Natural Disasters, Climate Change, and Sovereign Risk

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November, 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 the 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)

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,...)
- Extreme weather events 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 quantitative 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 obstacle 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

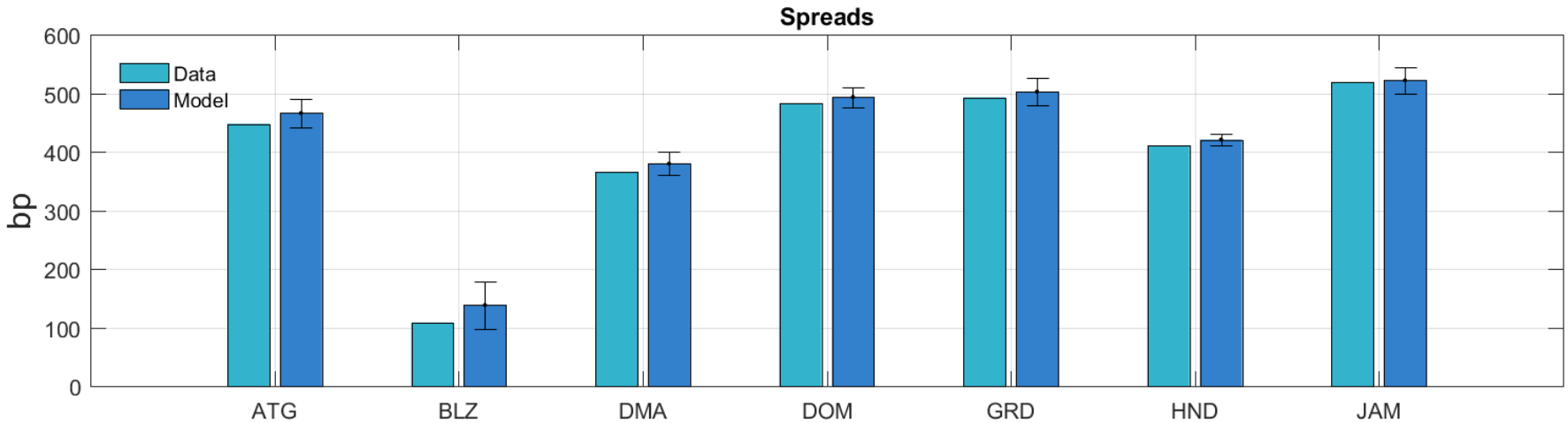
Calibration

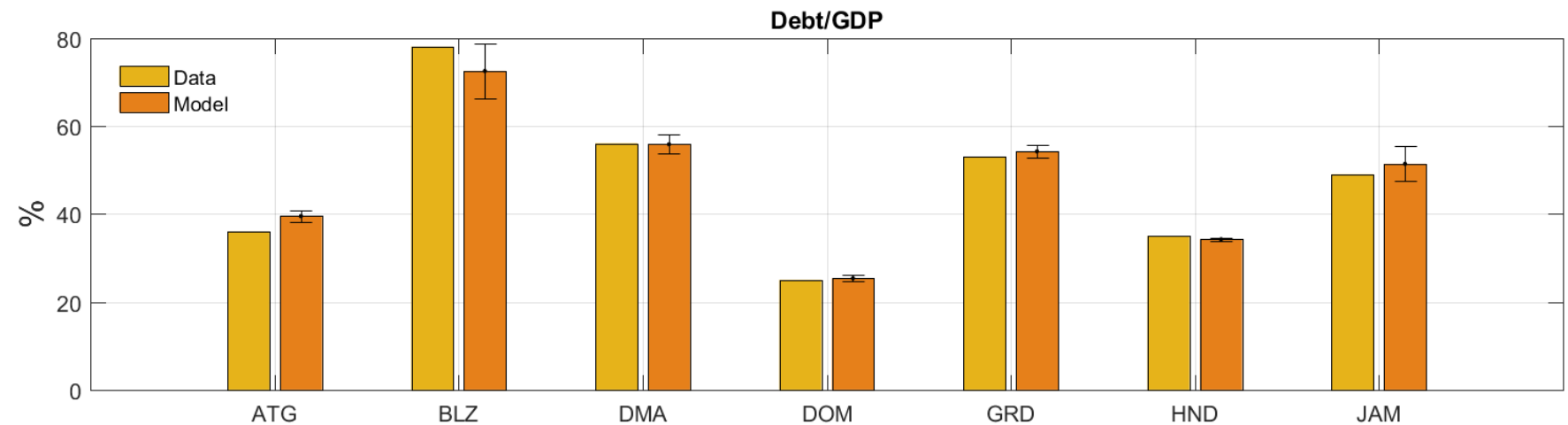
Model is calibrated to reproduce 7 Caribbean economies at the annual frequency:

