Commodity Price Beliefs, Financial Frictions and Business Cycles

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Preliminary Work

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Commodity cycle challenges macro and financial stability

- Commodity price volatility has affected commodity-exporters macro performance, through now well-known changes in incentives to borrow/lend in presence of financial frictions[2]

[2] See Mendoza (1991;95), Uribe & Yue (2006), Bianchi, Boz & Mendoza (2012), Bianchi & Mendoza (2015)]

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- This kind of risk to oil exporting economies is usually uninsured in international financial markets and the macro and financial adjustment works through the real exchange rate (RER) and net foreign financial assets (NFA)
- Furthermore, with financial frictions (collateral constraints) there is a pecuniary externality: agents do not internalize when they borrow in "good times" that high leverage causes collapse in collateral values and credit crunch in "bad times" (Fisherian deflation)

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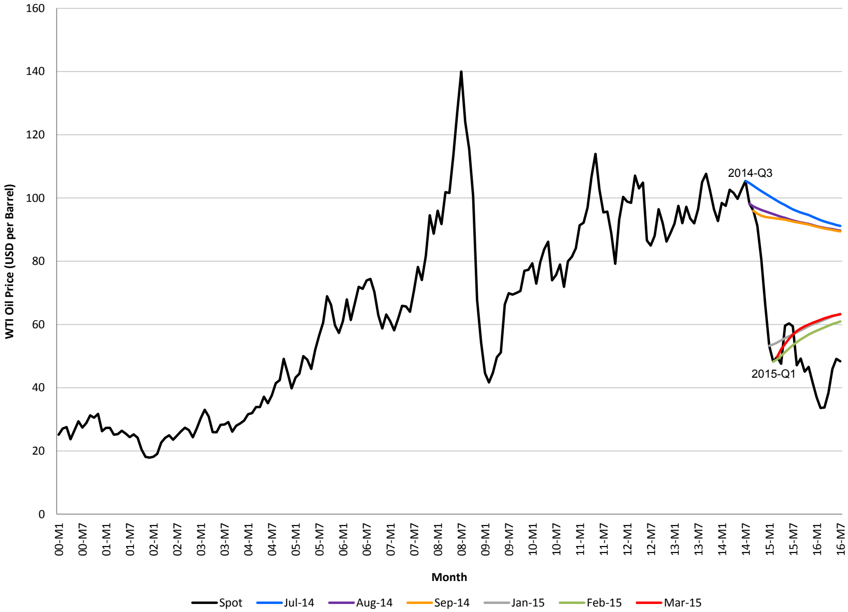
Uncertainty reflected in spot prices as well as in futures



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- Natural resources are known to be affected by political instability, changes in their market structure, structural changes in technology to exploit them, shifts in global demand, etc.
- As a result, discovering the true process of commodity prices is an ongoing business as the academic debate also illustrates: Hamilton (2003), Rebucci and Spatafora (2006), Hamilton (2008), Kilian (2009) and Baumeister & Kilian (2015).

Commodity price beliefs interact with financial frictions

- When there is uncertainty about commodity price fundamentals, optimistic beliefs or good news about commodity prices strengthen incentives to borrow "today" and increase expected future borrowing capacity[3] but also...

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- ... and if followed by disappointing price outcomes, the probability of a financial crisis rises because of higher leverage and the endogenous cutback in commodity extraction.

- In this paper, discrepancies between initial expectations about prices and actual and posterior expected prices can be an important source of macro and financial instability because it affects non-trivially both households and firms.

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A model of a commodity exporting economy...

- Time, $t = 0, 1, 2, \dots$, economy with y^T, y^N and a stock of commodity $\bar{s} > 0$, all in fixed supply. Every t there is $s_t \in [0, \bar{s}]$ extracts $x_t \in [0, s_t]$ and discovers $d \geq 0$:

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- Commodity price p_t has a "true" TPM, $Q(p_{t+1}, p_t)$, unknown to agents. The value of a competitive firm with perfect access to financial markets is:

$$v(s_t, p_t) = \max_{x \in [0, s_t]} \left\{ p_t x_t - e(s_t, x_t) + R^{-1} \mathbb{E}_t^B \left[v\left(s_{t+1}, p_{t+1}\right) \right] \right\}$$

E_t^B is conditional on the agents beliefs with the information available up to t. Rational expectations: $\mathbb{E}_t$.

