“The effects of oil and mineral taxation on sector performance”

Guillermo Perry (Universidad de los Andes)
Sui-Jade Ho (University of Michigan – Ann Arbor)

This presentation

1. Motivation

1. The issues

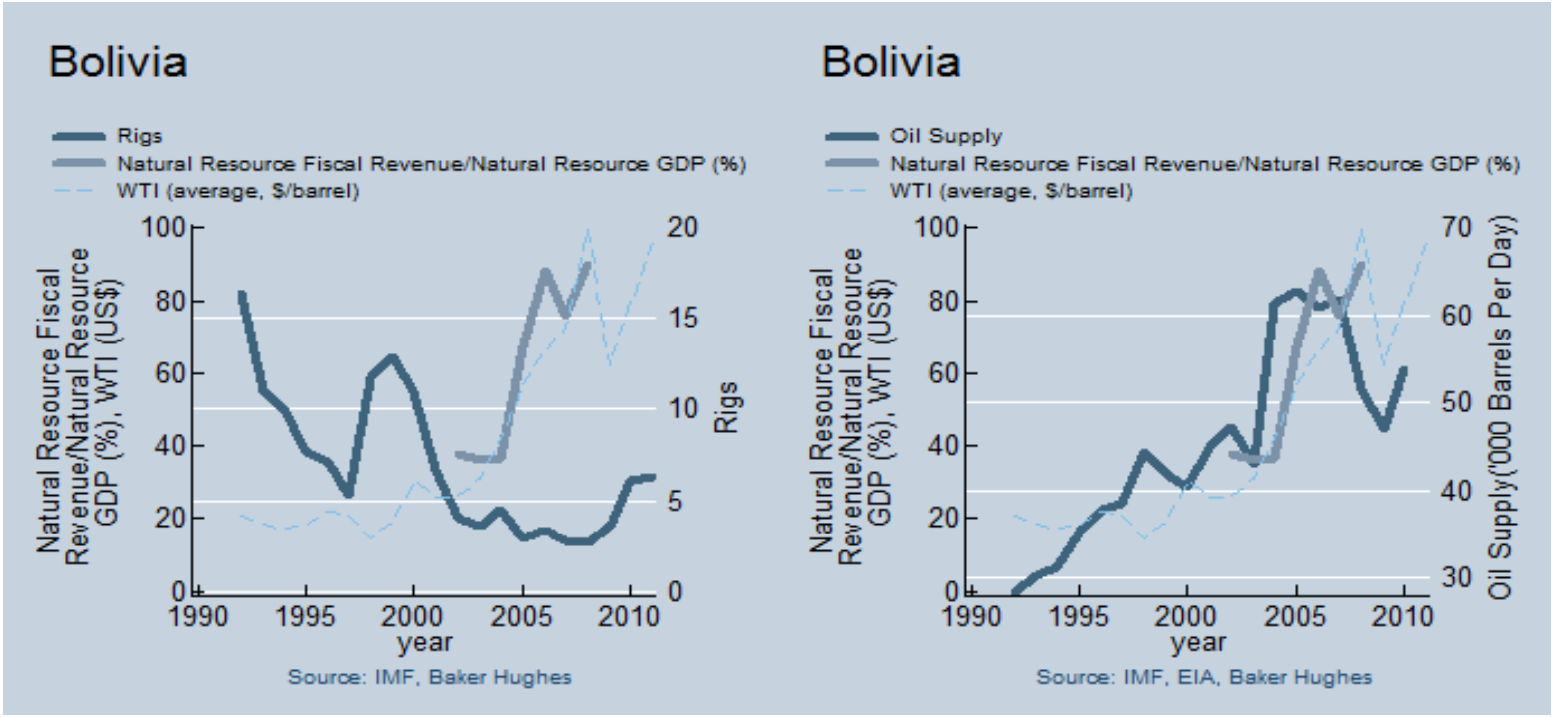
1. The Data