- 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

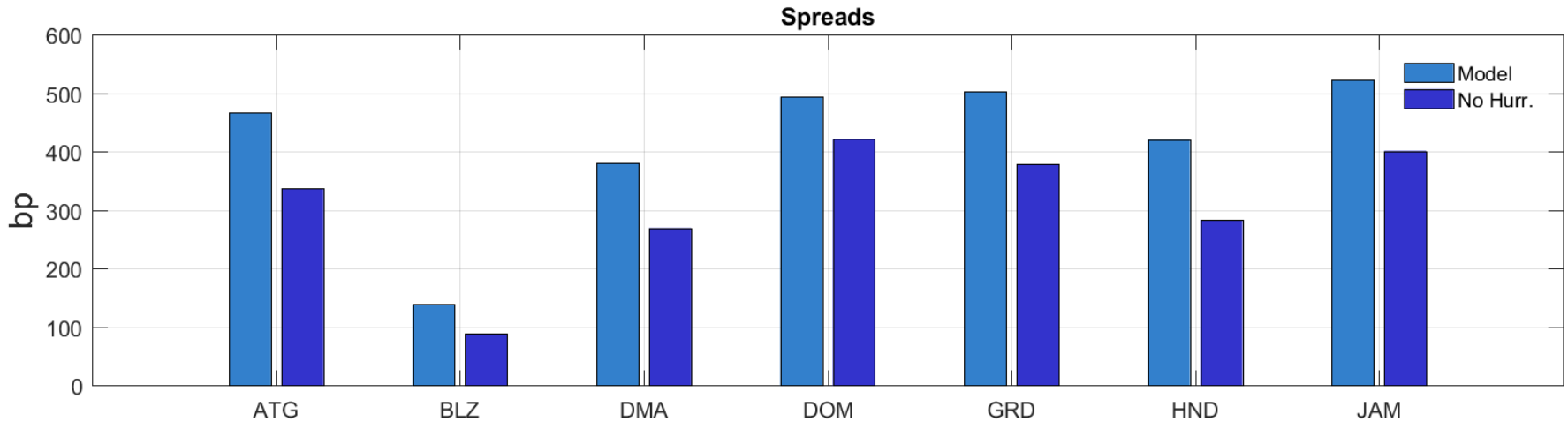


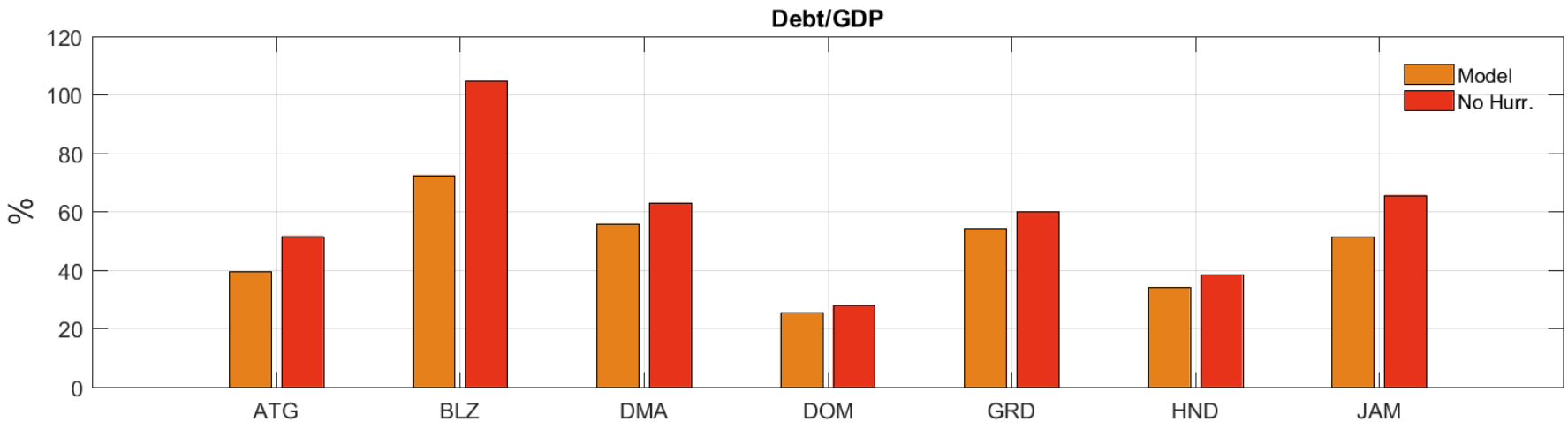


Counterfactual Exercises

- Eliminate hurricane risk
