Commodity Prices and Sovereign Default: A New Perspective on the Harberger-Laursen-Metzler Effect

Franz Hamann[1] Enrique G. Mendoza[2] Paulina Restrepo-Echavarria[3]

ASSA Meetings, Philadelphia 2018

Introduction

- International oil price volatility has affected oil-exporter macro performance, through changes in incentives to
  - exploit a natural resource (real assets) affecting reserves and extraction of oil
  - consume and borrow/lend (financial assets)
  - incentives to repay or default, affecting sovereign risk and asset prices

Introduction

- International oil price volatility has affected oil-exporter macro performance, through changes in incentives to
  - exploit a natural resource (real assets) affecting reserves and extraction of oil
  - consume and borrow/lend (financial assets)
  - incentives to repay or default, affecting sovereign risk and asset prices

- In this paper we document how sovereign risk is affected by:
  - a country's ability to extract oil
  - its stock of oil reserves

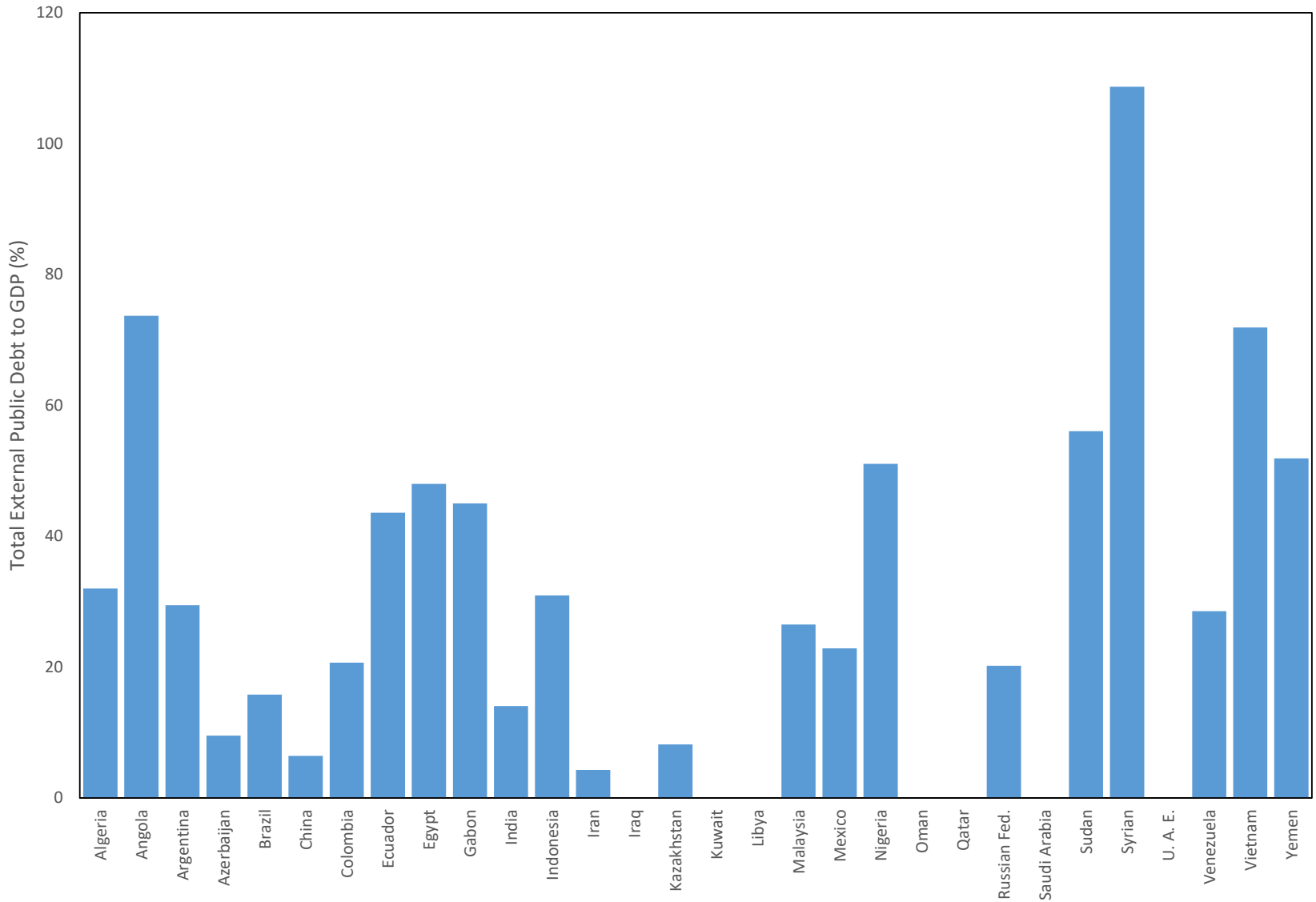
Introduction

- International oil price volatility has affected oil-exporter macro performance, through changes in incentives to
  - exploit a natural resource (real assets) affecting reserves and extraction of oil
  - consume and borrow/lend (financial assets)
  - incentives to repay or default, affecting sovereign risk and asset prices

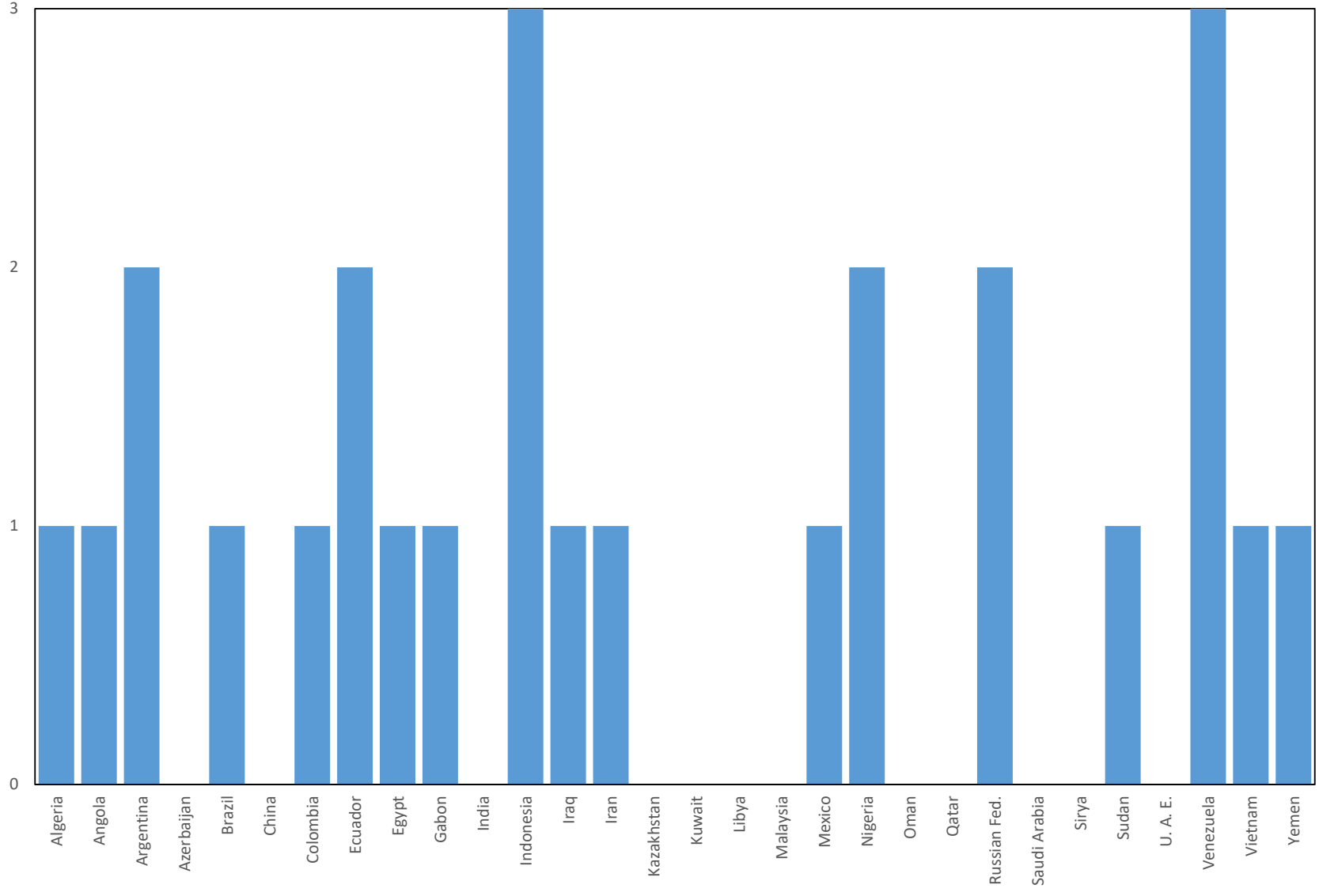
- In this paper we document how sovereign risk is affected by:
  - a country's ability to extract oil
  - its stock of oil reserves