1. Empirical Strategy and Results

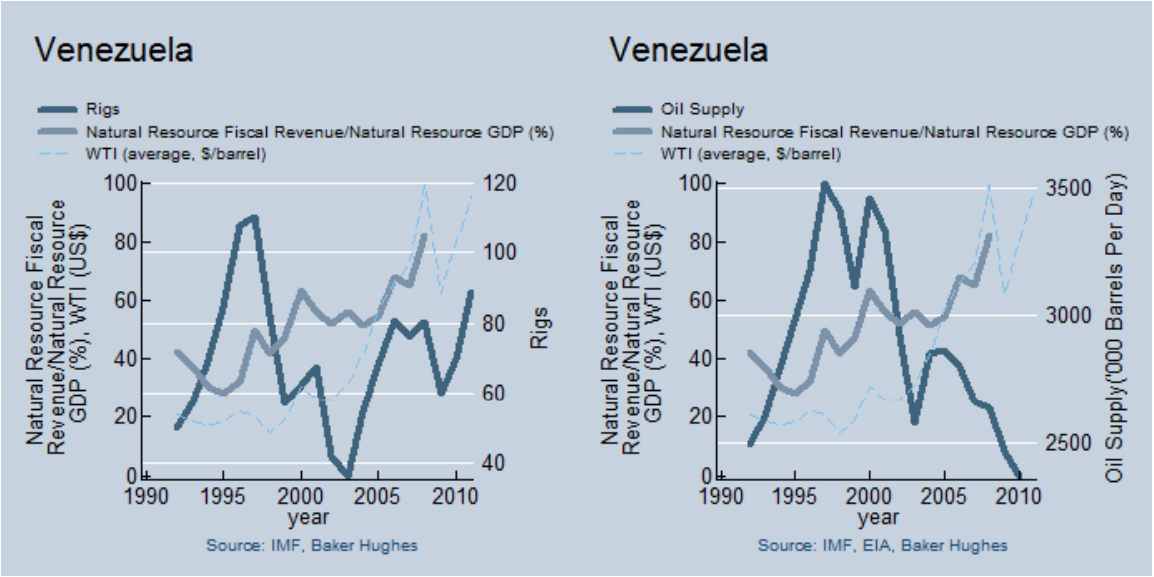
1. Main Conclusions

1. Motivation

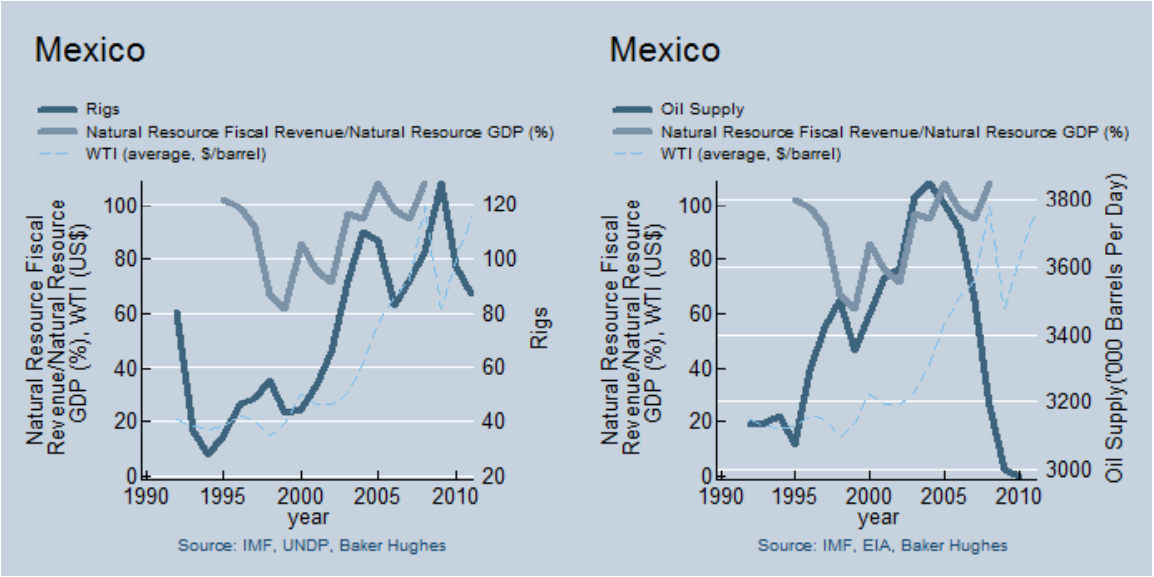
Oil taxation has increased recently in many countries, with effects on investment and output: the case of Bolivia



