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CLIMATE ADAPTATION
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MEASURING & REDUCING SOCIETAL IMPACTS

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Showing off Cleaner Hands:
Mandatory Climate-Related
Disclosure by Financial Institutions
and the Financing of Fossil Energy

Showing off cleaner hands: mandatory climate-related disclosure by financial institutions and the financing of fossil energy

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UCLA's Climate Adaptation Research Symposium - 8 Sept. 2021

Opinions expressed are those of the authors and do not necessarily reflect the views of the Banque de France or the Eurosystem

Motivation

- COP21, December 2015 : Need to shift global funding towards low carbon activities to curb global greenhouse gas (GHG) emissions → calls for action adressed to private finance
- Since Carney (2015), lot of attention devoted to improving climate-related transparency of financials.
- Private coalitions for sustainable finance (*TCFD, Climate action 100+* etc.) supporting **voluntary** disclosure
- In parallel, a move from regulators towards **mandatory** disclosure :
  - France (this paper), incoming in EU (SFDR, CSRD), in the US (SEC public consultation)
  - June 2021 : G7's endorsement of mandatory reporting following TCFD guidelines
- What benefits shall we expect of imposing carbon disclosure requirements on financial institutions ?

This paper

Does mandatory climate-related disclosure by financial institutions lead them to divest from carbon-intensive industries ?

- Natural experiment : French law in 2015, enacted as of January 2016 (**Art. 173-6** of *Loi TECV*) ▸ *Details*
  - Objective : disclosure of exposure to climate-related risks/ climate change mitigation plans
  - Target : institutional investors (insurers, pension funds, investment funds)
  - Unique in Europe at the time.
- Impact metrics : changes in holdings of fossil energy securities. Rationale :
  - Production/combustion of Fossil fuels ≈ 90% of CO2 emissions
  - Increased scrutiny by NGOs and public opinion

Hypothesis : transparency regulation ⇒ incentives to cut priorily funding to fossil fuels, responsible for the bulk of CO2 emission and under public opinion scrutiny

What we do

- We merge two large granular datasets over 2013-2019 :
  1. Universe of bonds and stocks outstanding of FF companies worldwide (identifiers : ISIN codes)
  2. What is held by Euro area investors (Eurosystem proprietary information on ISIN-level securities holdings at the sector-country level)

- Final sample : 7,040 securities (5,143 bonds/1,897 stocks) issued by 2,757 different FF companies and held by euro area financials

- We run Diff-in-diff regressions, comparing FF holdings :
  - by treated sector-country pairs (Insurance/Pension Funds and Asset Managers in France) vs control sector-country pairs (financials in all other countries + French banks)
  - Before/After January 2016
  - Controlling for all potentally confounding effects (demand/supply, macro, country- and sector-specific heterogeneity, price fluctuations)

Main findings

Main take away : mandatory climate-related disclosure caused significant decrease in funding of fossil energy firms (mutatis mutandis)

- Economically significant : relative reduction in holdings by 44%
- Effect along both intensive and extensive margins
- Not an artefact of price fluctuations
- Robust to sequential exclusion of control countries

Additional findings :

- Stronger impact on coal and holdings of stocks + strong (euro area) home bias
- Firm-level regressions : investors forced to climate-related disclosure foster firms' adoption of emission reduction targets.

Related literature

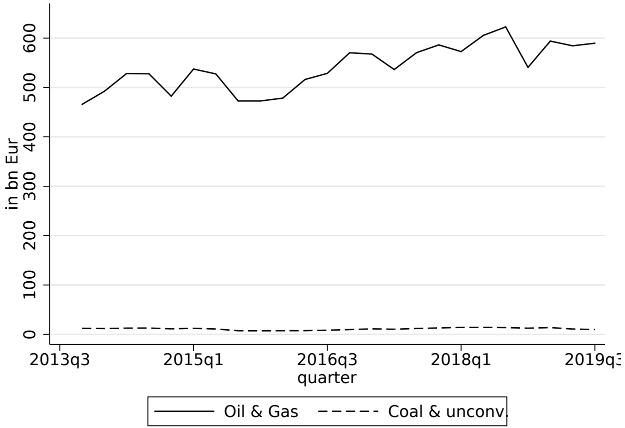
- **Effects of mandatory information disclosure on financial markets.** Financial disclosure : Stiegler (1963), Goldstein and Yang (2017), Jayaraman and Wu (2019). ESG disclosure : Christensen et al., 2017, Ioannou and Serafeim (2017). Carbon emissions : Downar et al. (2019), Jouvenot and Krueger (2020).

⇒ This paper : effects of regulation requiring *investors* to report on their carbon footprint

- **Do investors care for climate ?** Pricing of climate risks : Bolton and Kacperczyk (2020), Ramelli, Ossola and Rankan (2020), Koelbel et al. (2020). Investors perception of risks and ESG performance : Gibson and Krueger (2017), Dyck et al. (2019), Boermans and Galema (2019).

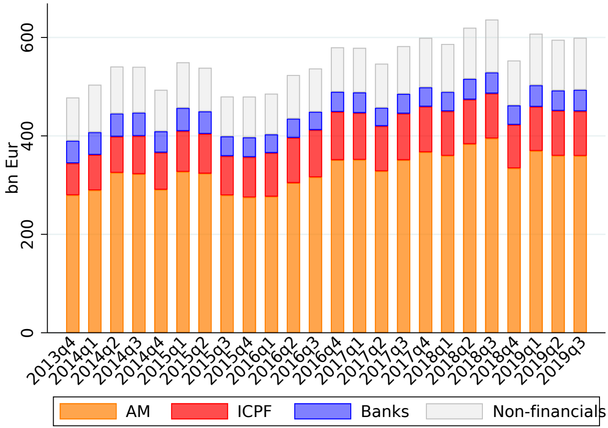
⇒ This paper : divestment from *fossil energy* firms *under constraint to publish* information on carbon footprint.

Euro area investments in fossil fuel firms on the rise



Note. Holdings of bonds and stocks reported by euro area investors (all sectors) in the SHS database. Current market value.

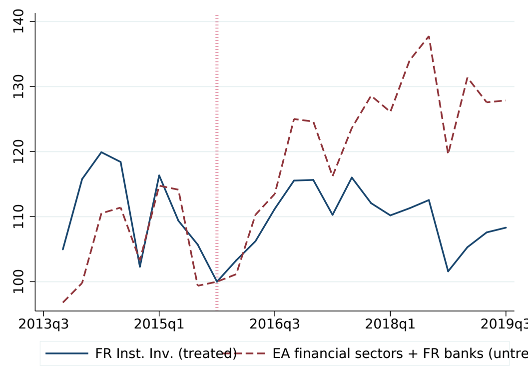
Exposure to fossil energy concentrated in financial sectors



Note. Holdings of bonds and stocks reported by Euro area investors, breakdown by holder sector (AM : Asset managers ; ICPF : Insurances and Pension Funds). Current market values. *Non-financials* include households, non-financial corporations and governement entities.

Preview : aggregate dynamics by treatment group

FIGURE : Cumulated holdings of fossil energy securities, treated vs control financial institutions (2015Q4=100)



Note. Cumulated amounts of fossil energy securities held by "treated" vs "control" institutions. Scaled at 100 in Decembre 2015 (vertical dotted line). Holdings are expressed at market value.