- Climate change

No Hurricane Risk - Lower Spreads, Higher Debt



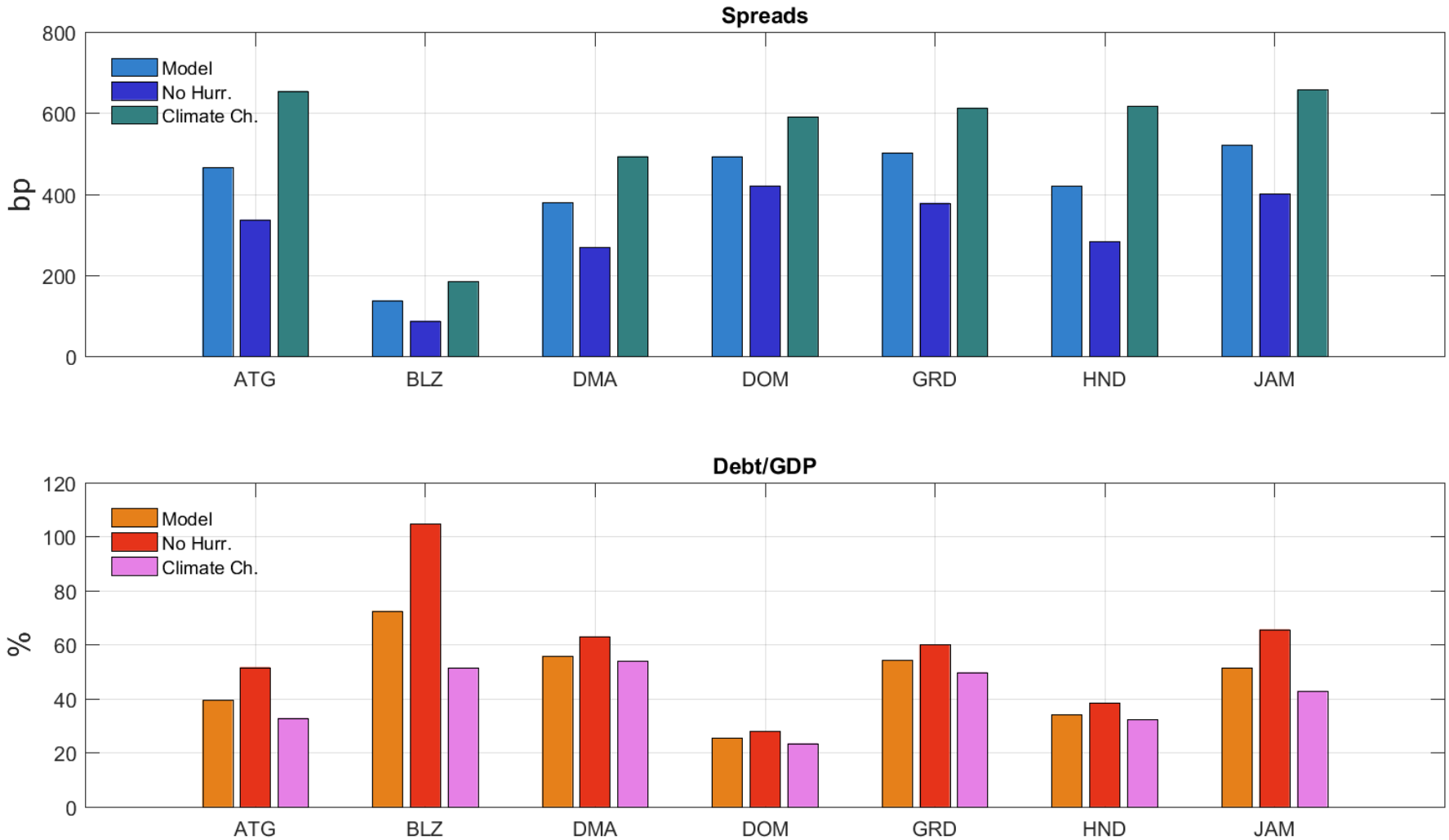


Climate Change

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

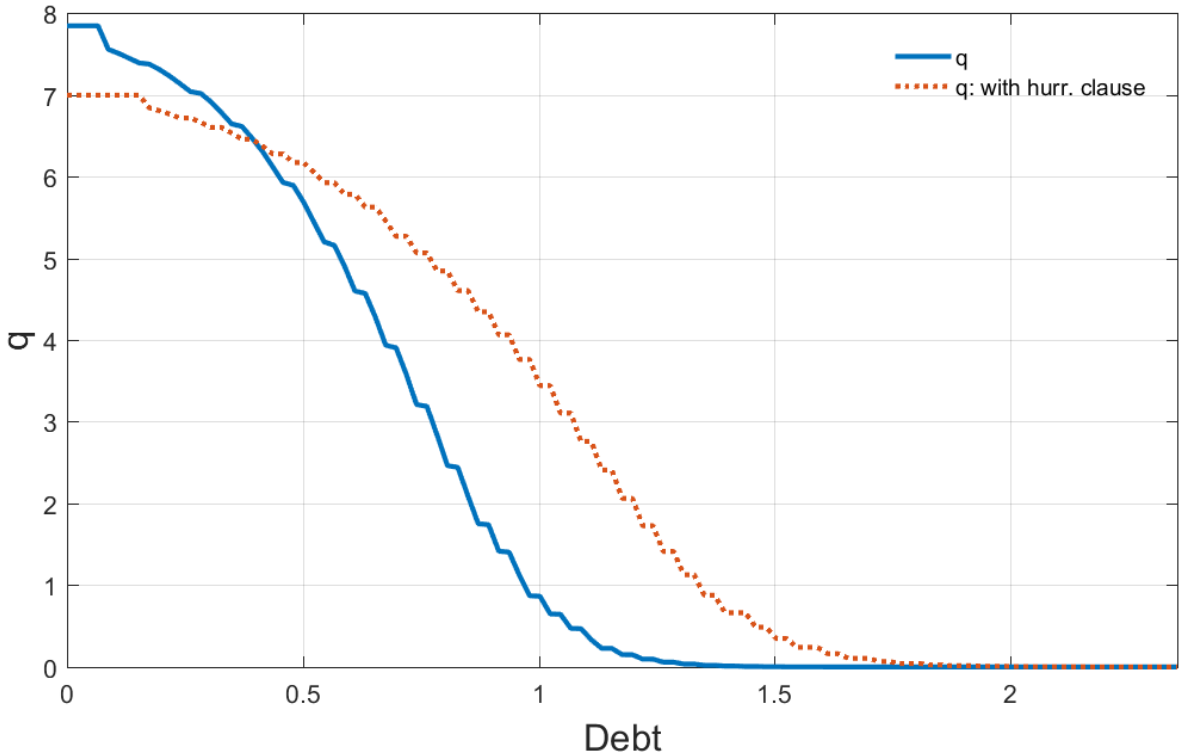
- Hurricane risk restricts governments' access to financial markets
- Debt-to-GDP ratios decline and spreads increase
- Climate change will further restrict on governments' market access