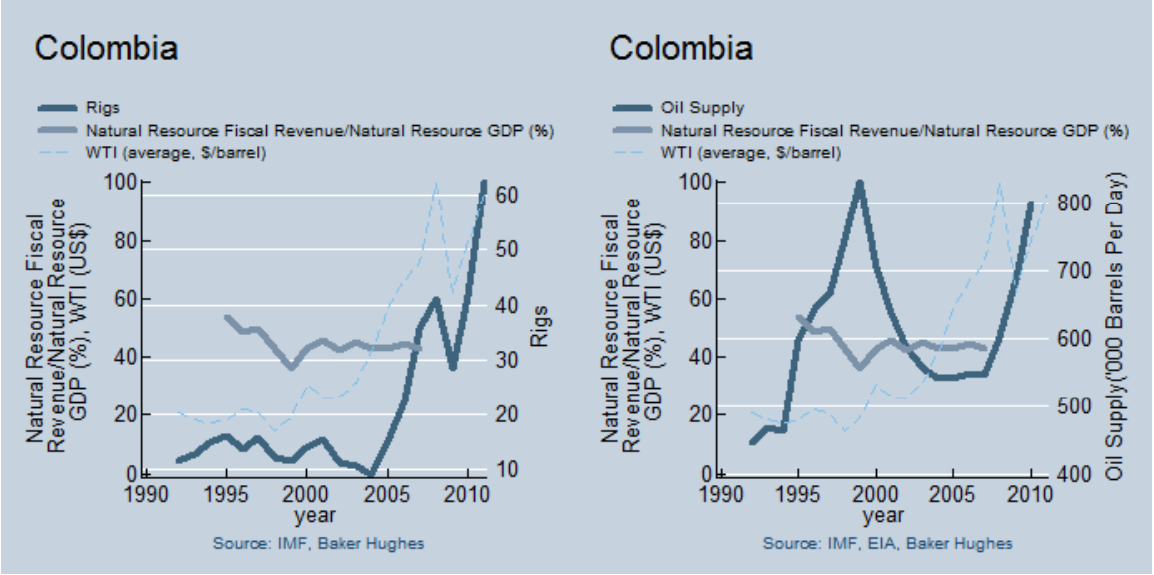
…the case of Venezuela



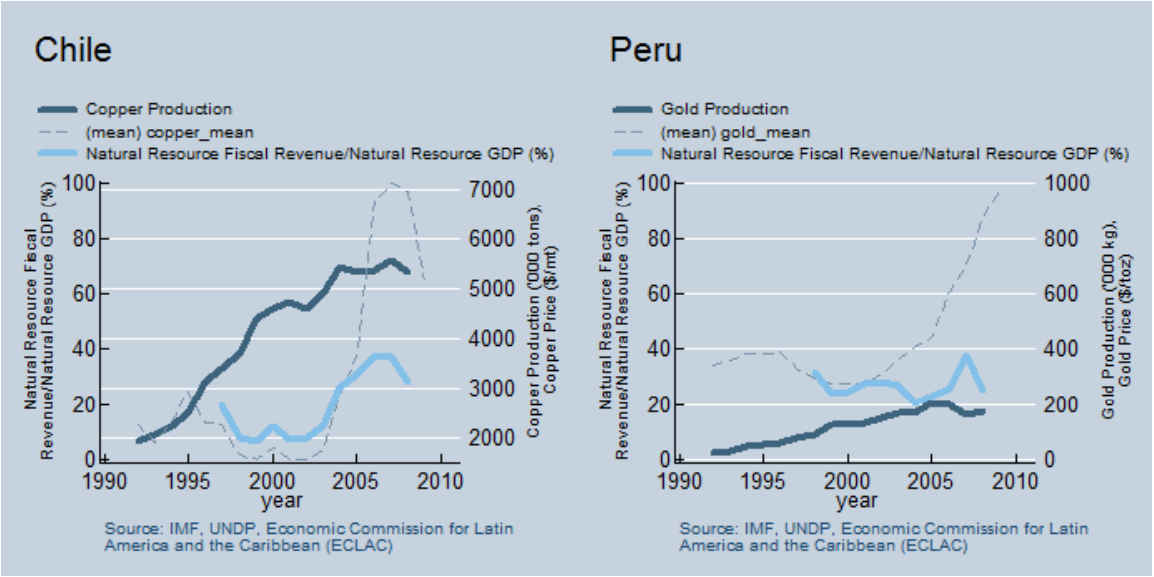
…the case of Mexico



…while there has been an increase in investment and output in other cases: the case of Colombia



The same has happened in minerals: the cases of Chile and Peru



2. The Issues

The trade-offs

- The temptation to increase taxes when prices rise is always there, but that may reduce investment and future production and hence future taxes
- This dilemma is more general: should a country that find oil impose a high government take to finance national development today or try to maximize oil investment and future production shifting tax collections to the future?
- This dilemma also affects the choice of taxes:
  - Signature bonuses or (traditional) royalties shift taxes upfront but increase investor risks and reduce investment (and distort investment and production decisions)
  - Pure profit taxes (with full investment expensing) maximize investment but increase government risks and shift taxes to the future

What do countries do in practice?

- There is a wide variety of Government takes,which may reflect different inter-temporal choices but may also respond to country specificities: geology, ideology, past oil history, country risk, etc
- There is also a wide variety of ways to extract oil rents (public enterprises, production sharing contracts –PSC-, different types of royalties and profit taxes, signature bonuses)

BUT:

What do countries do in practice?

- Most countries that rely on private investment either have:
  - A mixture of *modest* royalties and *high* profit taxes or
  - PSC's that are actually equivalent to modest royalty cum high profit tax systems (eg, use caps on ´investment´ oil)