Impact of mandatory disclosure : intensive margin

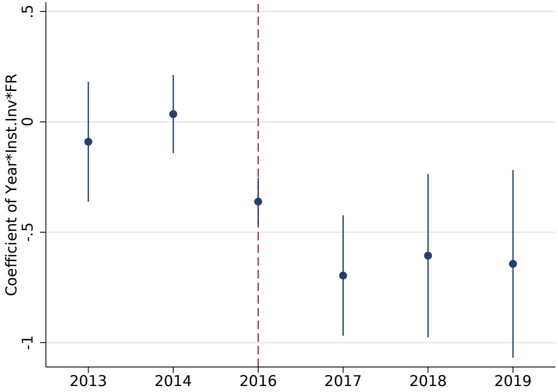
$$\begin{aligned} b_{ihct} = {} & \beta_1 Post_t \times InstInv_h \times FR_c \\ & + \beta_2 POST_t \times FR_c + \beta_3 POST_t \times InstInv_h + \beta_4 InstInv_h \times FR_c \\ & + \gamma_{c,h} + \gamma_{i,t} + \gamma_{c,t} + \gamma_{h,t} + u_{ihct} \end{aligned} \tag{1}$$

	(1)	(2)	(3)	(4)	(5)
Post × InstInv × FR	-0.470**	-0.569***	-0.628***	-0.585***	-0.580***
	[0.208]	[0.197]	[0.169]	[0.148]	[0.107]
Interacted terms	Yes	Yes	Yes		
ISIN FE	Yes	Yes			
Time FE	Yes	Yes			
Country FE	Yes				
Sector FE	Yes				
Country × Sector FE		Yes	Yes	Yes	
Country × Time FE				Yes	Yes
Sector × Time FE				Yes	Yes
ISIN × Time FE			Yes	Yes	Yes
ISIN × Sect. × Count. FE					Yes
Nb clusters	57	57	57	57	57
Observations	587,455	587,455	571,967	571,967	565,672
Adj. R2	0.56	0.62	0.59	0.59	0.90

Note. Dependent variable : holdings at market value (in log) at the ISIN-holder sector-holding country level. Estimation period : 2013-2019. Standard errors are clustered at the holding sector-holding country level.

Economic significance : $\beta_1 = -0.585 \Leftrightarrow$ holdings $\downarrow$ by 44% (*mutatis mutandis*).

Intensive margin, dynamic



Note. Estimated coefficients of the triple interaction terms *Year* × *InstInv* × *FR* in a dynamic version of baseline equation. 2015 is taken as a reference year and hence omitted. The vertical dotted line in 2016 corresponds to the year when the new climate-related disclosure regulation was enacted in France.

Robustness checks : summary

Results qualitatively robust to :

- **Selection of control countries :** dropping each control country in turn
- **Price fluctuations :** computing real holdings at 2015q4 prices
- **Accounting better for heteroscedasticity :** PPML regression
- **Cross-sectional approach :** collapsing time dimension into two 3-years periods.
- **Extensive margin :** running a similar specification to explain the probability of holding fossil energy securities

Extensions : fuel type, institution type, security type, home bias

Differentiated effects by :

- **Fuel type :** $\downarrow -75\%$ if coal/unconventional vs $\downarrow -42\%$ if oil/gas
- **Green bonds :** No impact of removing Green bonds (cf. Bloomberg and Refinitiv lists)
- **Security type :** $\downarrow -74\%$ if stocks vs $\downarrow -2\%$ if bonds (non-significant)
- **Issuer country :** $\downarrow -55\%$ if non-EA vs $\downarrow -13\%$ if EA.

Going for real effects

- Firm-level analysis. Idea : firms whose capital is more held by treated investors might align faster with green transition

TABLE : Firm-level regressions : adoption of CO2 emission targets.

	All firms		Firms held>0 FR II	
	(1)	(2)	(3)	(4)
Treatment intensity	5.276***	11.117***	4.484***	9.374***
	[1.454]	[2.623]	[1.431]	[2.542]
ROA(2015)	-0.541***	-0.917***	-0.636**	-1.054***
	[0.166]	[0.207]	[0.289]	[0.371]
Market cap(2015) (ln)	0.404***	0.568***	0.343***	0.468***
	[0.050]	[0.069]	[0.059]	[0.075]
Country FE	No	Yes	No	Yes
Observations	827	453	361	218
Pseudo R^2	0.28	0.43	0.16	0.32

Note. Cross-sectional probit regressions. Dependent variable : dummy equal to one when the firm has adopted a target for reducing its CO2 emissions as of the end of 2019. *Treatment intensity* is defined at the firm level as the share of equity held by French institutional investors, as of 2015Q4. Market capitalization in expressed in Eur, as of 2015Q4. Columns 1-2 : all fossil fuel firms, even if not held by French institutional investors in 2015. Columns 3-4 : sample restricted to firms with positive treatment intensity. All firm-level controls as of end 2015. White-robust standard errors.

Conclusion

Mandatory climated-related disclosure by investors instrumental in curbing funding of fossil energy industry.

- Calls for extension of such regulation to all types of investors, ideally at EU level.
- Voluntary coalitions may help, but not enough to wipe out effect of regulation over time (Bingler, Kraus, Leippold, 2021 : "Cheap talk and cherry-picking")
- Harmonized reporting may prove more effective (Jouvenot and Krueger, 2020), but even loosely defined reporting standards help.

Appendix

The 2015 French law on climate-related disclosure

Law on Energy transition and green growth (TECV)

- Passed on 17 August 2015, in run-up to Paris COP21
- Enacted by a decree on 29 December 2015, entered into force on 1 January 2016

Art. 173-6 of the law pioneers mandatory climate-related reporting by investors in Europe

- Target : asset management firms (AM - *Sociétés de gestion*), insurance companies and pension funds (ICPF) in France
- Scope : three dimensions of climate-related impact and responsibility :
  - Carbon footprint of investment portfolio
  - Analysis of exposure to physical and transition risks
  - Own contribution to climate change mitigation (portfolio alignment, green share etc.)
- Consistent with disclosure recommendations of FSB's TCFD
- No harmonized methodologies, *Comply-or-explain* basis

The 2015 French law on climate-related disclosure (2)

Implementation of Art. 173-6 monitored by public supervisors (AMF, ACPR) and NGOs (WWF, Novethic...)

- Focus mostly on compliance and quality/sincerity of firms' reports
- Shared conclusion : still insufficient provision of information by many institutions
  - French regulators [ACPR/AMF/DGT/MTES (2019)] : only half of the 48 large institutions publish information on all required dimensions

In contrast, we focus here on investments into fossil energy corporations (holdings of bonds and shares)

No similar regulatory change elsewhere in the Euro area up to 2019

- Revision of 2014 EU NFR Directive, including (non-binding) guidelines on climate-related disclosure starting June 2019
- Consultation on EU sustainable finance strategy starting February 2020 $\Longrightarrow$ SFDR, March 2021.

