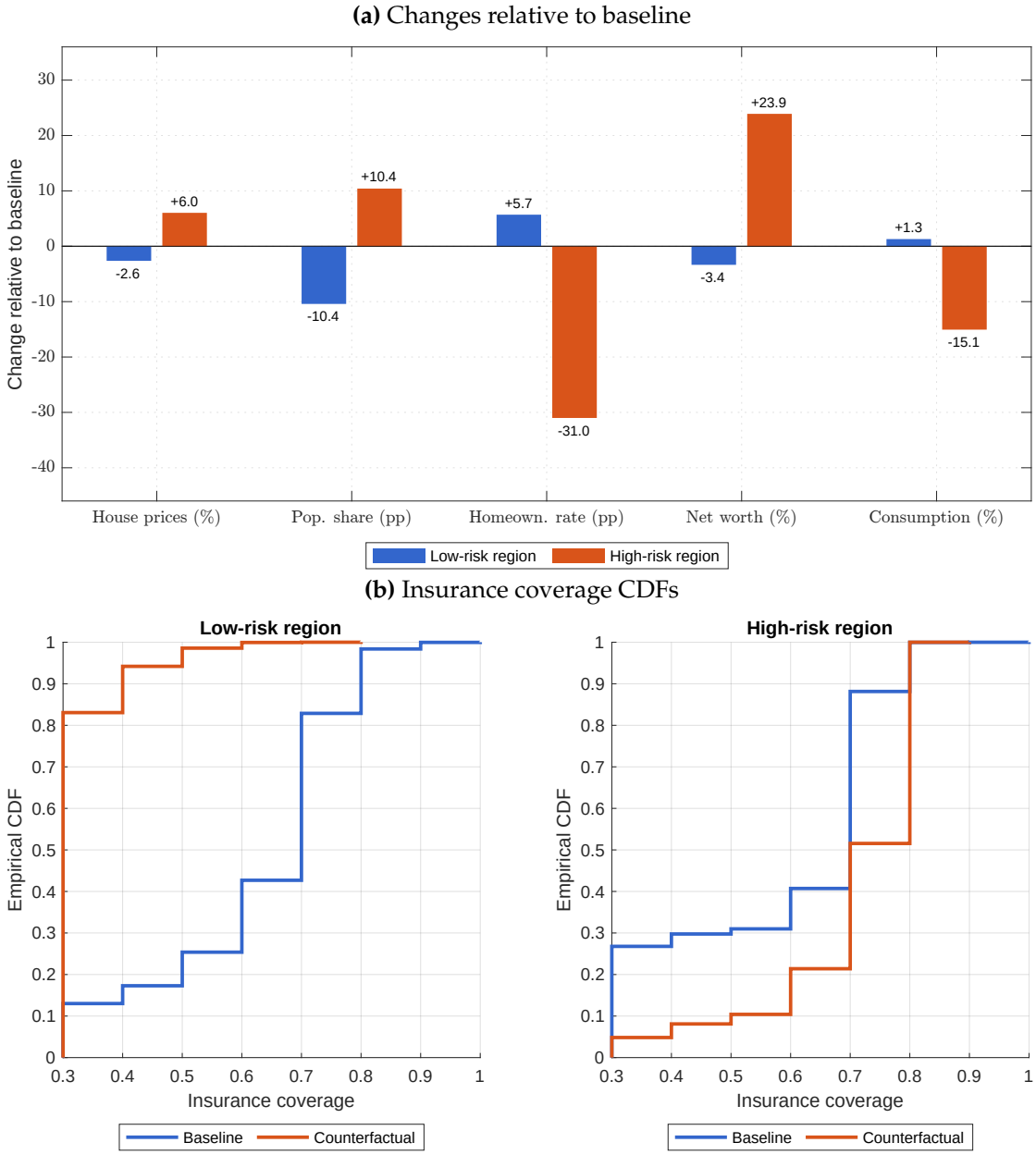

*Notes: Panel (a) plots percentage and percentage point changes in key steady-state outcomes relative to baseline, by region, when the insurance cost-of-capital $c$ is increased by 10%. Panel (b) plots the empirical CDFs of insurance coverage for homeowners by region. The solid blue line shows the baseline and the solid orange line shows the counterfactual.*

**Figure 6:** Climate risk counterfactual: equilibrium changes and insurance coverage




*Notes: Panel (a) plots percentage and percentage point changes in key steady-state outcomes relative to baseline, by region, when the disaster probability in the high-risk region is increased by 10%. Panel (b) plots the empirical CDFs of insurance coverage for homeowners by region. The solid blue line shows the baseline and the solid orange line shows the counterfactual.*

**Figure 7:** Cross-subsidization counterfactual: equilibrium changes and insurance coverage




*Notes: Panel (a) plots percentage and percentage point changes in key steady-state outcomes relative to baseline, by region, when high-risk region insurance prices are capped at 90% of baseline ($\lambda = 0.90$) with a revenue-neutral compensating markup in the low-risk region. Panel (b) plots the empirical CDFs of insurance coverage for homeowners by region. The solid blue line shows the baseline and the solid orange line shows the counterfactual.*