- Signature bonuses are increasingly rare and small (only in cash strapped poor countries)
- Royalties are increasingly looking more like profit taxes (sensitive to prices, rents or profits: eg, Chile, Peru)
- Actual profit taxes usually have a "royalty" type component (eg, not full expensing of investment)
- Some public enterprises have become corporatized, issue shares and are taxed like others

Reasons behind convergence in tax structure

- Appart from differences in ideology or country risk:
  - Moving out of Signature Bonuses or high traditional royalties to reduce investment and efficiency costs
  - Making royalties price and profit sensitive to reduce investment and efficiency costs but also to reduce political risk
  - BUT, keeping some form of modest royalties to reduce government cash risks and political risks
- Consideration of political risks make a combination of modest royalties and high profit taxes close to an “optimum” (reduce political risks for investors while keeping efficiency costs low)
- However, only countries with “sound” institutions seem to move towards “better” taxes

3. The Data

Data limitations

- We do not have comparable figures on oil investment
  - We use net increases in active rigs as a proxy
  - Pros and cons:
    - Exploration and development of new findings need new wells and thus increases in net rigs
    - But not all rigs cost or produce the same (On vs. Off-shore)
    - Old fields may shut down wells or need large increases for secondary recovery
- We do not have comparable figures on tax composition
  - We use as proxies for the quality of taxes (composition, design, stability) either RWI indexes or WB institutional indexes interacted with average tax ratios. This maybe the best possible approximation given previous discussion.