Back

Toan Phan

Senior Economist, Federal Reserve Bank of Richmond

Climate Defaults and Financial Adaptation

Climate Defaults and Financial Adaptation

Toan Phan* & Felipe Schwartzman*

UCLA Climate Adaptation Symposium

*FRB Richmond

Big picture of climate economics through the lens of post-crisis macrofinance

- Our agenda: Understand roles of financial frictions (ff) in climate economics
- Context
  - Lesson from post-crisis macrofinance literature: shocks can be amplified and propagated because of ff (e.g., small initial subprime losses triggered a prolonged global financial crisis)
  - However, ff are largely absent from current climate econ lit (esp, IAMs); potential amplification and propagation of direct climate damages are largely understudied
  - Incorporating ff into climate models could potentially help us understand pressing policy questions (e.g., how do climate risks affect financial stability, or financial policies)

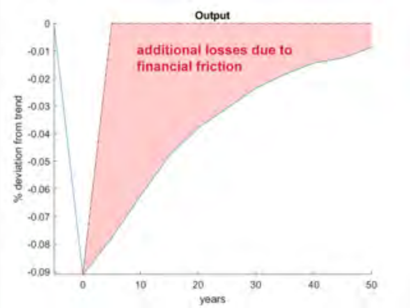
This paper

- Consider a relevant friction: sovereign default risk
- Goals: Develop a theoretical framework to understand
  - Roles of default risk in small economies exposed to climate-related disasters
  - Roles of financial adaptation (different from physical adaptaion)
- Method:
  - Small open economy growth model with default risk & disaster risk
  - Model very tractable; evaluate theoretical predictions against existing empirical patterns
  - Model quantifiable; calibrate to estimates of cyclone damages

Main findings

- Vicious investment-default cycle

- This vicious cycle significantly delays recovery



- Financial adaptation can reduce welfare loss of climate change, but only partially

Model in a nutshell

- Small open economy; representative government with Epstein Zin preferences. Production:

$$Y_t = \left(e^{-\text{disaster damage}_t} K_t\right)^{\alpha} (A_t)^{1-\alpha}$$

- Sovereign debt market:
  - Government issues non-contingent one-period bonds to risk-neutral foreign lenders
  - Default cost assumption: fraction ℓ of output is lost (and no credit exclusion)
  - Tractable equilibrium bond pricing:

$$q_t = \frac{1}{1+r}\left(1 - \overbrace{\Pr[\text{debt}/\text{gdp}_{t+1} > \ell\ ]}^{\text{default prob or spread}}\right)$$

▸ Spread surface plot

▸ Model details

Analytical results

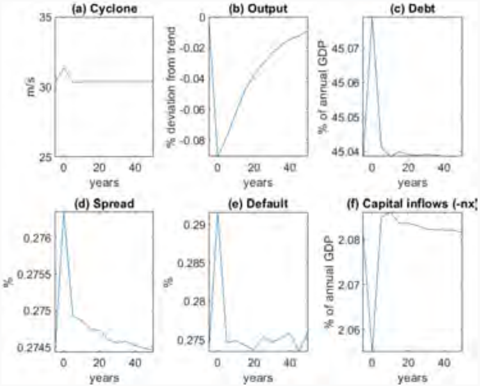
- In the paper, we show that equilibrium spread schedule (borrowing cost)
  1. Increases in borrowing
  2. Decreases in investment
  3. Increases in disaster risk
- Implications: emerging economies with more climate vulnerability face
  - higher borrowing costs &
  - higher probability of debt crises
  - Consistent with empirics in Barnett et al (2020), Beirne et al (2020), Kling et al (2018)

Quantitative exercise (currently work in progress)

Key parameters:

- Calibrate disaster process and damage intensity to match state-of-the-art empirical estimates of cyclones (Hsiang Jina 2014, Bakkensen Barrage 2019)
- Calibrate default cost to match average observed debt/GDP ratio of emerging economies
- A period: 5 years

Impulse responses to a cyclone activity shock

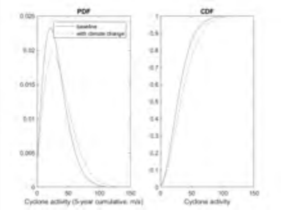


Maria shock

- Output: Very slow recovery (largely consistent with empirics from Hsiang Jina 2014 & our own estimates using Bakkensen Barrage's data)
- Spread & equilibrium default: both significantly increased after cyclone shock (consistent with Klomp 2015, 2017)

Climate change & financial adaptation

- Assume cyclone risk increased by 20% (Emmanuel et al. 2008's estimate for West Pacific basin in 2090 under business as usual)



- Assume country can optimally choose to adopt two forms of financial adaptation:
  - Disaster insurance sold at actuarially fair price ▸ Details
  - Issue catastrophe sovereign bonds (bonds contingent on disaster realization) ▸ Details

Welfare effects

	short-run	long-run
Increased cyclone risk[1]	-1.64%	-3.24%
Insurance[2]	0.18%	0.23%
CAT bonds[2]	0.06%	0.09%
Insurance+CAT bonds[2]	0.25%	0.34%

- **Welfare loss** from increased cyclone risk: ∼3% of permanent consumption
- **Financial adaptation** can reduce this loss by ∼10%
  - CAT bonds raise ex-ante debt capacity
  - Disaster insurance speeds up ex-post recovery (consistent with empirics in von Peter et al 2012)

Notes
1: change relative to baseline economy
2: change relative to economy with increased cyclone risk due to climate change
Short-run: welfare change evaluated at a fixed net worth ($V^{new}(\bar{m})/V^{old}(\bar{m})$, $\bar{m} = E[m|\text{old}]$)

Long-run: steady state welfare change ($E[V^{new}(m)|\text{new}]/E\left[V^{old}(m)|\text{old}\right]$)

Conclusion

Tractable & quantifiable framework to analyze

- Climate default risk, i.e., interaction between
  - Physical risk of climate-related disasters
  - Financial risk of sovereign default
- Financial adaptation
  - Provision of insurance-linked securities/contracts
- Main findings:
  - Default risk significantly delays post-disaster recovery (via a vicious investment-default feedback loop)
  - Significant welfare loss from increased cyclone risk in calibrated economy with financial friction
  - Financial adaptation can help (to a moderate degree)

Appendix

Model details

- Production

$$Y_t = \left(\overbrace{e^{-x_t d_t}}^{\text{disaster risk}} K_t \right)^{\alpha} A_t^{1-\alpha}$$

  - disaster onset $x_t \in \{0,1\}$, $\Pr(x_t = 1) = p$
  - disaster damage $d_t \overset{\text{iid}}{\sim} \Phi_d$ over $\mathbb{R}_+$
  - TFP has volatile trend: $\ln \frac{A_t}{A_{t-1}} = g_t$ (Aguiar Gopinath 2007)
    - Assume iid g_t (for simplicity)

- Epstein Zin preferences

$$V_t = \left(C_t^{1-\iota} + \beta E_t \left(V_{t+1}^{1-\gamma} \right)^{\frac{1-\iota}{1-\gamma}} \right)^{\frac{1}{1-\iota}}$$

  - Detrend variables by TFP $v_t := \frac{V_t}{A_t}, k_t := \frac{K_t}{A_t}, b_t := \frac{B_t}{A_t}, \ldots$

Sovereign borrowing

- In each t, after shocks realize, country chooses: **repay/default**; **new debt issuance** b_n; new investment k_n
  - Debt instrument: non-contingent one-period bonds
  - Law of motion with shocks:

$$b' = e^{-g'} b_n$$

$$k' = e^{-x'd'-g'} k_n$$

- Cannot commit. **Default cost: fraction ℓ of output is lost**
  - Note: no credit exclusion (great tractability & credit exclusion is generally not quantitatively important in sov debt models)

- Default iff

$$\underbrace{k'^{\alpha} + (1-\delta)k' - b'}_{\text{net worth } m'_{Repay}} < \underbrace{(1-\ell)k'^{\alpha} + (1-\delta)k' - 0}_{m'_{Default}}$$

Recursive formulation

- *Very tractable* model: net worth is only state variable

$$v(m)^{1-\iota} = \max_{k_n,b_n} c^{1-\iota} + \beta E\left[v(\max\{m'_R, m'_D\})^{1-\gamma} e^{(1-\gamma)g'}\right]^{\frac{1-\iota}{1-\gamma}}$$

$$\text{s.t. } c = m - k_n + q(b_n,k_n)b_n$$

- Risk-neutral lenders' bond pricing:

$$q(b_n,k_n) = \frac{1}{1+r}\left(1 - \overbrace{\Pr[\underbrace{\frac{b'}{y'}}_{\text{debt/gdp}} > \ell\,]}^{\text{default prob or spread } s(b_n,k_n)}\right)$$