Disaster Clauses

Modeling Disaster Clauses

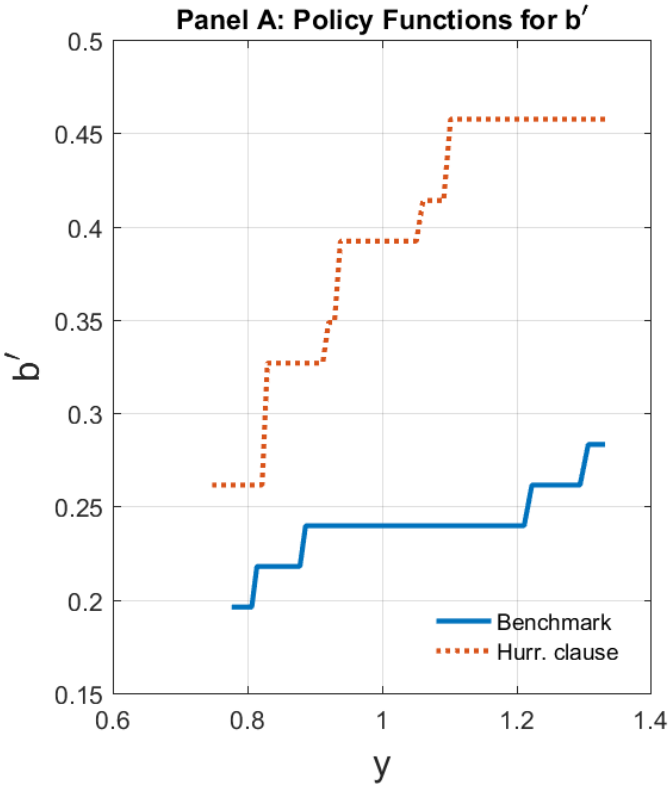
- Disaster clauses allow for a one-period debt moratorium, when hurricanes hit
- Governments choose whether to activate the clause
- No output cost of activating the hurricane clause