Data description

	Oil Rich Countries (n=32)				Oil Rich and Mineral Rich Countries (n=42)			
	Mean	Standard deviation	Min	Max	Mean	Standard deviation	Min	Max
Hydrocarbon exports (billions, local currency units) per '000 population	0.004	0.006	0.000	0.050	n.a.	n.a.	n.a.	n.a.
Mining Value Added (% of GDP)	30.27	19.77	1.93	91.95	27.84	19.18	1.93	91.95
Active Rigs per '000 population	0.003	0.004	0.000	0.024	n.a.	n.a.	n.a.	n.a.
Oil Production ('000 barrels per day) per '000 population	0.246	0.349	0.003	1.458	n.a.	n.a.	n.a.	n.a.
Oil and mineral taxes/Oil and mineral GDP	58.18	21.98	6.72	99.76	52.61	24.48	2.37	99.76
Oil taxes/Production (in '000 billion, local currency unit)	0.006	0.006	0.000	0.040	n.a.	n.a.	n.a.	n.a.
Oil taxes/hydrocarbon exports	0.630	0.366	0.062	2.912	n.a.	n.a.	n.a.	n.a.
Revenue Watch Index	52.61	23.07	11.60	96.40	53.24	22.08	11.60	96.40
World Bank Governance Index (Government Effectiveness) [0-5]	2.15	0.78	0.96	4.75	2.18	0.78	0.96	4.75
Real GDP per capita	6,956	9,310	265	42,133	6,072	8,691	228	42,133

Period: 1992-2008 for most countries (with some exceptions due to data availability)

4. Empirical Strategy and Results

Estimating increases in active rigs

Basic equation:

(1) $$RIGSit = \alpha + \beta\, RIGSi,t-1 + \gamma\, Pit + \omega\, \sigma Pit + \varphi\, \delta RESit + \Omega\, Rit + \pi\, NRTAXit + n\, \mu i + wt + \epsilon it$$

Where:

- *Pit* are present, expected (futures) prices (or alternatively lagged prices to account for adaptive expectations)
- *ϱPit* is a measure of volatility of prices;
- *∂RESit* are recent reserves findings (total RES also used);
- *Rit* is the relevant interest rate (never significant)
- *NRTAXit* is the tax ratio. The latter was estimated, alternatively, as the ratio of total oil related fiscal revenues (compiled from IMF sources) to oil production, GDP or net exports per capita

Table 1 – **Equation 1** Level of active rigs. Fixed Effects

	Rigs (1)	Rigs (2)	Rigs (3)
Average oil prices	.	0.337***	0.236**
	.	0.116	0.116
Standard deviation of oil prices	0.115***	-0.011	0.05
	0.028	0.065	0.066
Δ in reserves	0.238**	0.238*	0.2
	0.115	0.122	0.138
Natural resource tax revenue/Natural resource GDP (-1)	-0.233***		
	0.063		
Natural resource tax revenue/Oil Production (-1)		-0.224***	
		0.059	
Natural resource tax revenue/Hydrocarbon exports (-1)			-0.229***
			0.061
Constant	3.184***	-1.973**	1.327***
	0.261	0.943	0.321
r2	0.234	0.24	0.275
N	332	388	370
Year Fixed Effects	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes

All variables are in logs. Significance level (* 0.10, ** 0.05, * 0.01)*

Table 2 –Equation 1 Level of active rigs. Instrumental Variables

	Rigs (1)	Rigs (2)	Rigs (3)
Average oil prices	-0.891	0.528**	0.339
	0.618	0.22	0.221
Standard deviation of oil prices	0.201	-0.121**	-0.134**
	0.163	0.062	0.063
Δ in reserves	0.131	0.099	0.108
	0.135	0.143	0.143
Natural Resource Tax Revenues/Natural Resource GDP (-1)	-0.411***		
	0.119		
Natural Resource Tax Revenues/Oil Production (-1)		-0.258***	
		0.099	
Natural Resource Tax Revenues/Hydrocarbon Exports (-1)			-0.319***
			0.118
r2	0.168	0.208	0.218
N	262	305	293
Instrumental Variables	*(1) Natural Resource Tax Revenues/Natural Resource GDP (-1)=WBGI-Government Effectiveness (-1)l2.lnnrtax_rate_new*		
	(1) Natural Resource Tax Revenues/Oil Production (-1)=WBGI-Government Effectiveness (-1)l2.lnnrtax_rate_prod		
	(3) Natural Resource Tax Revenues/Hydrocarbon Exports (-1)=WBGI-Government Effectiveness (-1)l2.lnnrtax_rate_exp		

