Climate Change and Long-Run Discount Rates: Evidence from Real Estate

November 2020

Introduction

- Key question in the debate on climate change: What is the **appropriate discount rate** for climate-change abatement policies?
  - Investments with uncertain long-run payoffs
  - Present value extremely sensitive to choice of discount rate
  - Wide range of suggested discount rates in theory and in practice (from 1% to 5%)

- In this paper:
  1. Additional evidence on the **term structure of discount rates** for housing, up to maturities of 300 years
  2. Provide new empirical evidence on the **exposure of housing to climate change**
  3. Build a flexible but tractable **framework** in which climate risk is endogenous to derive implications about discounting climate change abatement investments

Outline

1. **Empirical evidence from real estate**
    - **The term structure of discount rates**
    - The exposure of housing to climate change risks
2. A structural model with endogenous climate change

Empirical evidence on long-run discount rates

- Giglio, Maggiori and Stroebel (2015): discount rate for housing **2.5%** at the long end
- This paper provides new evidence that the short-end of the discount curve is much higher, and the average is **6%**
- Implies a **downward-sloping** term structure of discount rates
- Note: this is a **risky** asset: risk premia are large in the short term, and lower in the long term

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Do house prices reflect climate change risk?

Identification problem

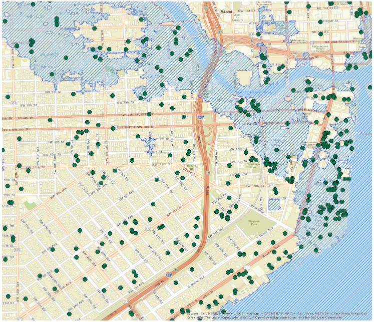
- Differential exposure to climate change correlated with amenities
  - Simple diff: compare houses on the coast with houses inland
- Alternative: exploit time-series changes in climate change risks
  - Diff-in-diff: compare houses on the coast with houses inland, as climate risks change
  - But climate risk is slow-moving
  - And climate change **risk** is correlated with **weather shocks**

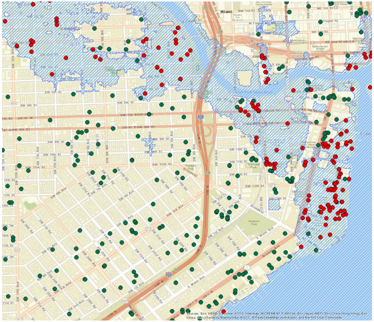
Our strategy

- Construct **climate change attention index** from real estate *listings* to do the diff-in-diff
- Show it captures changing risks, not weather shocks, using *rental data*

Do house prices reflect climate change risk?

- Identify **geographies** exposed to climate change risk in Florida, New Jersey, North and South Carolina by using NOAA maps
- Indicator of flooding if sea levels rise by 6 feet





Do house prices reflect climate change risk?

- In each zipcode and month, construct a **climate attention index** as the fraction of listings mentioning climate-related texts
- Both time variation and spatial variation

Looking for a family home that's ready to move in and only 6 years old? This 4 bedroom 2 1/2 bath plus office/hobby room is in a great neighborhood in the award-winning Carolina Forest school district and is priced to sell! [...] All the items in the garage convey- such as lawn mower, freezer, safe, hurricane coverings for windows, edger, etc. ***Not in a flood zone, it's high and dry!*** *[...] Only 15 minutes to the beach.* ***Not in a flood zone.*** *Come and see!*

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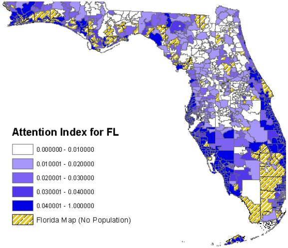

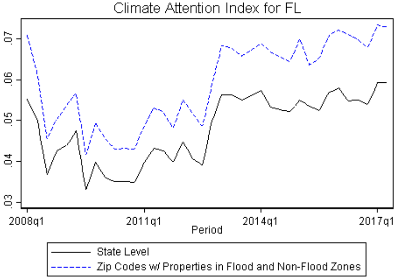

Do house prices reflect climate change risk?