- Present a SOE sovereign risk model with incomplete international financial markets, in which optimal oil extraction and sovereign default interact, to help us understand these facts.

Average Ext. Public Debt of Net Oil Exporters (1979-2010)



Default Episodes (1979-2010)



Measure of Country Risk: Institutional Investor Index

- The Institutional Investor's country credit ratings, are a sovereign debt risk index for the 1979-2010 period. It is published biannually in the March and September issues of Institutional Investor magazine. Those ratings are based on a survey of leading international bankers, who are asked to rate each country on a scale from 0 to 100 (where 100 represents maximum creditworthiness). The answers are then weighted in accordance with the particular bank's global exposure and the level of sophistication for that country's analysis systems.

Empirical Results

	Δ Inst. Investor Index		
	Model (1)	Model (2)	Model (3)
Convergence coefficient			
Inst. Investor Index (-1)	-0.248***	-0.199***	-0.248***
	(0.0235)	(0.0231)	(0.0233)
Short-run coefficients			
Δ Oil GDP	0.0356**	0.0400**	0.0351**
	(0.0160)	(0.0166)	(0.0159)
Δ Non-oil GDP	0.389***	0.419***	0.377***
	(0.0732)	(0.0755)	(0.0725)
Δ Oil reserves	0.0429*	0.0488*	0.0515**
	(0.0256)	(0.0267)	(0.0256)
Δ Ext. pub. debt	-0.0611***	-0.0837***	-0.0628***
	(0.0213)	(0.0239)	(0.0231)
Δ NFA		-0.0326	-0.0282
		(0.0326)	(0.0312)
Long-run coefficients			
Oil GDP	0.0506	0.0787	0.0507
	(0.0404)	(0.0513)	(0.0401)
Non-oil GDP	0.0632	0.158**	0.0771
	(0.0537)	(0.0703)	(0.0536)
Oil reserves	-0.0855*	-0.100*	-0.121***
	(0.0453)	(0.0596)	(0.0460)
Ext. pub. debt	-0.190***	-0.148***	-0.117***
	(0.0347)	(0.0547)	(0.0424)
Default	-0.348***		-0.350***
	(0.0526)		(0.0523)
NFA		0.324***	0.242***
		(0.109)	(0.0821)
Constant	0.767***	0.308	0.705***
	(0.196)	(0.194)	(0.195)
Observations	512	509	509

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Summary of Evidence in Oil Exporting Countries

- In the short run, sovereign rating (measured by the Institutional Investor's Index) is:
  - negatively associated with an increase in external public debt
  - positively associated with non-oil output growth
  - positively associated with oil production growth

Summary of Evidence in Oil Exporting Countries

- In the short run, sovereign rating (measured by the Institutional Investor's Index) is:
  - negatively associated with an increase in external public debt
  - positively associated with non-oil output growth
  - positively associated with oil production growth
- In the long run, sovereign rating is:
  - positively associated with oil and non-oil production
  - negatively associated with the size of the country's oil reserves
  - negatively associated with the size of public debt (and defaults)

A Quantitative Model of Sovereign Default

- Small open economy with two types of goods:
  - tradable non-storable consumption good (y_t)
  - stock of oil (s_t) out of which x_t units can be extracted
- Oil company
  - discovers oil at a fixed rate (d)
  - extracts it at a cost, $e = \psi(\frac{x}{s})^{\gamma}$
- Sovereign government:
  - receives profits from oil company
  - issues debt but cannot commit to repay
- Relative price of oil (p_t) and consumption good are exogenous stochastic processes

Oil producing company problem

$$\max_{x_t, s_{t+1}} E_t \sum_{t=1}^{\infty} Q_{t-1}(p_t x_t - e(s_t, x_t))$$

subject to

$$s_{t+1} = s_t - x_t + d, \tag{1}$$

$$0 \leq x_t \leq s_t + d, \tag{2}$$

where

$$Q_t = q(b_1, s_0, y_0, p_0)\, q(b_2, s_1, y_1, p_1) \ldots q(b_{t+1}, s_t, y_t, p_t),$$

and $q(b_{t+1}, s_t, y_t, p_t)$ is the realization of the stochastic discount factor in t.

