Università Commerciale
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Explaining Greenium in a Macro-finance Integrated Assessment Model

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1. Introduction

Research question

- How do climate disasters (e.g., hurricanes, floods, droughts, etc) affect equity returns and capital investments of green and brown firms?
- What are the asset pricing implications of a climate disaster shock?

What I do

- Provide novel empirical evidence that relates climate disaster shocks with equity returns and investments.
- Build a macrofinance model with a climate system to **quantitatively** explain my findings.

What I find

- Green stocks carry **lower** premium than brown stocks (a **Greenium**).
- A climate disaster shock depreciates stock market, but green stocks depreciate **less** than brown stocks.
- Green (Brown) firms increase (decrease) capital investment during a climate disaster.
- A simple analytical model qualitatively explain the empirical findings.
- A macrofinance integrated assessment model (IAM) quantitatively matches economic quantities & asset prices.

2. Data and Empirical Method

- Sort **global** firms using the E-score from Refinitiv Asset4.
- Aggregate economic losses (in U.S. dollars) due to climate disasters $\Rightarrow$ a **disaster index**.
- Cross-sectional asset pricing tests on the greenium.
- Panel regressions & event studies to investigate how green and brown stock returns and investments respond to a disaster shock.

3. Empirical Results

- Green stocks have 3.8% lower return (annualized) than brown stock, i.e., a negative greenium.

Factors	Constant	CAPM	FF3	FF5	FF5&MOM
Green minus Brown α (%)	3.83	2.43	2.17	3.91	3.98
s.e. (%)	(1.39)	(1.18)	(0.98)	(1.22)	(1.25)

- A disaster shock depreciates green stocks **less** than brown stocks.
- Green (Brown) investment increases (decreases) during a climate disaster.

	Stock returns		Investment	
	(1)	(2)	(3)	(4)
disaster	-0.282***	-0.285***	-0.110***	-0.121***
	(0.012)	(0.012)	(0.027)	(0.035)
Escore $\times$ *disaster*	0.0380***		0.289***	
	(0.006)		(0.062)	
GreenDummy $\times$ *disaster*		0.0257***		0.231***
		(0.005)		(0.048)
Controls	Yes	Yes	Yes	Yes
Firm FE & Time FE	Yes	Yes	Yes	Yes
Obs.	384,224	381,554	105,265	104,563
Adj. R^2	0.04	0.04	0.323	0.323

Contact Information

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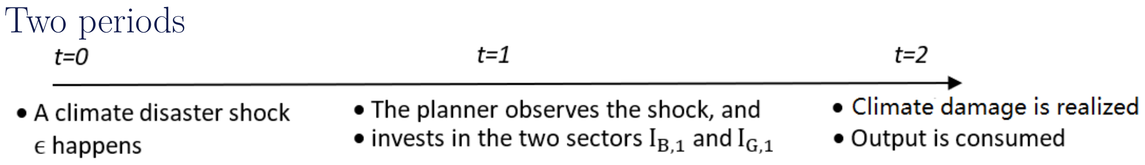
4. A Simple Analytical Model

- Two periods



- Production function with climate damage

$$Y_2 = \left(1 - \underbrace{D(I_{B,1}, \epsilon)}_{\text{climate damage}}\right) \cdot \underbrace{f\left(I_{G,1}, I_{B,1}\right)}_{\text{Pre-damage output}}$$

- **Key assumption:** $\frac{\partial^2 D}{\partial I_B \partial \epsilon} > 0$, a disaster shock increases belief about marginal cost of brown investment
- **Implications**:
  1. a disaster shock decreases (increases) optimal brown (green) investment
  2. green stocks appreciate relative to brown stocks under investment friction

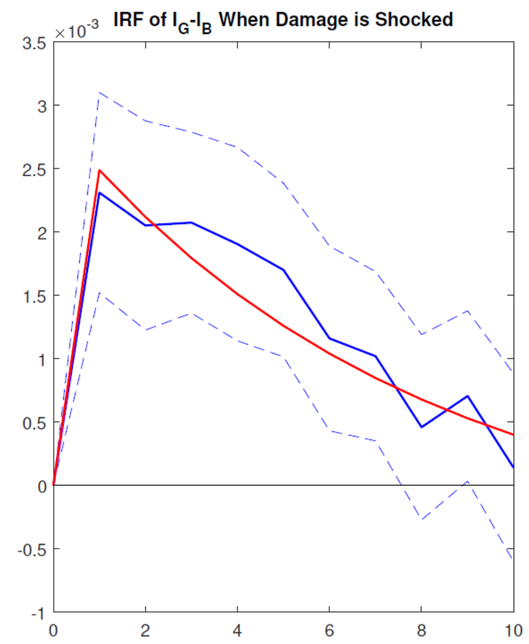
5. The Macro-finance IAM

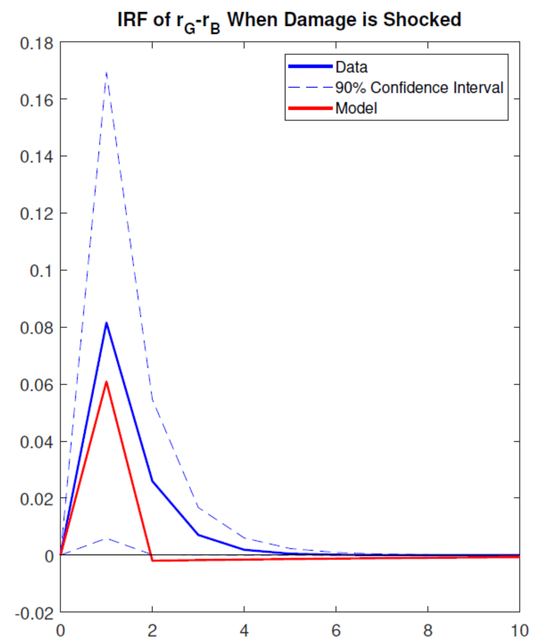
Key ingredients:

- Recursive preference: prices **news** about (i) productivity shock and (ii) climate damage (i.e., disasters).
- Climate feedback + investment friction: heterogeneous disaster exposures of green and brown stocks.

Key Success:

- Model quantitatively explains equity premium & **greenium**.
- Model matches IRFs of stock returns & investments to a disaster.





Model implication:

- The Social Cost of Carbon is \$40.4 per tonne of carbon.

6.Conclusion

Empirics:

- A negative greenium in the cross section of global stock market.
- A positive disaster shock (i) appreciates green stocks relative to brown stocks, (ii) increases capital investments of green firms.

Theory:

- A production model with climate feedback generates heterogeneous disaster exposures of green and brown firms.
- This model contributes by (i) explaining asset prices in IAM, and (ii) introducing climate risks in macrofinance.