	Dependent Var: log(Prices)		Dependent Var: log(Rents)	
	(1)	(2)	(3)	(4)
Flood Zone	0.004		0.041***	
	(0.015)		(0.012)	
log(Index by Zip-Year)	-0.024***	-0.029**	0.018***	0.005
× Flood Zone	(0.005)	(0.010)	(0.004)	(0.005)
Property Controls	✓	.	✓	.
Zip × Quarter FE	✓	✓	✓	✓
Property FE	.	✓	.	✓
R-squared	0.585	0.721	0.728	0.942
N	7,287,000	3,485,238	2,142,433	1,191,657

$$log(P)_{i,h,g,t} = \alpha + \beta log(Index_{g,t}) \times FloodZone_h + \gamma FloodZone_h + \delta Z_h + \phi_g \times \psi_t + \epsilon_{i,h,g,t}$$

Do house prices reflect climate change risk?

- House prices are directly affected by climate change risks
- No effect on rents
- Next, we build a structural model with climate change risk and draw implications for climate change abatement

Outline

1. Empirical evidence from real estate
   - The term structure of discount rates
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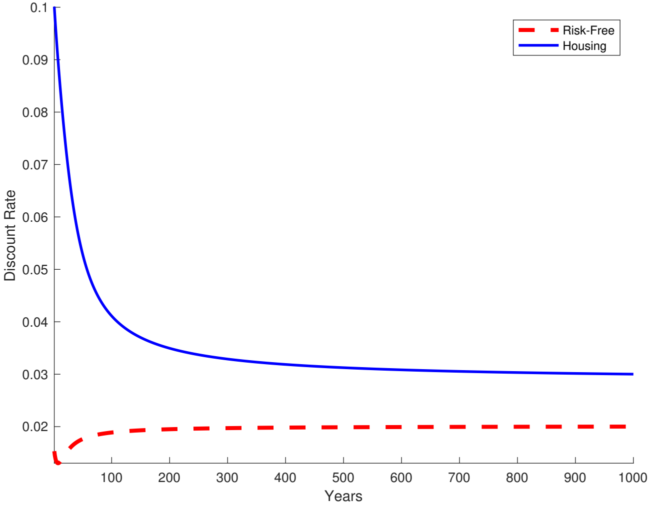
2. **A structural model with endogenous climate change**
   - Details in the paper

Implications for climate change investment

- The discount rate is always below the risk-free rate
  - They are hedges to aggregate risks
- At long horizons, the long-term discount rate on housing (2.6%) is an upper bound on the climate mitigation discount rate
  - Rules out many discount rates used in practice

A structural model with endogenous climate change risks



Implications for climate change investment

- Build a model with rare climate disasters, and endogenous feedback between economy and climate
- Calibrate it to the empirical data discussed above
- Housing plays a special role in the calibration: because it's exposed to climate risk, it's particularly informative about it
- Using the calibrated model, we can consider different climate abatement investments, and quantify appropriate discount rates
- Note: **because climate abatement investments are hedges, they are discounted at rates below the risk-free rate!**

A structural model with endogenous climate change risks

- Aggregate consumption is exposed to climate disasters J

$$\Delta c_{t+1} = \mu + x_t - J_{t+1},$$

$$x_{t+1} = \mu_x + \rho x_t + \phi J_{t+1},$$

- J_t: $\xi \in (0,1)$ with probability λ_t, otherwise 0.
- Similarly, housing dividends (rents):

$$\Delta d_{t+1} = \mu_d + y_t - \eta J_{t+1},$$

$$y_{t+1} = \mu_y + \omega y_t + \psi J_{t+1}.$$

- Recovery after a disaster: $\psi > 0, \phi > 0$
- Interpretation: **adaptation**