- Optimal policies are $x_t^*(p_t, s_t; b_{t+1})$ and $s_{t+1}^*(p_t, s_t; b_{t+1})$ and optimal profits π_t^* are transferred to the sovereign

Sovereign's problem

The sovereign:

$$V(b,s,y,p) = \max\left\{v^{nd}(b,s,y,p), v^{d}(s,y,p)\right\},$$

Repay:

$$v^{nd}(b,s,y,p) = \max_{\{c,b'\}}\left\{u(c) + \beta E\left[V\left(b', s'^{*}\left(p,s;b'\right), y, p\right)\right]\right\}$$

$$c - b = y + \pi^{*}\left(p,s;b'\right) - q\left(b',s,y,p\right)b',$$

where

$$\pi^{*}\left(p,s;b'\right) = px^{*}\left(p,s;b'\right) - e(s,x^{*}\left(p,s;b'\right)).$$

Default:

$$v^{d}(s,y,p) = \max_{\{c\}}\left\{u(c) + \beta\left(1-\lambda\right)Ev^{d}\left(s'^{d},y,p\right) + \beta\lambda EV\left(0,s'^{*}\left(p,s;0\right),y',p'\right)\right\}$$

$$c = \left[1 - \delta_0\left(y + \pi^{d}\left(p,s\right)\right)^{\delta_1}\right]\left(y + \pi^{d}\left(p,s\right)\right).$$

Default and the price of sovereign debt

The default set is given by

$$D(b,s) = \left\{ \{y,p\} : v^{nd}(b,s,y,p) \leq v^{d}(s,y,p) \right\}$$

The probability of default at $t+1$ perceived as of date t is given by

$$d\left(b', s'^{*}\left(b';p,s\right),y,p\right) = \int \int_{D(b',s)} dz_y\left(y' \mid y\right) dz_p\left(p' \mid p\right)$$

The risk-neutral price of the sovereign bond is

$$q\left(b';s,y,p\right) = \bar{q}\left(1 - d\left(b';s,y,p\right)\right)$$

Two-Period Model

- The firm chooses extraction in the first and second period, given a stock of oil, such that:

$$\max_{x_1 \geq 0, x_2 \geq 0} p_1 x_1 - e(x_1, s_0) + q E_{p_2} [p_2 x_2 - e(x_2)]$$

subject to

$$s_0 = x_1 + x_2.$$

- Let $x_1^*(p_1, E(p_2) s_0; q(B_1))$ and $x_2^*(p_1, E(p_2), s_0; q(B_1))$ be the optimal extraction policies.

Two-Period Model Continued

- The default decision (after x_2^* is observed) is:

$$d = \begin{cases} 1 & \text{if } u\left(\left[1-\delta_0\left(y_2+\pi_2^*\right)^{\delta_1}\right]\pi_2^*\right) \geq u\left(y_2+\pi_2^*+B_1\right) \\ 0 & \text{otherwise} \end{cases}$$

- Thus, given B_1, there is a $\tilde{p_2}$:

$$\tilde{p_2}x_2^*\left(p_1,\tilde{p_2},s_0;q\right) = \left(-\frac{B_1}{\delta_0}\right)^{\frac{1}{\delta_1+1}} - y_2$$