All variables are in logs. Significance level (* 0.10, ** 0.05, * 0.01)*

Table 3A – Level of active rigs. Equation 1 with Institutions and OPEC dummies (Fixed Effects)

	Rigs (1)	Rigs (2)	Rigs (3)	Rigs (4)
Average oil prices	0.326***	.	.	.
	0.115	.	.	.
Standard deviation of oil prices	0.005	0.062*	0.077**	0.093**
	0.064	0.034	0.036	0.036
Reserves	-0.176***	-0.179**	-0.139*	-0.107
	0.063	0.079	0.083	0.083
Δ in reserves	0.325***	0.270*	0.266*	0.278*
	0.124	0.15	0.149	0.148
Natural Resource Tax Revenues/Oil Production (-1)	-0.212***	-0.143**	-0.154**	-0.154**
	0.059	0.067	0.067	0.067
WBGI-Government Effectiveness X Natural Resource Tax Revenues/Oil Production		0.015*	0.015*	0.01
		0.009	0.008	0.009
OPEC X Future Oil Prices			-0.065	-0.246***
			0.042	0.081
OPEC X Future Rigs				0.148***
				0.057
Constant	-1.414	0.79	0.614	0.378
	0.955	1.001	1.005	0.998
r2	0.257	0.198	0.205	0.225
N	388	306	306	306
Year Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes

**All variables are in logs*

Estimating increases in oil production

Bassic equation:

(2) $$\partial Zit = \alpha + \beta\, \partial RIGSit + \gamma\, Pit + \theta\, NRTAX\, it + \mu i + wt + \epsilon it$$

- For model (2), the data for oil production and rigs were detrended -as recommended in Esparsa et al 2012-.

- The three different measures of natural resource taxes were used to test if there are different effects depending on the measure of tax ratios

Table 4 Equation 2 Changes in oil production. Variations around trend
(Pooled OLS and Country and Year Fixed Effects)

	POOLED			Country and Year Fixed Effects		
	Oil production(cycle)	Oil production (cycle)	Oil production (cycle)	Oil production (cycle)	Oil production (cycle)	Oil production (cycle)
	(1)	(2)	(3)	(4)	(5)	(6)
Rigs_cycle	0.058	0.119*	0.049	0.110**	0.091**	0.033
	0.076	0.065	0.048	0.046	0.04	0.031
Average oil prices	0.192***	0.228***	0.233***		.	.
	0.028	0.028	0.024		.	.
Standard deviation of oil prices	-0.055***	-0.106***	-0.109***	0.068***	0.068***	0.067***
	0.015	0.018	0.017	0.013	0.012	0.01
OPEC X Oil Prices	0.001	0	0.001	0.014	0.003	-0.005
	0.005	0.005	0.004	0.015	0.012	0.009
Natural Resource Tax Revenues/Natural Resource GDP	0.032			0.027		
	0.021			0.028		
Natural Resource Tax Revenues/Oil Production		0.006			0.005	
		0.023			0.025	
Natural Resource Tax Revenues/Hydrocarbon Exports			0.01			-0.01
			0.018			0.019
Constant	-0.707***	-0.559*	-0.659***	-0.144	0.067	0.013
	0.106	0.334	0.069	0.119	0.357	0.028
r2	0.142	0.105	0.134	0.574	0.601	0.726
N	335	389	353	335	389	353