Back

Higher investment lowers default risk & borrowing cost

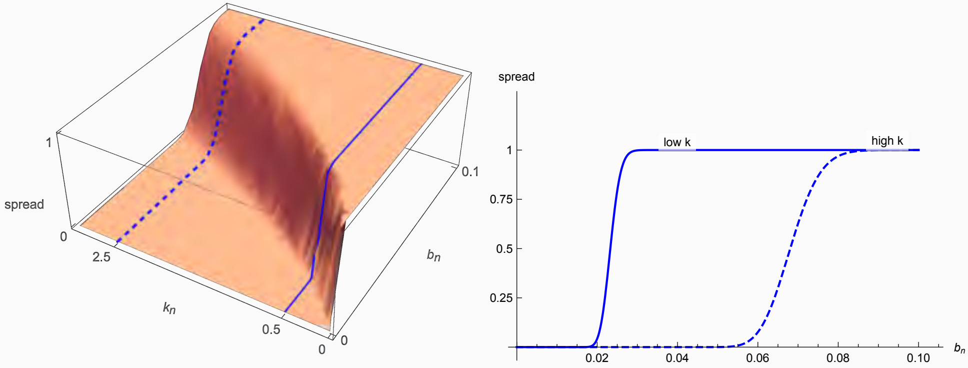
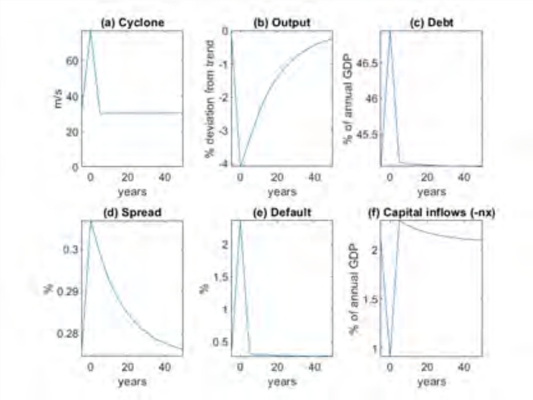


Figure 1: Default probability as function of investment k_n and bond issuance b_n

Back

Impulse responses to a "Maria shock"



- Cyclone activity at $t = 0$ increases to 77m/s (max wind speed of Hurricane Maria)
  - Note nonlinear response of equilibrium default to cyclone activity shock
  - Reflects nonlinearity in default decision: country chooses to do so only in very bad states

Back

Details: Disaster insurance

- Country can buy disaster insurance. Assumptions:
  - Sold at *actuarily fair price*
  - Contract is *intratemporal* (while bonds are intertemporal)
  - Country receives insurance payments *regardless* of default
  - Timing: country chooses insurance after g' realizes but before disaster or default decisions

back

Details: CAT bonds

- Catastrophe bonds: face value $\rightarrow 0$ if $x = 1$ (disaster hits) and $d > \bar{d}$ (damage exceeds a certain threshold)
- Optimization problem:

$$v(m)^{1-\iota} = \max_{k_n, b_n, \theta} c^{1-\iota} + \beta E \left[v(\max\{m'_R, m'_D\})^{1-\gamma} e^{(1-\gamma)g'} \right]^{\frac{1-\iota}{1-\gamma}}$$

$$\text{s.t. } c = m - k_n + q(b_n, k_n, \theta) b_n, \; \theta := \frac{B^{CAT'}}{B' + B^{CAT'}}$$

◂ back

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Banking on Carbon: Corporate Lending and Cap-and-Trade Policy

Banking on Carbon: Corporate Lending and Cap-and-Trade Policy

Ivan Ivanov[†], Mathias Kruttli[†], and Sumudu Watugala[‡]

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September 8, 2021

The views expressed here are those of the authors and not necessarily those of the Federal Reserve Board of Governors or the Federal Reserve System.

Outline

Motivation

- Debate on climate change and financial stability.
- Discussion centers around physical and transition risks.
  - *"... **transition risks**: the financial risks which could result from the process of adjustment towards a lower-carbon economy"* (Carney, 2015).
  - Tradeoff between physical and transition risks.
- Banks are some of the largest stakeholders in the transition to a low-carbon economy:
  - Mandatory emissions reductions could adversely affect borrowers.
  - Does climate change regulation affect bank health and financial stability?

Our paper

- Focus on a prominent policy tool in climate change regulation: cap-and-trade programs.
- Study cap-and-trade bills as they move through the legislative process.
  - Isolate period of high transition risk.
  - Heterogeneous treatment of firms.
- Analyze how banks manage exposure to affected private and public firms.
  - Assess bank expectations of program impact on firms.
  - Important evidence for architects of cap-and-trade programs.
- Examine the California and Waxman-Markey cap-and-trade bills.
  - Different time periods and treatment dimensions help assess external validity.

The California cap-and-trade bill

Passed in 2011 and implemented in 2013.

The Waxman-Markey cap-and-trade bill

Passed the House in June 2009 and, after high probability of passing the Senate, ultimately failed in July 2010.

Main results

- Banks gain flexibility to revoke credit in response to cap-and-trade regulation. Covered firms have:
  - Shorter loan maturity
  - Decrease in share of term loans
  - Interest rates increase
  - Total loan commitments and utilization unchanged
- Results concentrated within private firms.
  - Banks expect private firms to face greater challenges.
- Banks also appear to reduce transition risks exposure by:
  - Selling loans to shadow banks.
  - Monitoring firms more closely.

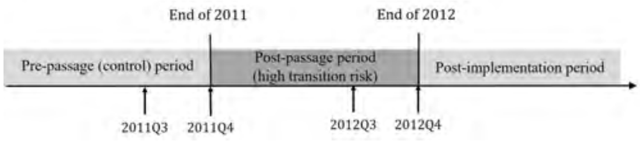
Outline

Data

- California analysis
  - Federal Reserve's Y-14 Collection:
    - Covers both syndicated and bilateral loans >$1 million since 2011.
    - Has interest rate data and includes smaller private firms.
  - Emissions data from the EPA
    - Mandatory reporting by facilities emitting $\geq$25,000MT/yr CO_2 equiv.
    - Covers both direct and indirect emissions.
    - Aggregate firms to the parent level and map to credit data.
- Waxman-Markey analysis
  - Shared National Credit (SNC) Program
    - Covers virtually entire syndicated loan market, including private firms.
    - Provides a complete view of lending syndicate, including non-bank participants.

Outline

Identification strategy: California cap-and-trade bill



- First difference: Compare lending in Q3-4 2011 (pre) to Q3-4 2012 (post).
- Second difference: Use EPA data to determine firms with large share of high emission facilities in California (Bartram, Hou, and Kim, 2021).
  - Threshold 1: Firm's CA emission $> 25\%$
  - Threshold 2: Firm's CA emission $> 50\%$

California regression specification

- Baseline regression specification:

$$y_{i,q} = \lambda I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}} + Controls_{i,q} + \psi_i + \phi_{q,ind} + \epsilon_{i,q}.$$

  - $I_{CA\_Emissions_i > 50\%}$ is 1 if firm i has a CA emission share of $> 50\%$, 0 otherwise.
  - Dependent variables are equilibrium outcomes of the loan contracting process between banks and firms:
    - Credit commitment
    - Maturity
    - Fraction of term loans (vs. credit lines)
  - λ is negative if banks cut credit commitment or seek higher contract flexibility.