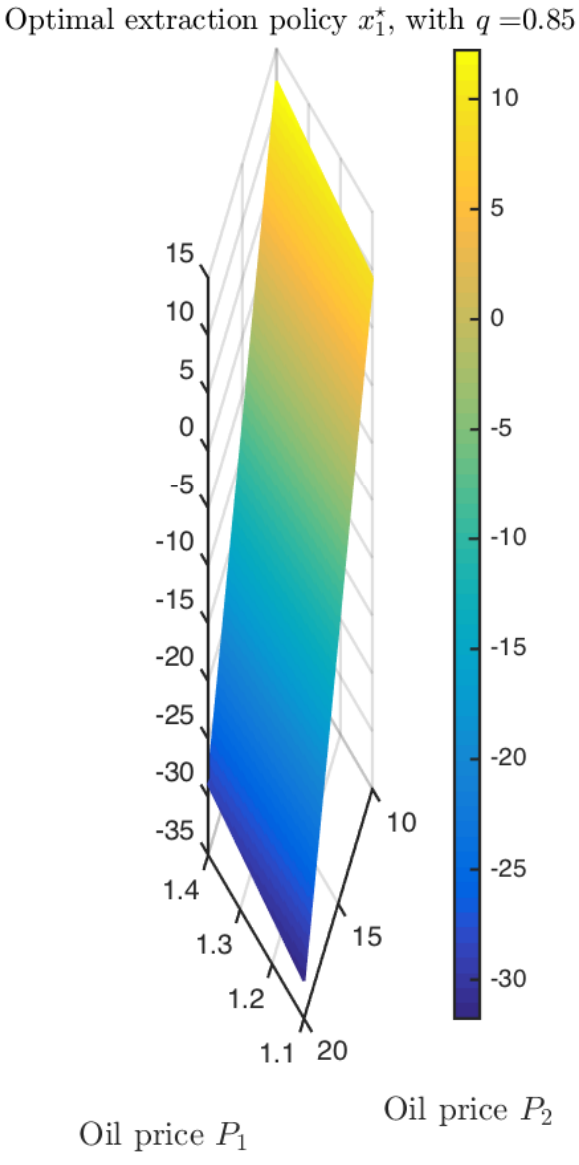
- The default probability is:

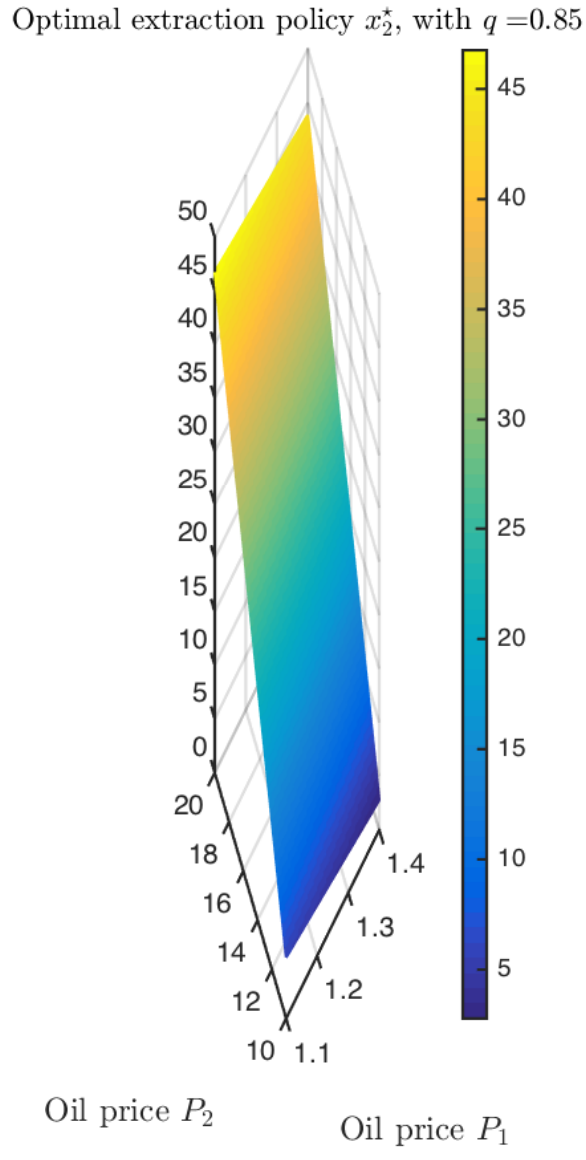
$$\delta\left(B_1,p_1,s_0\right) = \int_0^{\tilde{p_2}} d\left(B_1;p_1,p_2,s_0\right)h\left(p_2\right)dp_2.$$