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- Inter-temporal optimality condition:

$$p_t - e_x\left(s_t, x_t\right) = \frac{\mathbb{E}_t^B \left[p_{t+1} - e_x\left(s_{t+1}, x_{t+1}\right) - e_s\left(s_{t+1}, x_{t+1}\right) \right]}{R}.$$

... with "liability dollarization"

Let $\tilde{x}$ be the firm's optimal extraction. HH maximize:

$$\mathbb{E}_0^B \left[\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma} \right]$$

$$c_t = \left[a \left(c_t^T \right)^{-\mu} + (1-a) \left(c_t^N \right)^{-\mu} \right]^{-\frac{1}{\mu}}, a > 0, \mu \geq -1$$

subject to

$$c_t^T + p_t^N c_t^N = y^T + \tau_\pi \pi \left(p_t, s_t \right) + \tau_E e(s_t, \tilde{x} \left(p_t, s_t \right)) + p_t^N y^N - b_{t+1} + R b_t$$

with $\pi \equiv p_t \tilde{x}_t - e \left(s_t, \tilde{x}_t \right)$ and $\tau_\pi \equiv \frac{\tau_S p_t \tilde{x}_t - \tau_E e(s_t, \tilde{x}_t)}{\pi_t}$ and

$$b_{t+1} \quad \geq \quad -\phi \left(y^T + \tau_\pi \pi \left(p_t, s_t \right) + \tau_E e(s_t, \tilde{x} \left(p_t, s_t \right)) + p_t^N y^N \right).$$

Rational expectations perfect information equilibrium

The recursive representation of REPI equilibrium conditions are:

$$
\begin{aligned}
p^N &= \left(\frac{1-a}{a}\right)\left[\frac{c^T}{y^N}\right]^{1+\mu} \\
c^{-\sigma} &= \beta R \mathbb{E}_t\left[\left(c'\right)^{-\sigma}\right] + \lambda \\
b' &= y^T + \tau_S p \tilde{x}\left(p, s\right) - c^T + Rb \\
b' &\geq -\phi\left(y^T + \tau_S p \tilde{x}\left(p, s\right) + p^N y^N\right)
\end{aligned}
$$

Equilibrium under Bayesian learning about commodity prices

- Follow Boz and Mendoza (2009) two-stage solution strategy:
  1. Bayesian learning. Take a history of price realizations observed up to date t, $p^t = (p_t, p_{t-1}, p_{t-2}, \ldots, p_1)$ and generate a sequence of posterior density functions $\left\{ f\left(Q^B \mid p^t\right)\right\}_{t=1}^{T}$ over T periods. Each f is a probability distribution over possible Q^B's. The date $t = 0$ priors depend on the assumed amount of agents prior knowledge.

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  2. The problem can be divided into a sequence of AU optimization problems (AUOP) for $t = 1, 2, \ldots, T$, each conditional on $\mathbb{E}_t\left[q_{hh}^B\right]$ and $\mathbb{E}_t\left[q_{ll}^B\right]$, where the time indexes identify the date of the beliefs that match the corresponding AUOP. So, we find a sequence of equilibrium policy functions for $\{x_t\}_{t=1}^{T}$ and $\{b_t'\}_{t=1}^{T}$, one for each set of beliefs at each date $t = 1, 2, \ldots, T$.

Anticipated utility optimal problem

The solution to AUOP at date t is given by $\tilde{x}_t(s,p)$ which solves

$$v_t(s,p) = \max_{x \in X} \left\{ [px - e(s,x)] + R^{-1} \mathbb{E}_t^B \left[v_t \left(s - x + d, p' \right) \right] \right\},$$

the policies $b'_t(b,s,p)$, $c_t(b,s,p)$, $c_t^T(b,s,p)$, $c_t^N(b,s,p)$, $\lambda_t(b,s,p)$ and a pricing function $p_t^N(b,s,p)$ that satisfy HH optimality as well as the MCC for T and NT sectors:

$$\begin{aligned}
p_t^N(b,s,p) &= \left(\frac{1-a}{a} \right) \left[\frac{c_t^T(b,s,p)}{y^N} \right]^{1+\mu} \\
c_t(b,s,p)^{-\sigma} &= \beta R \mathbb{E}_t^B \left[c_{t+1}(b,s,p)^{-\sigma} \right] + \lambda_t(b,s,p) \\
b'_t(b,s,p) &= y^T + \tau_S p \tilde{x}_t(s,p) - c_t^T(b,s,p) + Rb \\
b'_t(b,s,p) &\geq -\kappa \left(y^T + \tau_S p \tilde{x}_t(s,p) + p_t^N(b,s,p) y^N \right)
\end{aligned}$$

Initial calibration: oil prices and the Colombian economy

- "True" price process: a hidden Markov model $p_t = p(I_t) + \epsilon_t$ where I_t is an indicator variable that records whether oil prices are high or low and ϵ_t is an identically and independently distributed normal random variable with mean 0 and variance σ_ϵ^2.