California analysis

	Log committed credit		Maturity (in months)		Term loans share (0 to 1)	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{CA\_Emissions_i>25\%} \times I_{\text{Post CA bill}}$	0.015		-3.905**		-0.245***	
	(0.061)		(1.670)		(0.034)	
$I_{CA\_Emissions_i>50\%} \times I_{\text{Post CA bill}}$		0.030		-4.946***		-0.262***
		(0.072)		(1.633)		(0.043)
Observations	2,717	2,717	2,717	2,717	2,717	2,717
R2	0.965	0.965	0.807	0.808	0.717	0.719
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes

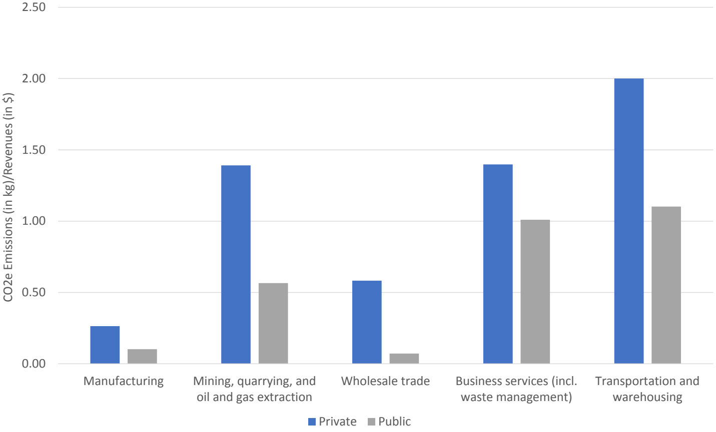
Firms with large CA emissions have:

- 4-5 months shorter maturity
- 0.25 lower term loan share

Private vs. public firms

- Results so far consistent with banks paying attention to transition risks.
- Explore heterogeneity in the effect of cap-and-trade programs on firms:
  - Important knowledge for the design of cap-and-trade policies.
- Different effects for public versus private firms?
  - Private (smaller) firms tend to be more financially constrained.
  - Economies of scale in regulation compliance.
  - Private firms tend to use older equipment and are likely less efficient.

Emissions inefficiency higher for private firms



California analysis - private firms only

	Log committed credit		Maturity (in months)		Term loans share (0 to 1)	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{CA\_Emissions_i > 25\%} \times I_{\text{Post CA bill}}$	0.028		-6.318**		-0.535***	
	(0.146)		(2.431)		(0.078)	
$I_{CA\_Emissions_i > 50\%} \times I_{\text{Post CA bill}}$		0.031		-5.539*		-0.498***
		(0.160)		(2.875)		(0.103)
Observations	1,546	1,546	1,546	1,546	1,546	1,546
R2	0.956	0.956	0.861	0.861	0.776	0.776
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes

Effects for private firms are substantially larger.

California analysis - public firms only

	Log committed credit		Maturity (in months)		Term loans share (0 to 1)	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{CA\_Emissions_i>25\%} \times I_{\text{Post CA bill}}$	0.223**		1.617		0.011	
	(0.086)		(3.160)		(0.040)	
$I_{CA\_Emissions_i>50\%} \times I_{\text{Post CA bill}}$		0.058		-1.788		0.001
		(0.113)		(4.234)		(0.043)
Observations	822	822	822	822	822	822
R2	0.977	0.978	0.810	0.811	0.829	0.829
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes

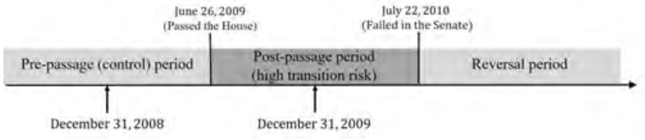
No effects for public firms.

California analysis - impact on interest rates

	Full sample				Private firms				Public firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$I_{CA\_Emissions_i>25\%} \times I_{\text{Post CA bill}}$	0.667*		0.538*		1.748**		1.013*		0.175		0.082	
	(0.395)		(0.270)		(0.719)		(0.552)		(0.458)		(0.474)	
$I_{CA\_Emissions_i>50\%} \times I_{\text{Post CA bill}}$		0.294		0.137		2.299**		1.356		-0.967*		-0.958*
		(0.662)		(0.523)		(1.031)		(0.889)		(0.480)		(0.508)
Observations	1,191	1,191	1,191	1,191	610	610	609	609	390	390	384	384
R2	0.911	0.910	0.919	0.918	0.953	0.954	0.959	0.959	0.916	0.917	0.925	0.927
Controls	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Banks require compensation from private firms for bearing transition risks.

Identification strategy: Waxman-Markey bill



- First difference: Compare lending in 2008 (pre) to 2009 (post).
- Second difference: Exploit difference in how high-emission manufacturing firms would be impacted by the law (Meng, 2017).
  - Manufacturing firms from sectors (6-digit NAICS) with an energy intensity of above 5% get allocated "free permits" for emissions.
  - Firms *below* the threshold are *treated*. Firms *above* the threshold are *controls*.
- Examine manufacturing firms close to the 5% threshold.

Waxman-Markey analysis: private firms

	Log committed credit		Maturity (in months)		Term loans share (0 to 1)	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{i \in Treated} \times I_{t=2009}$	-0.049		-10.317*		-0.240***	
	(0.059)		(5.181)		(0.068)	
$I_{i \in TreatedWide} \times I_{t=2009}$		0.053		-8.354*		-0.214***
		(0.071)		(4.573)		(0.052)
Observations	170	276	170	276	170	276
R2	0.965	0.954	0.820	0.852	0.868	0.842
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Lead bank FE	Yes	Yes	Yes	Yes	Yes	Yes

Again, substantially stronger effect for private firms:

- 9 months shorter maturity
- 0.20 lower term loan share

Waxman-Markey analysis: public firms

	Log committed credit		Maturity (in months)		Term loans share (0 to 1)	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{i \in Treated} \times I_{t=2009}$	0.108		-0.532		0.060	
	(0.088)		(2.304)		(0.056)	
$I_{i \in TreatedWide} \times I_{t=2009}$		0.066		1.969		0.041
		(0.062)		(2.368)		(0.051)
Observations	172	348	172	348	172	348
R2	0.945	0.963	0.926	0.858	0.876	0.858
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Lead bank FE	Yes	Yes	Yes	Yes	Yes	Yes

No effect for public firms.

Outline

Banks manage transition risks in alternative ways

- So far, results consistent with banks managing transition risk by increasing contract flexibility.

- Banks have alternative ways to mitigate exposure to firms covered by a cap-and-trade program.

- Sell syndicated loans on the secondary loan market.
  - SNC comprehensively covers the participants in lending syndicates over the life of the loan.
  - Observe dynamics for both banks and shadow banks.

- Unlike equilibrium outcomes of the loan contracting process, banks can unilaterally decide to sell loans.
  - Isolate banks expectations for firm outcomes.

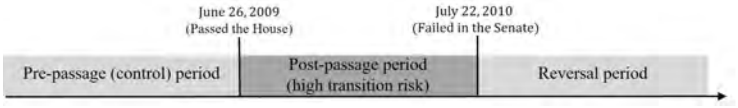
Loan sales and the Waxman-Markey bill

- Lenders with higher ex ante exposure to GHG-emitting firms participate less in covered firms' syndicates and more likely to sell loans.
- Shadow bank share increases by about 0.07 (avg. 0.15).