- The optimal B_1 is:

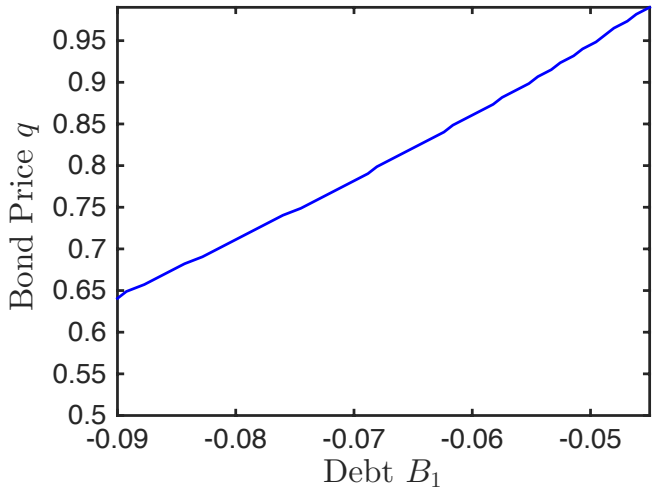
$$\begin{aligned} &\max_{B_1} u\left(y_1+\pi_1^*-q\left(B_1,p_1,s_0\right)B_1\right) \\ &+\beta\left\{\delta\left(B_1,p_1,s_0\right)\int_0^{\tilde{p_2}(B_1,p_1,s_0)} u\left(\left[1-\delta_0\left(y_2+\pi_2^*\right)^{\delta_1}\right]\pi_2^*\right)h(p_2)dp_2\right. \\ &\left.+\left[1-\delta\left(B_1,p_1,s_0\right)\right]\int_{\tilde{p_2}(B_1,p_1,s_0)}^{\infty} u\left(y_2+\pi_2^*+B_1\right)h(p_2)dp_2\right\} \quad . \end{aligned}$$