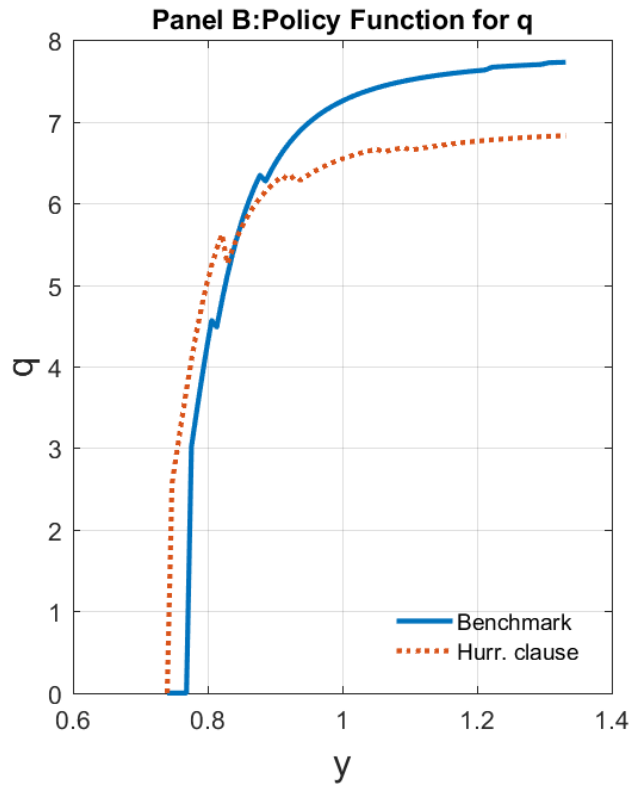
Hurricane Clause: Price Function



- 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 small

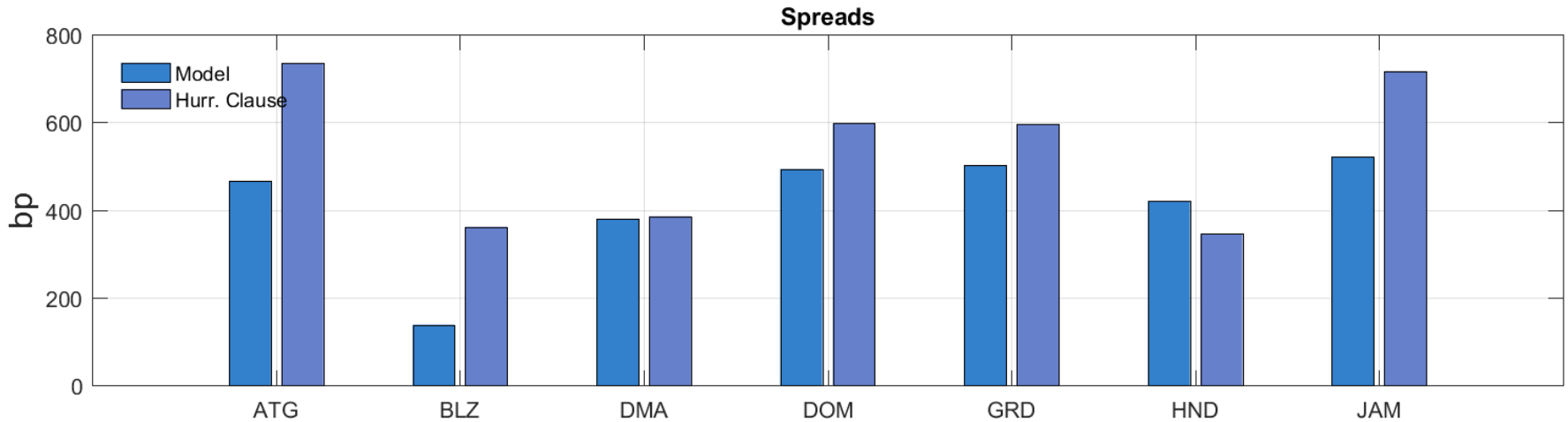
Hurricane Clause: Policy Functions

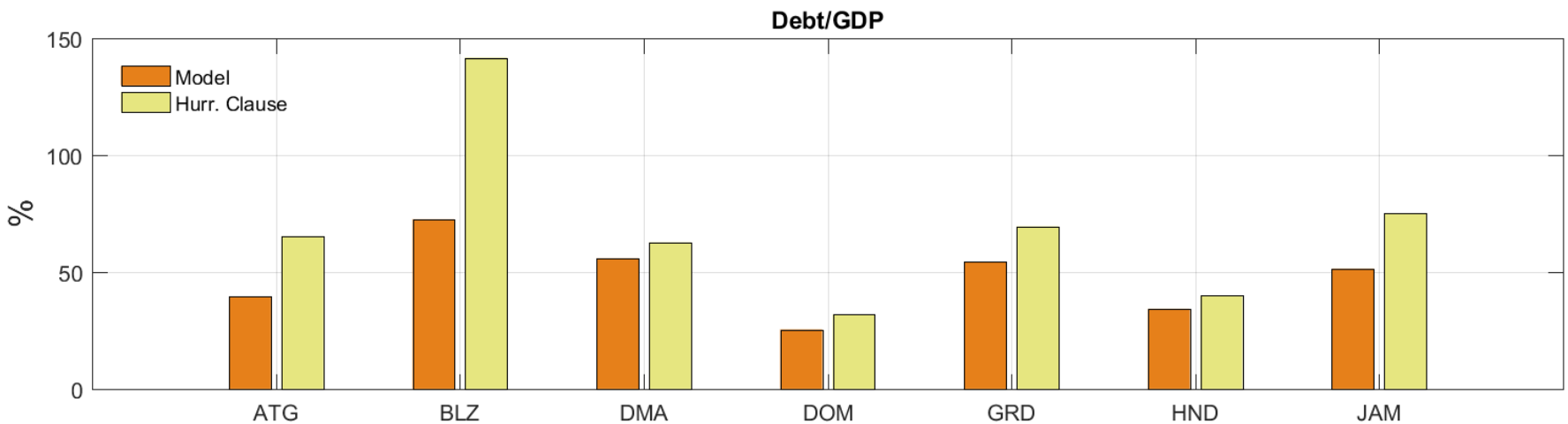