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- We apply Hamilton (1989) Markov switching estimator on quarterly real oil prices covering the period 1970:1 to 2014:2. As a proxy for real oil prices we take the BRENT crude oil price in nominal US dollars deflated by the United States Consumer Price Index. The base year for the US CPI is 1983.

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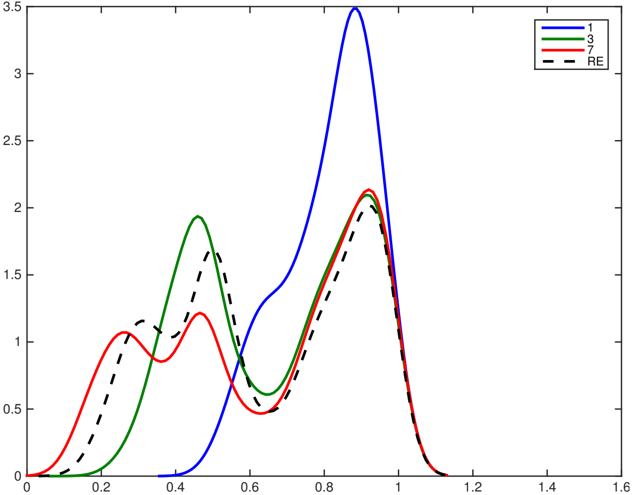
- Take the model ergodic moments under REPI to match both aggregate and sectoral (oil) Colombian data.

Debt distribution from low to high commodity prices

In $t = 1$, $p_t = p_h$ and then for $t = 2, \ldots, 7$ $p_t = p_l$.



Price collapse after a long period of high prices

- Experiment: we date the start of the high commodity price regime in the 2009:4 and its end on 2014:3. The low oil price regime goes from 2014:4 to 2016:1. We assume that agents have uninformative initial priors and experience the high-oil price regime during five years, followed by a year and a half of low prices.

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- Case 1: the sequence of revenues is $\{p_t x_t\}_{t=1}^{T}$ with $\{x_t = d\}_{t=1}^{T}$. This case is analogous to a small open economy with a stochastic endowment of tradable goods.

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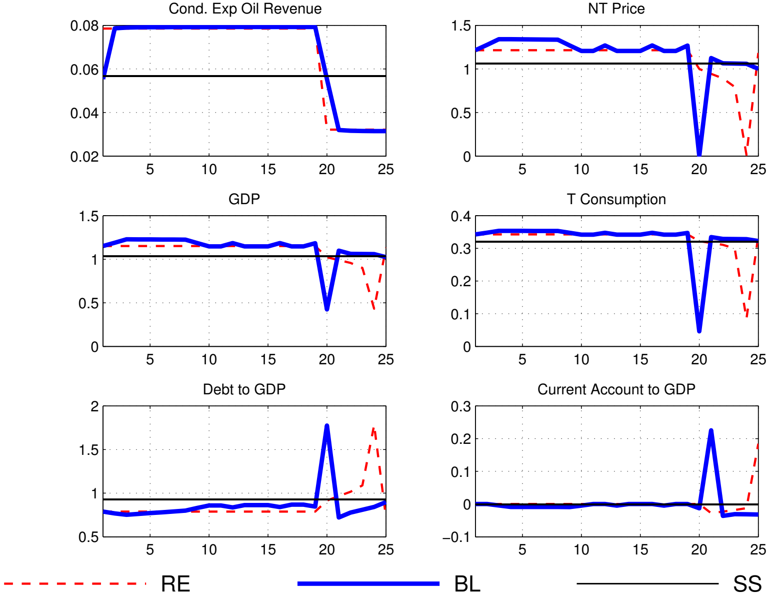
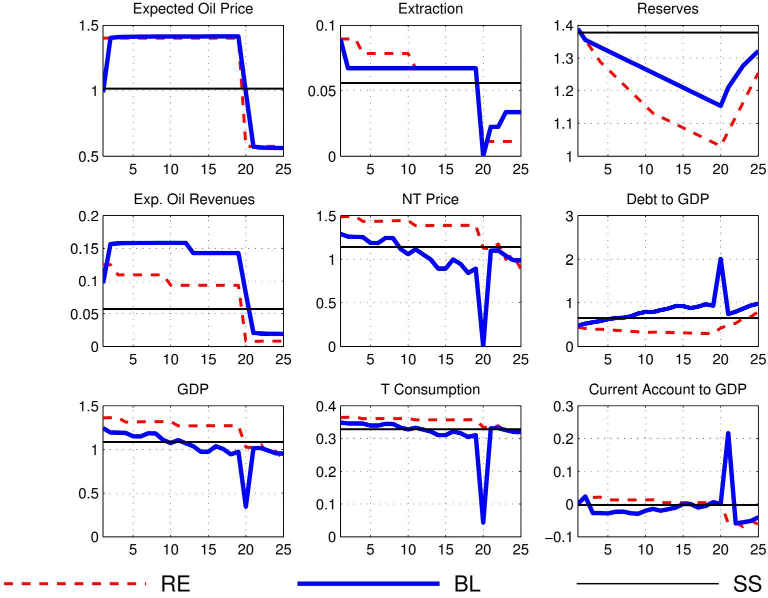
- Case 2: commodity extraction is endogenous and responds to the random movements of commodity prices and we take the sequences $\{p_t\}_{t=1}^{T}$ and $\{\tilde{x}_t(p,s)\}_{t=1}^{T}$.