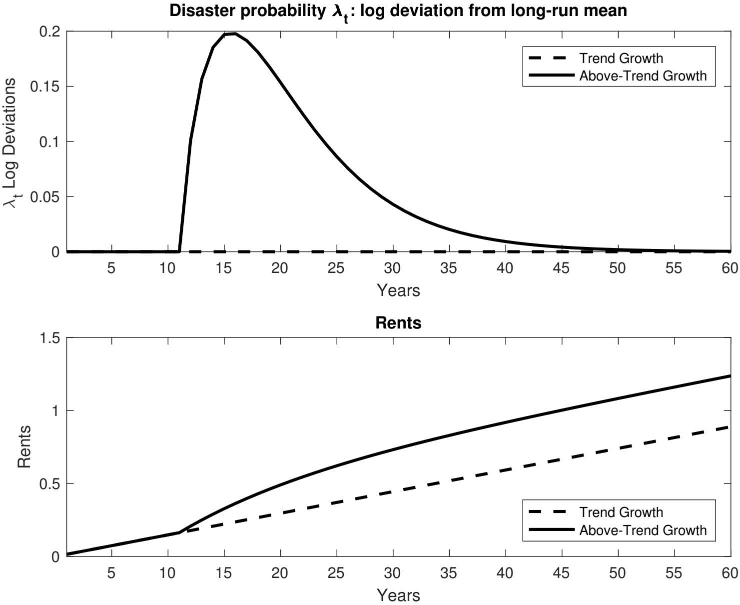
A structural model with endogenous climate change risks

- Climate risk is in turn affected by the economy

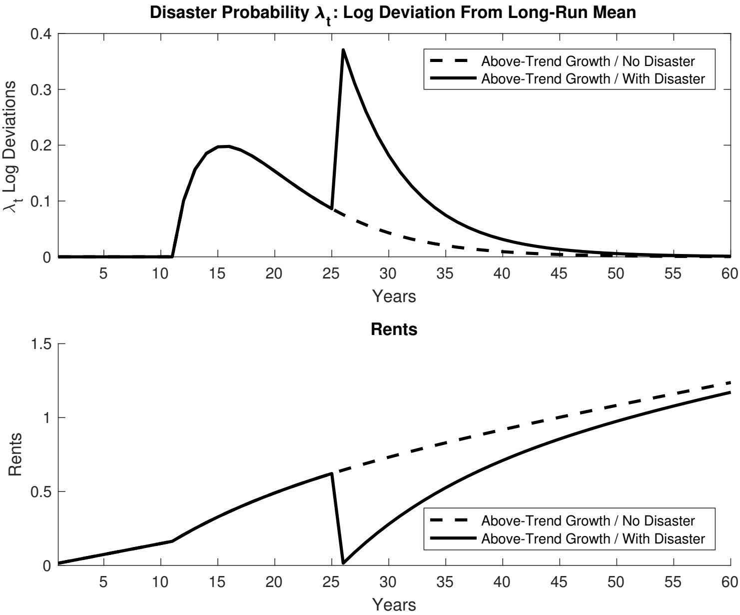
$$\lambda_{t+1} = \mu_\lambda + \alpha\lambda_t + \nu x_t + \chi J_{t+1}.$$

- x_t is the process driving expected consumption growth
- Periods with high consumption growth accumulate higher disaster risk
- Future climate risk also increases after a disaster (vicious cycles)