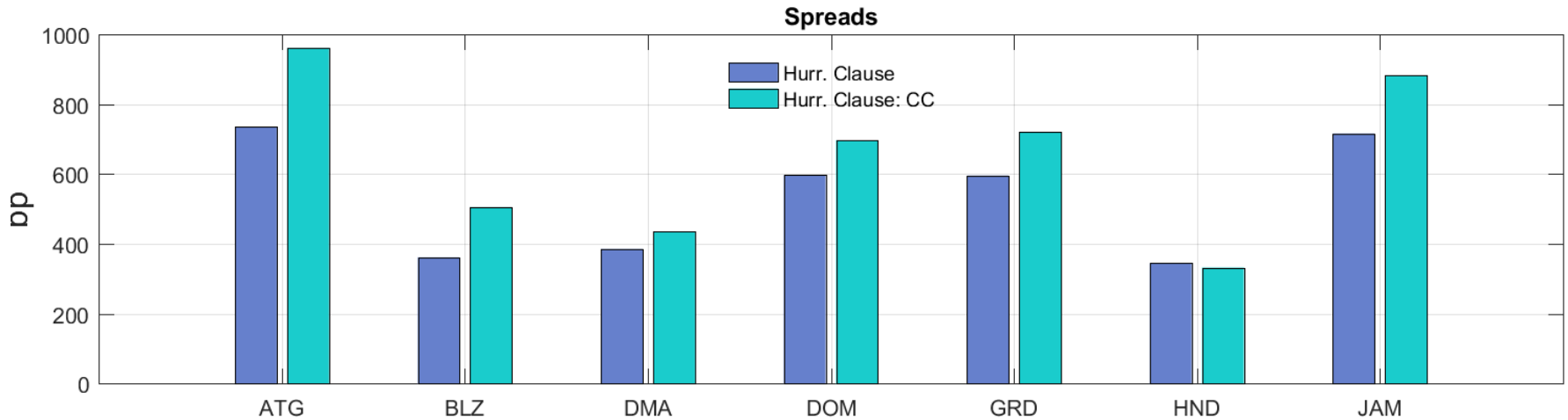
- Sizable increase of government debt
- In equilibrium, the price of government debt declines

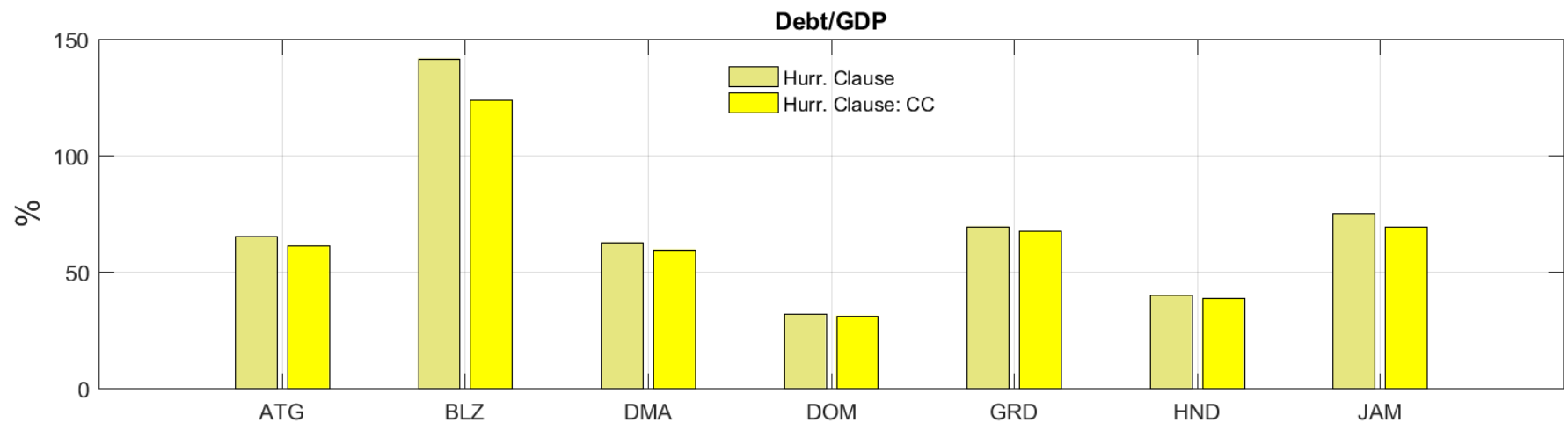
Hurricane Clause - Higher Spreads, Higher Debt