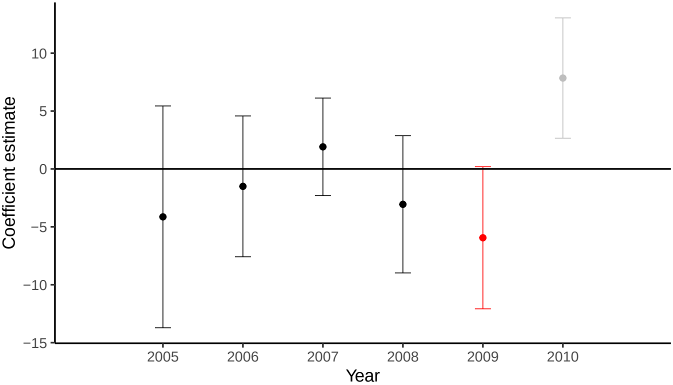
	All firms		Private firms		Public firms	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{i \in Treated} \times I_{t=2009}$	0.054**		0.071*		0.026	
	(0.026)		(0.037)		(0.029)	
$I_{i \in TreatedWide} \times I_{t=2009}$		0.067***		0.107***		0.019
		(0.022)		(0.026)		(0.027)
Observations	342	624	170	276	172	348
R2	0.877	0.883	0.841	0.844	0.928	0.927
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Lead bank FE	Yes	Yes	Yes	Yes	Yes	Yes

Placebo tests

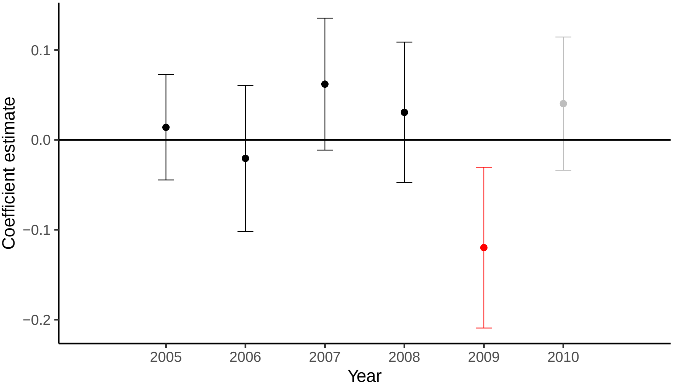
- Do treated and control groups exhibit similar trends before treatment occurred?
- Using two different natural experiments with similar findings alleviates this concern.
- Placebo regressions for Waxman-Markey analysis.
  - "Falsify" treatment in the years before the bill's passage.
  - We should see reversal of effects in 2010 when the bill fails the Senate.



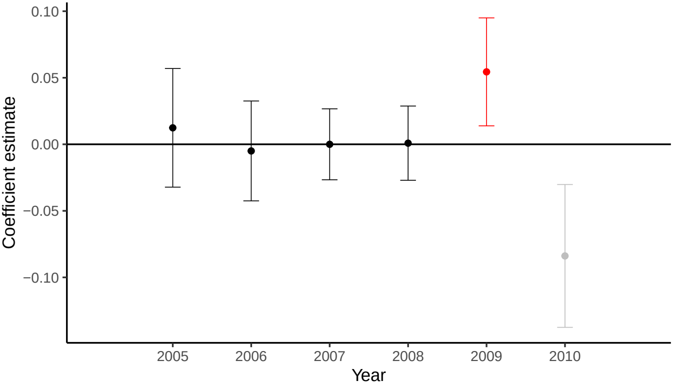
Placebo test: remaining maturity



Placebo test: term loans share



Placebo test: shadow bank share



Firm balance sheet effects

- We use Y-14 balance sheet information for private and public firms.
- Covered firms increase both cash holdings and capital expenditures right after the CA bill's passage.
- These effects revert to pre-passage levels following the bill's implementation.

Outline

Conclusion

- We show that banks act swiftly to reduce transition risks
  - Require additional compensation for bearing transition risk.
  - Reduce syndicate participation in favor of shadow banks.
  - Transition risks unlikely to pose systemic stability risks for banking sector.
- Effects concentrated within the subsample of private firms.
- Adverse effects of cap-and-trade programs on affected private firms:
  - Evidence potentially useful for design of cap-and-trade policies.

Outline

Waxman-Markey regression specification

- Baseline regression specification:

$$y_{i,t} = \lambda I_{i \in Treated} \times I_{t=2009} + Controls_{i,t} + \psi_i + \phi_t + \gamma_b + \epsilon_{i,t}.$$

  - $I_{i \in Treated} = 1$ if firm i does not receive a free permit, 0 otherwise.
  - Same dependent variables as for California analysis:
    - Credit commitments
    - Maturity
    - Fraction of term loans (vs. credit lines)
  - λ is negative if banks cut credit commitments or seek higher contract flexibility.

- Different cap-and-trade bill, but we find results in the same direction and of similar magnitude.

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Natural Disasters, Climate Change, and Sovereign Risk

Natural Disasters, Climate Change, and Sovereign Risk

Enrico Mallucci

Federal Reserve Board

September, 2021

Disclaimer: The views in this paper are solely mine and should not be interpreted as reflecting the views of the Federal Reserve System or of any other person associated with these institutions.

Motivation

Wide range of shocks may tip countries with fiscal vulnerabilities in a sovereign debt crisis (Erce et al., 2020):

- Domestic shocks (i.e. banking crises, political uncertainty)
- International shocks (i.e fluctuations of commodity prices or risk-free rate)
- Disasters (i.e. pandemics, wars, natural disasters)

Motivation II

- Studies on the link between disasters and sovereign risk have lagged behind
  - Wars (Horn et al., 2020)
  - Pandemics (Arellano et al., 2020)
  - Natural disasters

Motivation III

Natural disasters appear especially salient:

- They have played an important role in recent default episodes (Moldova 1993, Ecuador 1997, Suriname 1998, Grenada 2004, Antigua y Barbuda 2004-2009,...)
- Evidence that vulnerabilities to climate change already affects borrowing costs (Cevik et al. 2020)
- Their frequency and intensity is expected to increase amid climate change
- Recent emphasis on natural disaster risk in macroeconomic risk management (IMF)

Motivation IV

Caribbean countries are especially vulnerable to extreme weather:

- They are regularly hit by major hurricanes
- They are small: natural disasters have a nation-wide impact

Some Caribbean countries have began to issue bonds with disaster clauses:

- Debt moratorium if the economy is struck by natural disasters
- Official lenders have endorsed disaster clauses

Grenada

Research Questions

- How do natural disasters affect sovereign risk?
- How will climate change affect governments' borrowing terms in the future?
- Can disaster clauses help?

I answer these questions through the lens of a sovereign default model that I calibrate to a sample of 7 countries:

- Antigua y Barbuda, Belize, Dominican Republic, Dominica, Grenada, Honduras, and Jamaica

Results

- Natural disasters reduce governments' ability to borrow
- Climate change will further reduce market access
- Disaster clauses improve governments' access to financial markets, but may lead to overborrowing
  - Debt limits may be needed in conjunction with disaster clauses

Model

Model Highlights

Endogenous sovereign default model á la Eaton-Gersovitz (1981):

- Benevolent government: Borrowing and default decisions maximize welfare
- Two costs of default: output cost of default and autarky
- Long-term debt (Hatchondo et al., 2009)
- Natural disasters: exogenous disaster risk affecting endowment