Price collapse after a long period of high prices in an endowment economy



Price collapse after a long period of high prices in an extraction economy



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- We showed how discrepancies between initial expectations about prices and actual and posterior expected prices can be an important source of macro and financial instability because it affects non-trivially both households and firms.
- Work in progress:
  - Analyze the quantitative effects of alternative beliefs
  - Shocks to R may be additional sources of uncertainty
  - Oil ownership and operations may matter
  - Financing extraction operations

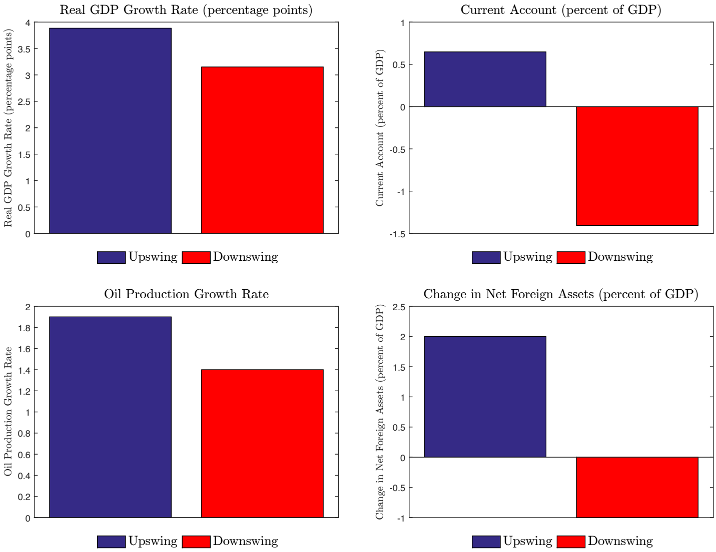
Sources of information

- 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.

Oil price upswings and downswings

Downswings		Upswings	
Period	Number of Months	Period	Number of Months
NOV 75 - OCT 78	36	NOV 78 - JAN 81	27
FEB 81 - JUL 86	66	AUG 86 - JUL 87	12
AUG 87 - NOV 88	16	DEC 88 - OCT 90	23
NOV 90 - DEC 93	38	JAN 94 - OCT 96	34
NOV 96 - DEC 98	26	JAN 99 - SEP 00	21
OCT 00 - DEC 01	15	JAN 02 - JUL 08	79
AUG 08 - MAY 10	22		
TOTAL	219	TOTAL	196

Oil price swings and macro performance of net oil exporters



[4]

[4] Each bar is calculated with the same methodology of figure 4.4 of the World Economic Outlook of April of 2012. For default events the average number of default events is calculated.

New Title

- Item 1
  - item a
  - item b

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  - item a
  - item b
- Item 2
  - item a
  - item b