HOW CLIMATE-AWAKE ARE FINANCIAL MARKETS?

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CLIMATE CHANGE POSES RISKS TO FINANCIAL MARKETS

- **Physical risks:** e.g. temperature rise, sea level rise, storms, floods, fires
- **Transition risks:** e.g. policy, consumer and investor preferences, technologies
- **These risks are not i.i.d**: trend and uncertainty
- **How do we know if these risks are priced in?**

WHY DO WE CARE ABOUT PRICING CLIMATE RISKS?

- **Capital misallocation:** if risks are not properly priced, we might be investing too much in highly exposed assets
- **“Green swan” risk:** if assets are mispriced severely, rapid repricing and stranded asset problems can have financial stability repercussions
- **Policy evaluation:** we use asset price responses to evaluate policy effectiveness

WE PROPOSE TO INTRODUCE CLIMATE BELIEFS INTO AN ASSET PRICING MODEL TO REFLECT

- **Trend:** climate parameter (= level and dispersion of global temperature) is trending since 1980s => climate risks are not i.i.d over time
- **Uncertain path:** fundamental uncertainty about eventual global warming, multiple scenarios depending on mitigation
- **Climate denial:** not everyone believes in the inevitability of climate change

WHAT WE LEARN:

- Beliefs affect the response of asset prices to physical climate shocks (climate disasters)
- Empirical literature can be placed in the context of belief parameters in the model
- There is some evidence of low climate optimism and low belief rigidity in asset price response to physical manifestations of climate change in the recent decade, but no consensus in the literature

MODEL:
SET UP FOLLOWS GABAIX (2012)

- Endowment economy with i.i.d. dividend shock
- CRRA preferences (CRRA coefficient = γ)
- Dividend and consumption costs of disasters

Disaster resilience parameter summarizes disaster effects, for asset *i*

$$H_{it} = \overbrace{p_t}^{\text{Subjective dis. prob.}} \mathrm{E}_t\left[\underbrace{B_{t+1}^{-\gamma}}_{\text{Effect of dis. on SDF}} \overbrace{F_{i,t+1}}^{\text{Effect of dis. on dividends}} - 1\right]$$

MODEL:
WE ADD EXPLICIT BELIEF FORMATION

- Disasters frequency follows Poisson distribution (Hale, 2024)
- Poisson parameter θ_t is unknown and not constant => subjective beliefs about it
- One extreme: climate denial $\theta_t = \theta_{t-1} \; \forall \, t$
- Another extreme: fully Bayesian

$$\theta_t = \Gamma\left(g_\theta \cdot \sum_{s=t_0}^{t-1} d_s + d_t,\ \frac{1}{t - t_0}\right)$$

MODEL:
WE ADD EXPLICIT BELIEF FORMATION

- g_θ is the trend which is unknown and is part of belief structure

$$g_\theta = \lambda \cdot g_{SSP1} + (1 - \lambda) \cdot g_{SSP3}, \quad \forall \lambda \in [0, 1]$$

  λ is the climate optimism parameter of beliefs

- Full belief structure

$$\theta_t = \mu \, \theta_{t-1} + (1 - \mu) \, \Gamma \left(g_\theta \cdot \theta_{t-1} + d_t, \ \frac{1}{t - t_0} \right)$$