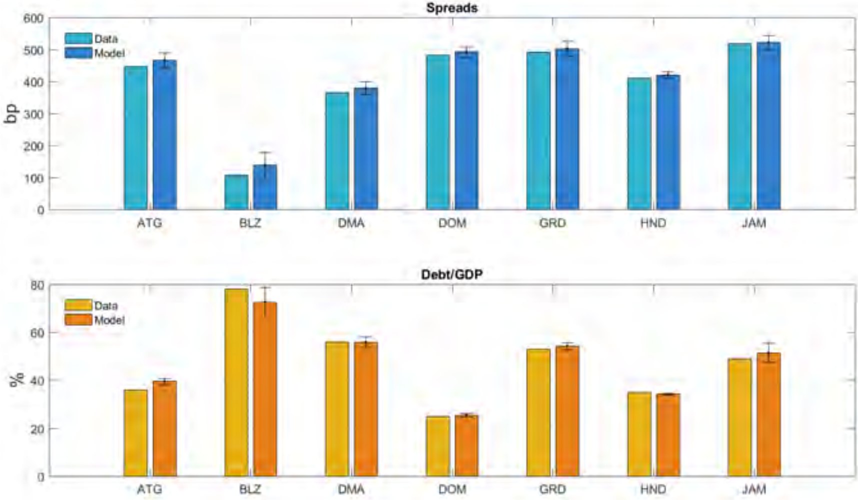
Calibration

Model is calibrated to reproduce 7 Caribbean economies at the annual frequency:

- Disaster risk parameters: frequency and intensity of major hurricanes (Cat. III and above)
- Income process parameters: GDP data from 1980 to 2019
- Discount factor and output costs of defaults are jointly calibrated to match spreads and debt-to-GDP ratios

Quantitative Analysis

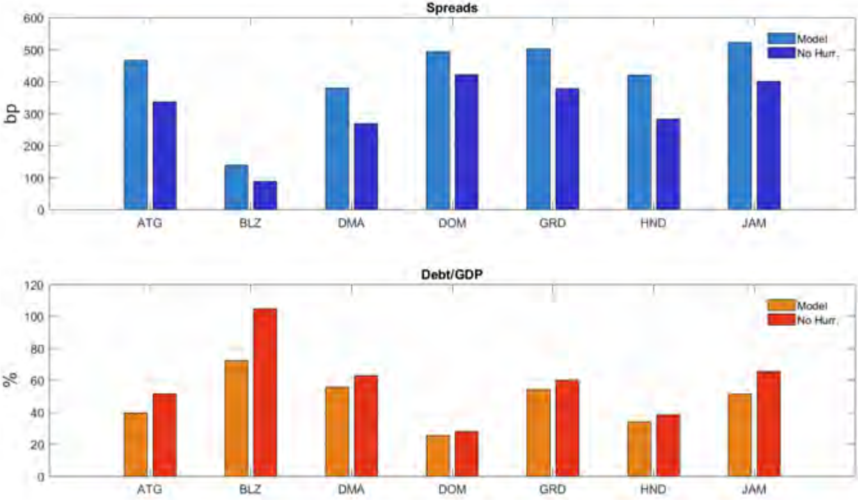
Moment Matching Exercise



Counterfactual Exercises

- Eliminate hurricane risk
- Climate change

No Hurricane Risk - Lower Spreads, Higher Debt

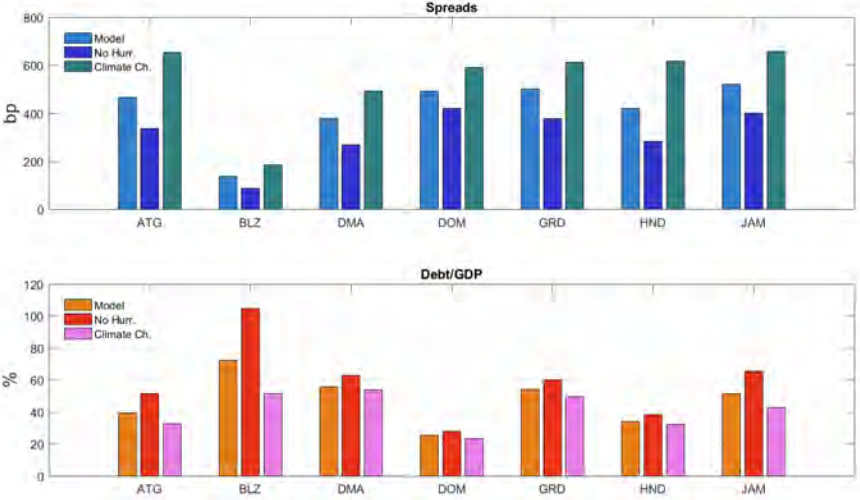


Climate Change

Higher frequency and intensity of major hurricanes:

- Frequency to increase 29.2% (Bhatia et al., 2018)
- Economic costs to increase 48.5% due to intensity of winds (Acevedo, 2016)

Climate Change - Higher Spreads, Lower Debt



Summarizing

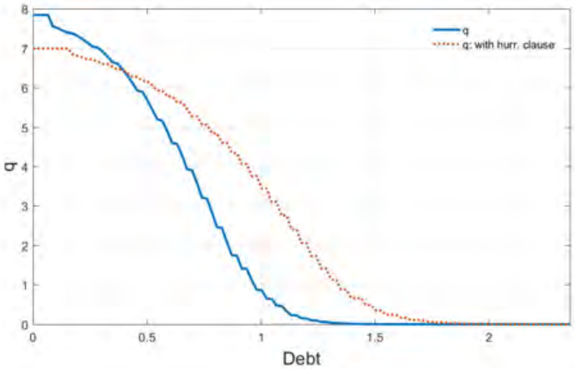
- Hurricane risk restricts governments' access to financial markets
- Debt-to-GDP ratios decline and spreads increase
- Climate change will further restrict on governments' market access

Disaster Clauses

Modeling Disaster Clauses

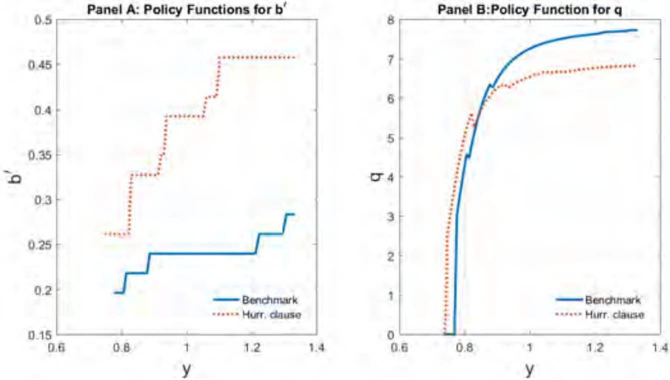
- Disaster clauses allow for a one-period debt moratorium, when hurricanes hit
- Governments choose whether to activate the clause
- No output cost of activating the hurricane clause

Hurricane Clause: Price Function



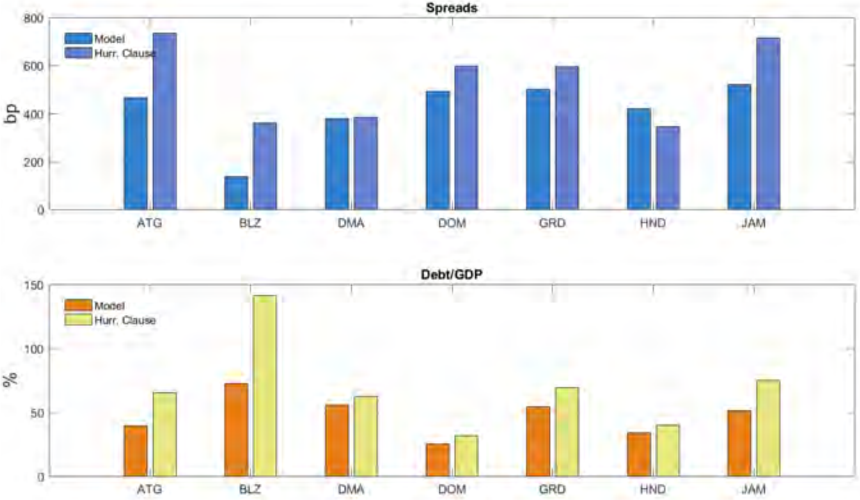
- Borrowing terms are generally better with disaster clauses: $q_{hc} \geq q$
- The risk of delayed repayment explains why $q_{hc} \leq q$ when default risk is zero