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_{WC}^{DL}	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

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

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

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:

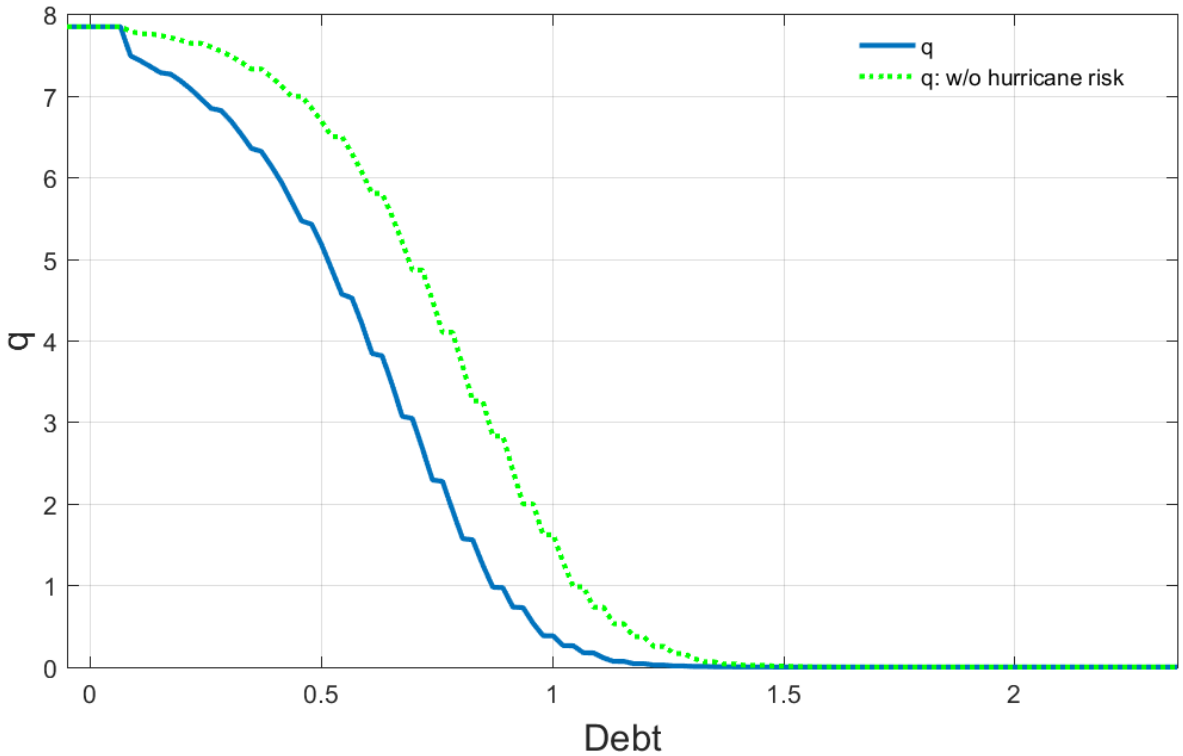
$$q\left(y,h,b\right)=\frac{1}{\left(1+r^{rf}\right)}E\left[\left(1-d'\right)+\left(1-\psi\right)\left(1-d'\right)q'\right]$$

Back

Eliminating Hurricane Risk -Intuition

Elimination of hurricane risk reduces output fluctuations:

- The price function shifts out



Back