  $\mu \in [0, 1]$ is belief rigidity parameter

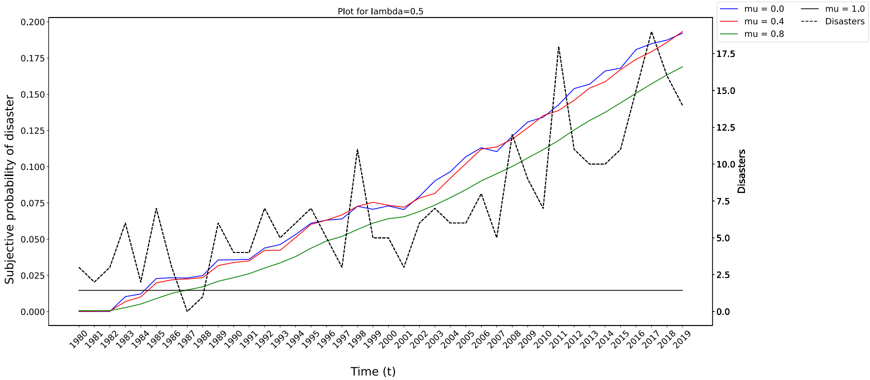
MODEL:
THE REST OF MODEL COMPONENTS

- Additional assumptions on inflation to price nominal assets
- Additional assumptions in conventional risk premia
- Closed form expressions for risk-free rate, government bonds of various maturities, bond risk premia, equity risk premia

MODEL: CALIBRATION 1954-1984, SIMULATION 1985-2019

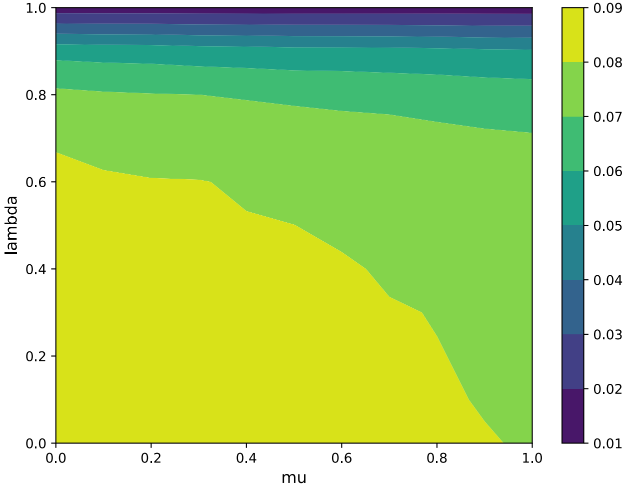
Variable	Source	1954-84	1985-2019
Measured directly or estimated from the data			
Disaster probability (p)	Derived from data	0.0723	Simulated
Mean-reversion of inflation (ϕ_i)	Quarterly inflation data	0.2475	0.8926
Mean-reversion of inflation jumps (ϕ_j)	Quarterly inflation data	1.4842	0.4661
Average inflation (I^*)	Quarterly inflation data	4.23	2.53
Average disaster-related jump in inflation (J^*)	Quarterly inflation data	N.A.	[0.36, 2.56]
Mean-reversion of climate resilience (ϕ_H)	From price/dividend ratio	0.24	0.062
Consumption/dividend growth rate (g_C)	From Gabaix(2012) and U.S. data	0.025	0.025
Calibration results			
CRRA (γ)		3	3
Discount rate (ρ)		0.034	0.034
Productivity loss (F)		0.95	0.905
Welfare loss (B)		0.7505	0.83
Sensitivity of inflation to disasters (κ)		0.1	0.1
Targeted moments (matched exactly) for 1954-84 calibration			
Mean risk free rate (r^f)	Average of end-of-the year values	0.0103	N.A.
Mean return on equity (r^e)	Average of end-of-the year values	0.0189	N.A.
Mean 5y-1y term premium	Average of end-of-the year values	0.0032	N.A.

RESULTS:
SUBJECTIVE DISASTER PROBABILITY

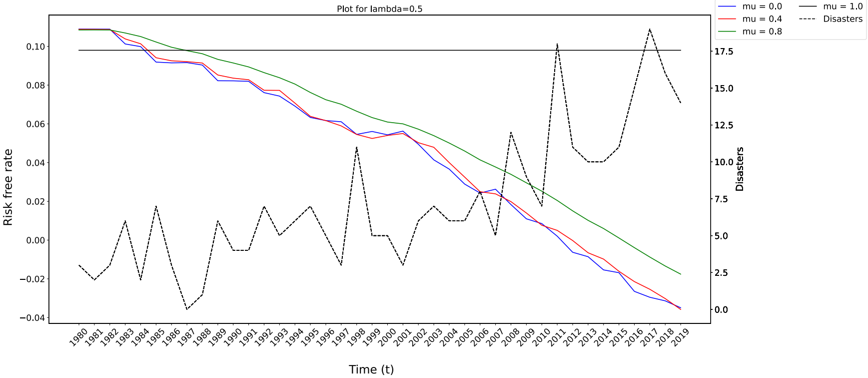


RESULTS:

SUBJECTIVE DISASTER PROBABILITY: AVERAGE 1985-2019

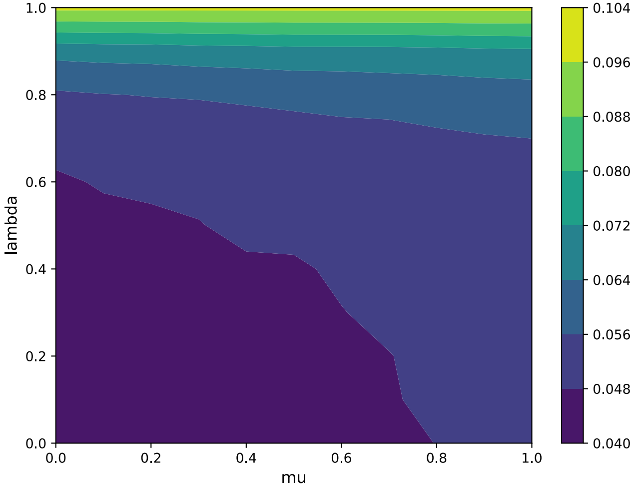


RESULTS:
RISK-FREE RATE



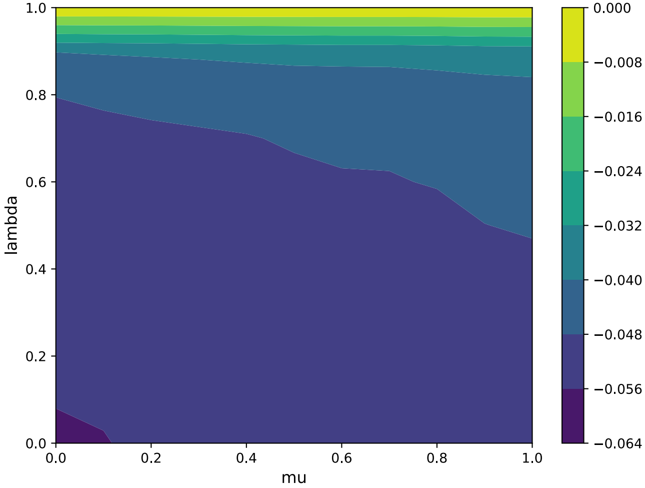
RESULTS:

RISK-FREE RATE: AVERAGE 1985-2019

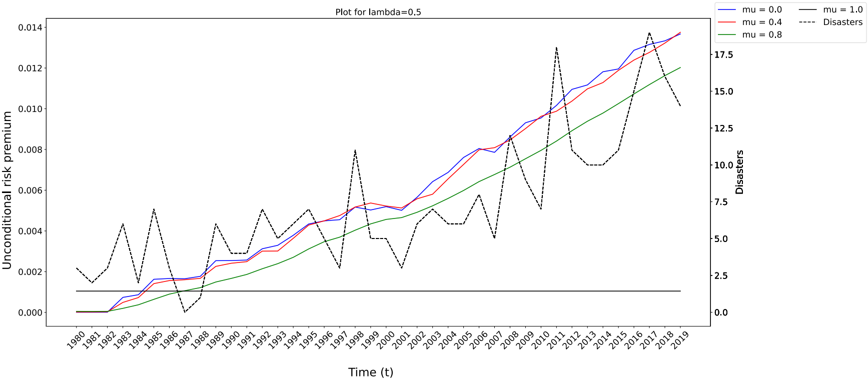


RESULTS:

RISK-FREE RATE: DISASTER YEAR - NON-DISASTER YEAR

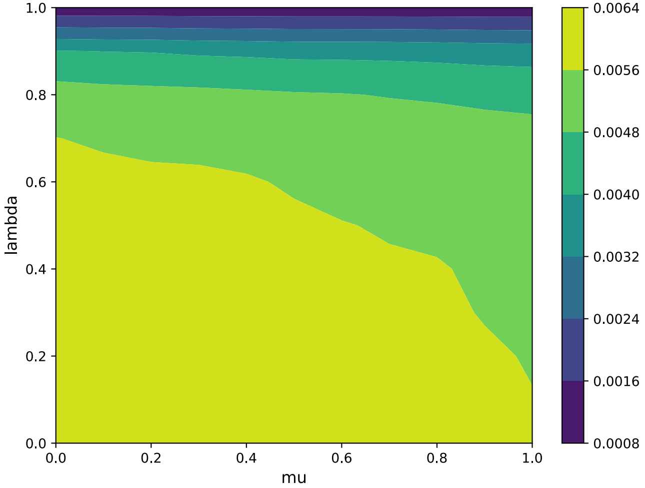


RESULTS:
EQUITY RISK PREMIUM



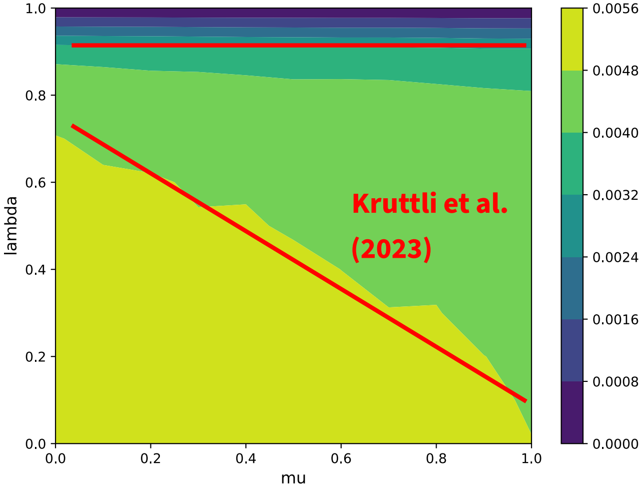
RESULTS:

EQUITY RISK PREMIUM: AVERAGE 1985-2019

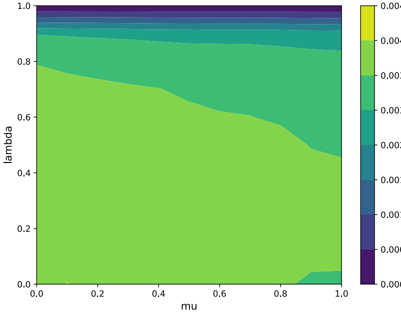


RESULTS:

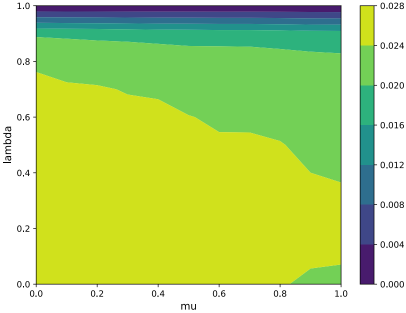
EQUITY RISK PREMIUM: DISASTER YEAR - NON-DISASTER YEAR



BOND RISK PREMIUM: DISASTER YEAR - NON-DISASTER YEAR



AAA bonds



B-rated bonds

CONCLUSIONS

- Belief structure matters for pricing assets in the presence of climate risks
- There are multiple dimensions over which climate beliefs need to be specified
- In the context of our model, some empirical results are consistent with low belief rigidity and low climate optimism
- Null results in the context of our model are consistent with either full belief rigidity or with high climate optimism (or both)
- All of the above assumes fully rational asset pricing conditional on climate belief structure