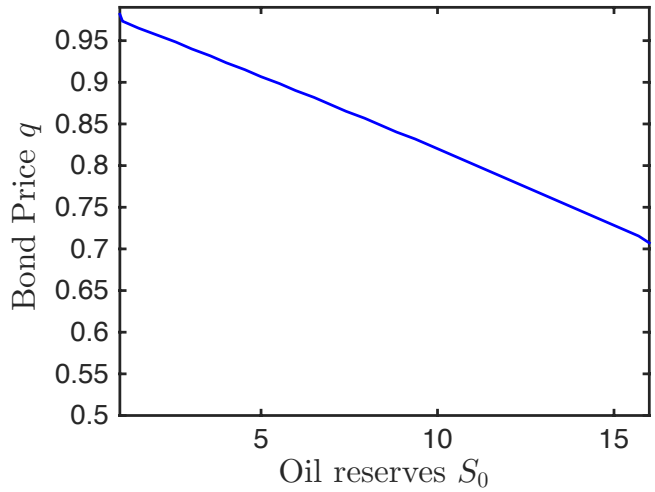
Optimal Extraction Policies

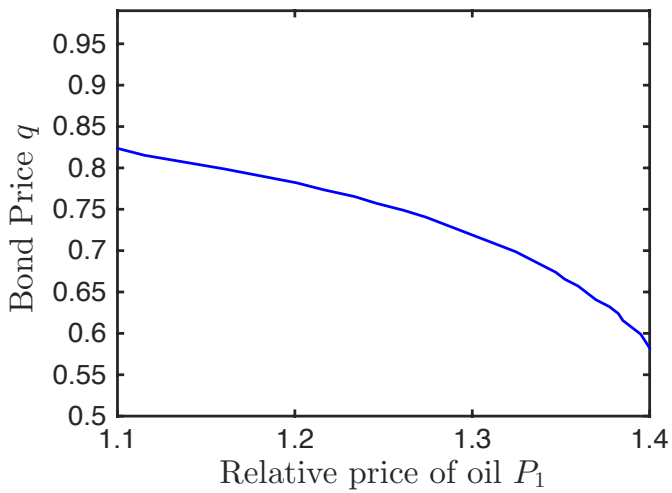


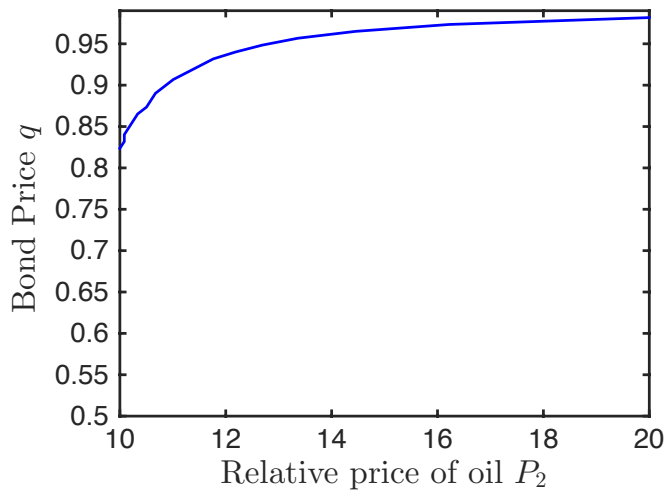


Comparative Statics









Calibration to Russia

- Russia National Accounts - Haver/OECD (2003Q1-2015Q4)
- GDP: World Bank's Global Economic Monitor (1995Q1-2015Q4) and Oil Rents (1989Q1-2015Q4)
- Risk premium: JP Morgan's EMBI+ GSS spread for the period 1997Q4-2017Q1
- Debt: WB-GEM Gross Ext. Debt Pos. to GDP (2003Q1-2017Q1)
- 3 Default episodes in XX century: Beim and Calomiris (2001) and Purcell and Kaufman (1993) database
- Default episodes and debt: Reinhart and Rogoff, AER (annual, 1800-2010) Total (public plus private) gross external Debt/GNP ratio is 40% (avg1992-2010)
- Financial exclusion: Richmond and Dias (2009)

Parametrization

Parameter	Description	Value
μ	risk aversion	2
$\bar{q}$	risk-free bond price	0.99
d	discovery rate	0.1
β	discount factor	0.794
δ_0	level parameter of default cost	0.045
δ_1	curvature parameter of default cost	2
λ	probability of re-entry	0.068
ϕ	level parameter of extraction cost	4.86
γ	curvature parameter of extraction cost	0.472

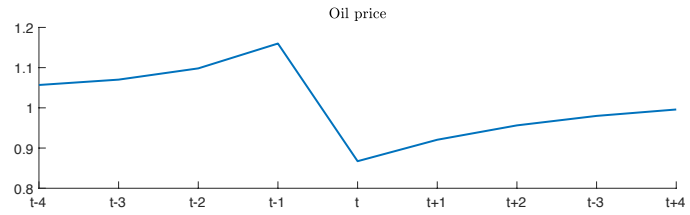
Matching Moments

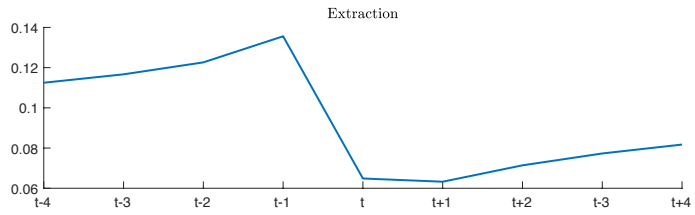
Description	Target	Model
Average reserves (in years)	18.4	19.6
Std dev of oil extraction(pct)	4.2	4.8
Default rate (pct)	2.3	1.3
Average external Debt to GDP (pct)	32	30
Average EMBI spread (bp)	674	1199
Std dev of bond price (pct)	7.4	19.3

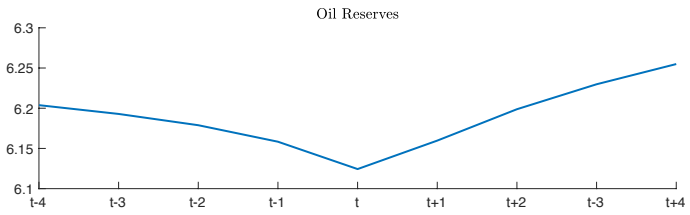
Can the model explain our empirical findings?