## **Table 1:** External parameters

| Parameter | Description | Value | Source/Target |
|---|---|---|---|
| **A. Preferences, Income, Mortgages, Housing** | | | |
| $\beta$ | Discount factor | 0.95 | standard |
| $\gamma$ | Risk aversion | 5 | standard |
| $\psi$ | Elasticity of intertemporal substitution | 0.5 | standard |
| $\alpha$ | Preference for housing | 0.4 | Favilukis *et al.* (2023) |
| $\epsilon$ | Elasticity of substitution consumption/housing | -0.5 | Elasticity of substitution consumption/housing of 2/3 |
| | Autocorelation permanent income | 0.953 | Kaplan & Violante (2022) |
| | Std. dev. permanent income | 0.20543 | Kaplan & Violante (2022) |
| | Std. idiosyncratic income | 0.22226 | Kaplan & Violante (2022) |
| $r$ | Risk-free interest rate | 0.02 | Average t-bill rate (FRED) |
| $r_M$ | Mortgage rate | 0.05 | Average mortgage rate (FRED) |
| $\overline{\theta}_{LTV}$ | LTV limit | 0.85 | Greenwald (2018) |
| $\overline{\theta}_{PTI}$ | PTI limit | 0.36 | Greenwald (2018) |
| $\phi^R$ | Rental premium (low / high region) | 0.015 / 0.009 | Avg price-to-rent ratio |
| $f_b$ | Proportional transaction cost buying | 0.01 | |
| $F_b$ | Fixed transaction cost buying | 1.5 | |
| $f_s$ | Proportional transaction cost selling | 0.05 | |
| $F_S$ | Fixed transaction cost of selling | 3 | |
| **B. Climate risk and insurance** | | | |
| $p_\chi$ | Climate shock probability (low / high region) | 0 / 0.08 | Bilal & Rossi-Hansberg (2025) |
| $\chi$ | Conditional loss from climate shock (low / high region) | 0 / 0.17 | Bilal & Rossi-Hansberg (2025) |
| $\bar{d}$ | Upper bound of baseline damage distribution | 0.05 | See text |
| $\alpha_{\text{base}}$ | Beta shape parameter (baseline damage) | 1 | See text |
| $\beta_{\text{base}}$ | Beta shape parameter (baseline damage) | 12.08 | Avg. insurance price & coverage |
| $c$ | Capital charge cost | 0.4 | See text |
| $\eta$ | Capital charge curvature | 3 | See text |
| $\mu$ | Constant markup | 0.05 | See text |
| $\omega_r$ | Insurance pass-through to rental units | 1 | |
| $\phi$ | Insurance coverage menu | {30%, 40%, . . . , 90%, 100%} | |
| **C. Geographic heterogeneity** | | | |
| | Amenity shifter low/high-exposure area | see text | Pop share of each location |
| | Homeownership value shifter low/high-exposure area | see text | Homeownership rate |
| | Moving costs between areas (in utils) | 0.009 | Avg migration Fl and U.S. |
| $\bar{I}_L$ | Housing supply level low-exposure area | n/a | Avg house price low-exposure area |
| $\bar{I}_H$ | Housing supply level high-exposure area | n/a | Avg house price high-exposure area |
| $\rho_L$ | Housing supply elasticity low-exposure area | 1.8134 | Elasticity Baum-Snow & Han (2024) |
| $\rho_H$ | Housing supply elasticity high-exposure area | 0.99568 | Elasticity Baum-Snow & Han (2024) |

*Notes:* One model period corresponds to one year. Targets are in annual terms.

**Table 2:** Targeted moments

| Variable | Data | Model |
|---|---|---|
| **A. Aggregate** | | |
| Avg income | 82.7 | 82.2 |
| Avg wealth/avg income | 6.33 | 7.4 |
| Avg house price/avg income | 6.06 | 6.1 |
| Avg rent/avg income | 0.25 | 0.25 |
| P90 LTV | 0.90 | 0.85 |
| P90 PTI | 0.48 | 0.43 |
| **B. Climate risk and insurance** | | |
| Avg property insurance premium | 1.123 | 1.753 |
| Avg property insurance coverage | 0.70 | 0.62 |
| **C. Geographic heterogeneity** | | |
| Avg moving rate between areas (%) | 2.20 | 1.56 |
| Population share in low-exposure area (%) | 93 | 90.12 |
| Population share in high-exposure area (%) | 7 | 9.88 |
| Avg house price low-exposure area ($ thousands) | 512 | 512 |
| Avg house monthly rent low-exposure area ($) | 1,740 | 1,721 |
| Avg house price high-exposure area ($ thousands) | 407 | 407 |
| Avg house monthly rent high-exposure area ($) | 1,917 | 1,845 |

*Notes:* Moments are in annual terms. The sources are

**Table 3:** Counterfactual experiments: steady-state outcomes

| | Baseline | | Insurance | | Climate | | Cross-Subsidy | |
|---|---|---|---|---|---|---|---|---|
| | US | FL | US | FL | US | FL | US | FL |
| House prices ($K) | 512 | 407 | 512 | 410 | 513 | 397 | 498 | 432 |
| Population share (%) | 90.1 | 9.9 | 90.1 | 9.8 | 90.2 | 9.8 | 79.7 | 20.3 |
| Homeownership rate (%) | 67.5 | 64.7 | 67.4 | 65.6 | 67.5 | 64.0 | 73.2 | 33.7 |
| Net worth ($K) | 554 | 628 | 554 | 644 | 557 | 580 | 535 | 778 |
| Consumption ($K) | 73.1 | 87.7 | 73.0 | 89.6 | 73.9 | 83.7 | 74.0 | 74.5 |
| Migration rate (%) | 1.58 | | 1.51 | | 1.85 | | 2.30 | |

*Notes: This table reports steady-state levels for the baseline economy and three counterfactual experiments. "Insurance" increases the cost-of-capital coefficient $c$ by 10%. "Climate" increases the disaster probability in Florida by 10%. "Cross-Subsidy" caps Florida insurance prices at 90% of baseline ($\lambda = 0.90$) with a revenue-neutral compensating markup in the rest of the US. House prices, net worth, and consumption are in thousands of dollars.*