Hurricane Clause: Policy Functions

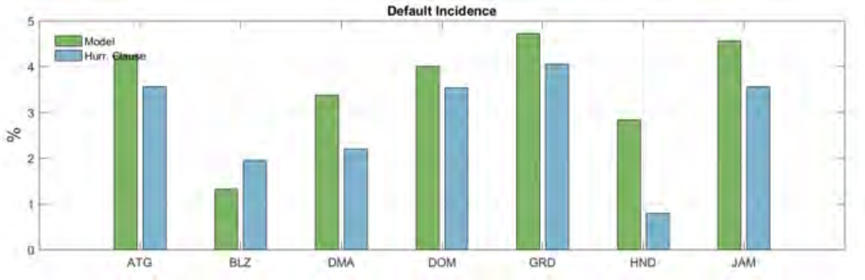


- Sizable increase of government debt
- In equilibrium, the price of government debt declines

Hurricane Clause - Higher Spreads, Higher Debt

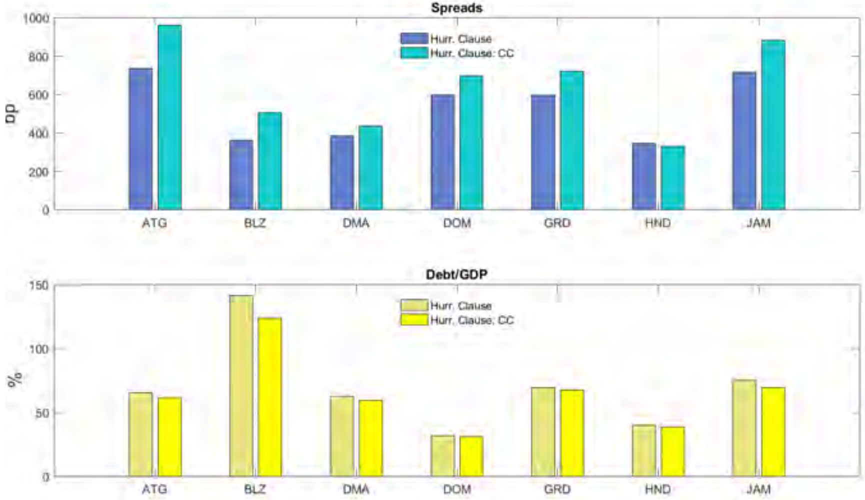


Hurricane Clause- Same Default Risk



- Default risk is little changed
- Rise in spreads is due to risk of delayed repayment
- Total borrowing costs are little affected by delay risk:
  - Price of government debt declines
  - Debt servicing costs decline

Climate Change - Higher Spreads, Same Debt



Climate Change

1. Without the hurricane clause:
   - Lower debt, higher spreads
2. With the hurricane clause:
   - Same debt, higher spreads due to delay risk
   - Hurricane clause insulate government against the rise in the frequency of disasters

Hurricane Clause: Welfare analysis

- Δ_{WC}: Consumption equivalent welfare change that makes an agent in the economy without disaster clauses indifferent between that economy and the one with the disaster clause
- Agents are worse off with hurricane clauses: overborrowing depresses consumption

Welfare Analysis

Moment	ATG	BLZ	DMA	DOM	GRD	HND	JAM
Δ_{WC}	-2.76%	-7.09%	-0.96%	-1.22%	-1.60%	-1.57%	-1.41%

Hurricane Clauses and Debt Limits: Welfare analysis

- Debt limit: debt levels cannot exceed those the baseline scenario
- Repeat welfare analysis: welfare increases

Welfare Analysis - Disaster Clause and Debt Limits

Moment	ATG	BLZ	DMA	DOM	GRD	HND	JAM
Δ^{DL}_{WC}	2.02%	3.63%	0.26%	1.34%	1.06%	1.19%	1.87%

Conclusions

- Natural disasters reduce governments' ability to borrow
- Climate change will further reduce market access
- Disaster clauses improve governments' access to financial markets, but lead to overborrowing
- Rich research agenda
  - Climate adaption policies
  - Official credit, international aids, private insurances

Motivation V

The case of Grenada is quintessential:

- Grenada began cumulating large deficits in the early 2000s
- September 2004, hurricane Ivan hits Grenada:
  - Damages worth 148% of GDP
  - The entire crop of nutmeg was wiped out
  - Tourism infrastructures were damaged
- In October 2004, debt restructuring
- In 2013, bonds featuring a disaster clause were issued

Back

Step I: Non-default Scenario

$$W^{nd}(y,h,b) = \max_{c,b'} \; u(c) + \beta \mathbb{E} W\left(y',h',b'\right)$$

$$\text{s.t.} \;\; c = y + q\left(b' - (1-\psi)b\right) - b$$

$$q(y,h,b) = \frac{1}{(1+r^{rf})} E\left[\left(1-d'\right) + (1-\psi)\left(1-d'\right)q'\right].$$

Government bonds are perpetuities with decay parameter ψ.

Step II: Default Scenario

$$W^d\left(y,h,0\right)=u\left(c\right)+\beta\mathbb{E}\left[(1-\lambda)W^d\left(y',h',0\right)+\lambda W\left(y',h',0\right)\right]$$

$$\text{s.t. } c=\delta(y)$$

Where $\delta(y)$ is an output cost of default

$$\delta(y)=\begin{cases} y & \text{if } y\leq\delta \\ \delta & \text{if } y>\delta \end{cases}.$$

Step III: Default Decision

Government compares value functions in the default scenario and in the non-default scenario:

$$W = \max_{d} \left\{ (1-d)\, W^{nd} + dW^{d} \right\}$$

- d: default decision
- W^{d}: value function in the default scenario
- W^{nd}: value function in the non-default scenario

International Lenders

- Have access to government bonds and risk-free bonds
- Price government bonds by arbitrage:

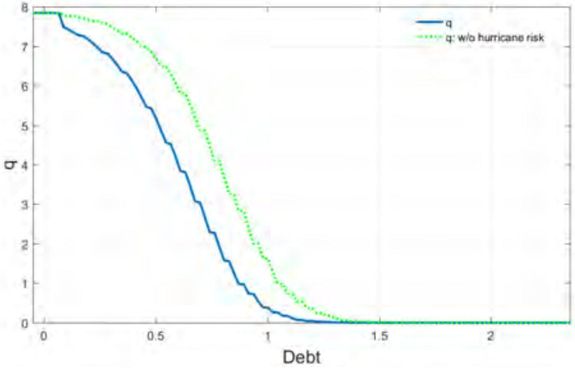
$$q\left(y,h,b\right)=\frac{1}{\left(1+r^{rf}\right)}E\left[\left(1-d'\right)+\left(1-\psi\right)\left(1-d'\right)q'\right]$$

Back

Eliminating Hurricane Risk -Intuition

Elimination of hurricane risk reduces output fluctuations:

- The price function shifts out



Back

Up next – 10:45am-12:15pm PT

SESSION 2.1

International Lessons on Climate Adaptation

SESSION 2.2

Before the Storm: Responses to Forecasts

SESSION 2.3

Quantifying and Minimizing the Impacts of Wildfires

SESSION 2.4

Proactive Planning for Resilient and Equitable Communities

CLIMATE ADAPTATION
RESEARCH SYMPOSIUM

MEASURING & REDUCING SOCIETAL IMPACTS

Thanks for tuning in!

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