A structural model with endogenous climate change risks



A structural model with endogenous climate change risks



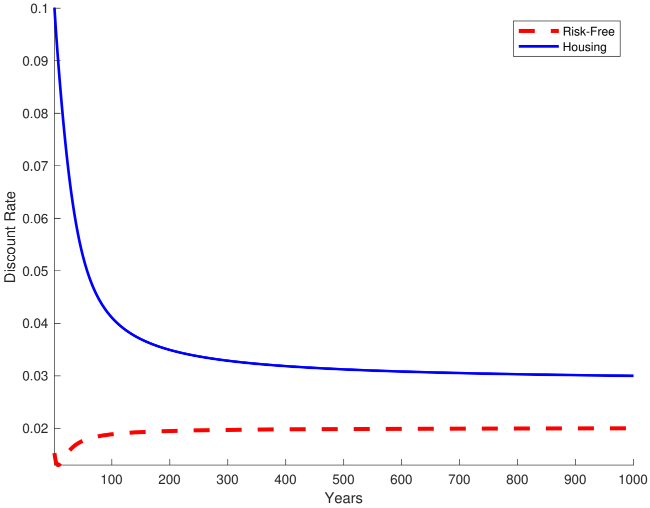
A structural model with endogenous climate change risks

- Standard CRRA utility

$$U(C_t) = \delta \frac{C_t^{1-\gamma}}{1-\gamma}.$$

- Solve the model almost entirely in closed form
- Calibrate it to match:
  1. Term structure of discount rates in the housing market
  2. Term structure of real risk-free rates
  3. The elasticity of house prices to climate risk
- Obtain implications about the term structure of discount rates for climate change

A structural model with endogenous climate change risks



- Matches the relative prices of freeholds and leaseholds of different maturity

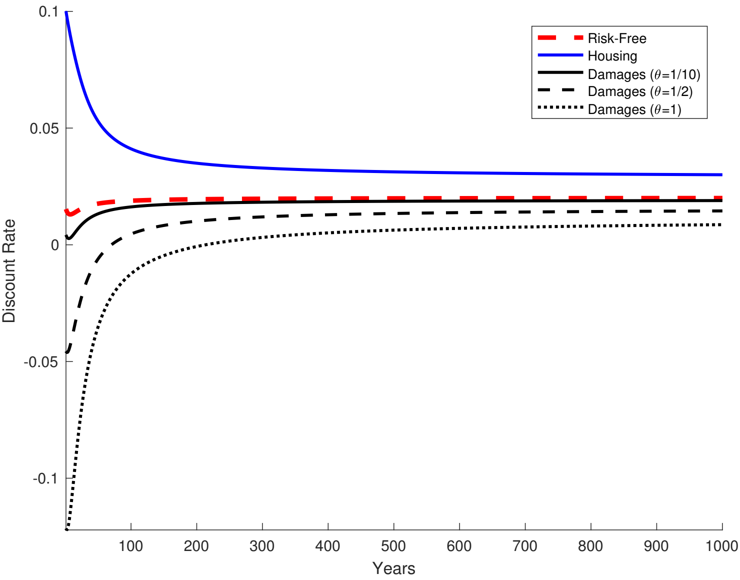
Climate change mitigation

- To think about climate change mitigation, we start by defining the **damages** process q

$$\Delta q_{t+1} = \mu_q - y_t + \eta J_{t+1}$$

- Note the mean reversion due to adaptation: climate change produces the most damage in the short term
- Climate change mitigation is **insurance** against those damages
- Pays $\boldsymbol{\theta \Delta q_{t+1}}$
- We can derive the term structure of discount rates for mitigation investments as a function of θ.

A structural model with endogenous climate change risks



Conclusion

- Present **new empirical evidence**
  - On the term structure of discount rates of housing
  - On the exposure of housing to climate risks
- Propose a new tractable **framework** with endogenous climate change risks
- Use the model to link the observed housing data to implications about climate change

Conclusion: challenges and opportunities

- Climate change is an incredibly complex problem
- Finance has a lot to say about it
- We are starting to make progress on many fronts, but many open challenges:
    - Measurement of climate risk and risk exposures
    - Perception of climate risks and communication
    - Integrating the empirical data (prices, physical processes) with theoretical models
    - Model uncertainty
- Many opportunities for work in this area!