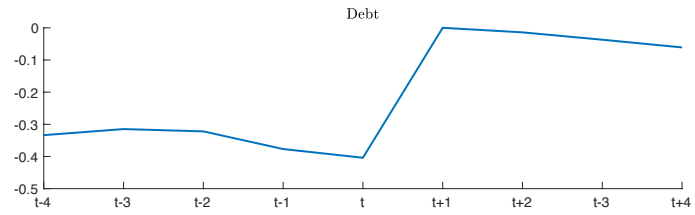
Average	Unconditional	Under Default	Under Repayment
Oil prices	1	1	1
Non-oil output	0.9	0.9	0.9
Oil reserves	6.16	6.43	6.10
Oil extraction	0.1	0.08	0.11
GDP	1	0.9	1.02
External debt (pct)	27	0	33
Sovereign debt price	0.71	0	0.85

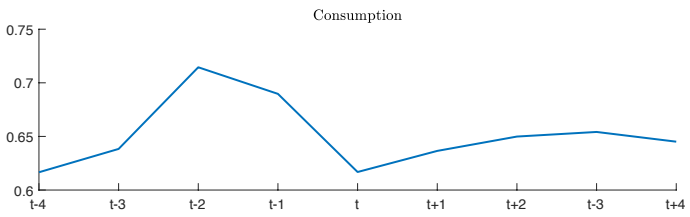
Dynamics around default episodes

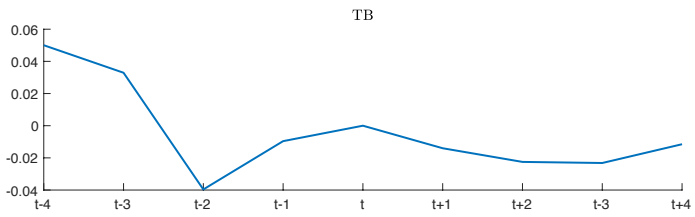


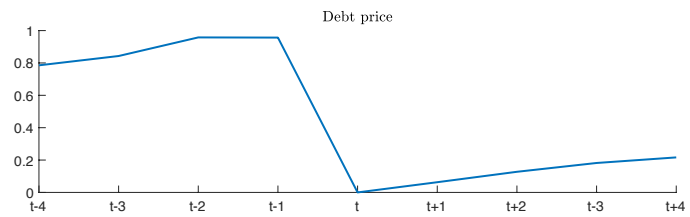


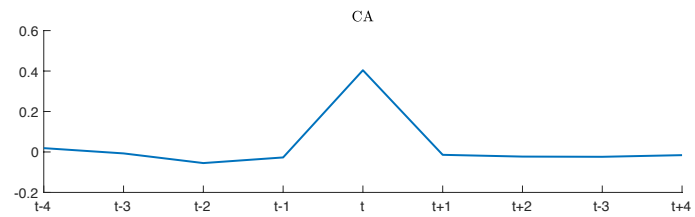












Final Remarks

- Document empirically how sovereign risk relates to oil ownership
- Model of natural resource extraction and sovereign risk that captures
  - larger oil reserves are associated with higher sovereign risk
  - more oil extraction is associated with lower sovereign risk

Final Remarks

- Document empirically how sovereign risk relates to oil ownership
- Model of natural resource extraction and sovereign risk that captures
  - larger oil reserves are associated with higher sovereign risk
  - more oil extraction is associated with lower sovereign risk
- Work in progress:
  - changes in the discovery rate
  - does oil ownership matter?

Data

- Country risk : Institutional Investor's country credit ratings. Annual data from 1979 to 2010.
- Oil reserves, oil production (thousand barrels per day): US Energy Information Administration dataset (EIA). Annual data from 1980 to 2013
- Brent spot oil price (USD per barrel): US Energy Information Administration dataset (EIA). Annual data from 1980 to 2013.
- Total public debt to GDP: World Development Indicators tables (WDI) and World Economic Outlook database (WEO). Annual data from 1979 to 2010.
- Net Foreign Assets: Lane and Milesi-Ferreti (2007). Annual data from 1970 to 2011.
- Default data: Borensztein and Panizza (2006). Annual data from 1979 to 2010.
- GDP: World Economic Outlook database (WEO). Annual data from 1979 to 2010.

Back