**All variables are in logs*

Table 6. Changes in oil production Reduced Form – GMM

	Oil production (cycle)	Oil production (cycle)	Oil production (cycle)	Oil production (cycle)	Oil production (cycle)	Oil production (cycle)
	Difference GMM			System GMM		
	(1)	(2)	(3)	(4)	(5)	(6)
Oil production (cycle) (-1)	0.100**	-0.071	-0.062	0.065	-0.067	-0.07
	-0.048	-0.055	-0.072	-0.052	-0.048	-0.071
Future Oil Prices	0.119***	0.168***	0.176***	0.265***	0.341***	0.378***
	-0.025	-0.041	-0.036	-0.059	-0.083	-0.099
Standard deviation of oil prices	-0.007	-0.089***	-0.085**	-0.002	-0.034	-0.031
	-0.023	-0.027	-0.033	-0.037	-0.05	-0.054
Reserves	-0.004	-0.002	0	-0.222*	-0.478	-0.689
	-0.006	-0.012	-0.01	-0.116	-0.354	-0.485
Δ In Reserves			-0.087			0.207
			-0.118			-0.252
Natural Resource Tax Revenues/Natural Resource GDP (cycle) (-1)_	-0.369**			-0.437*		
	-0.178			-0.227		
Natural Resource Tax Revenues/Oil Production (cycle) (-1)		-0.373*			-0.433**	
		-0.188			-0.178	
Natural Resource Tax Revenues/Hydrocarbon Exports (cycle) (-1)			-0.404			-0.404**
			-0.256			-0.19
Constant	-0.378***	-0.446***	-0.483***			
	-0.071	-0.114	-0.083			
N	343	386	362	315	357	334

**All variables are in logs*

Estimating increases in oil and mineral GDP (reduced form)

Bassic equation:

(3) $$Zit = \alpha + \gamma Pit + \omega \sigma Pit + \pi NRTAXit + \mu i + wt + \epsilon it$$

Where

- *Zit* stands for detrended oil and minerals GDP
- *Pit* for the price (or weighted index of prices) of main non-renewable commodity (ies)
- *NRTAX* stands for the tax ratio estimated in two ways: as the oil and mineral related fiscal revenues ratio to either oil and mineral GDP or net oil and mineral exports per capita

We also estimated this equation with indexes of institutions as self standing variables and interacted with prices and tax ratios

Table 8. Equation 3A. The effect of tax ratios and institutions on oil and mining GDP. (OLS, Fixed Effects)

Dep Var	Contribution of Oil and Mining to GDP (%) (1)	Contribution of Oil and Mining to GDP (%) (2)
Natural Resource Tax Revenue/Natural Resource GDP	-0.049*	-0.052**
	0.026	0.026
WBGI-Government Effectiveness	2.055	2.349
	4.237	4.202
WBGI-Government Effectiveness X Natural Resource Tax Revenues/Natural Resource GDP	-1.611	-1.742
	1.109	1.096
WBGI-Government Effectiveness X Oil Prices	0.793	0.843
	0.659	0.654
WBGI-Government Effectiveness X Gold Prices	-3.307**	-3.038*
	1.619	1.557
WBGI-Government Effectiveness X Copper Prices	2.814***	2.911***
	1.072	1.055
WBGI-Government Effectiveness X Diamond Prices	0.982	1.053
	0.952	0.945
WBGI-Government Effectiveness X Silver Prices	-0.113	-0.034
	0.942	0.933
WBGI-Government Effectiveness X Alumina Prices	0.343	0.455
	2.068	2.045
Constant	-22.521**	-20.867**
	10.941	10.348
r2	0.546	0.545
N	466	466

*All prices are in logs. Additional controls include natural resource prices and standard deviations (suppressed).

Table 9. Equation 3. The effect of tax ratios on oil and mining GDP. GMM estimations

Dep Var	Contribution of Mining to GDP (%) (1)	Contribution of Mining to GDP (%) (2)
	Difference_GMM	System_GMM
Instrumental Variable	WBGI-Government Effectiveness	WBGI-Government Effectiveness
Contribution of Mining to GDP (%) (-1)	0.137	0.857***
	0.13	0.093
Natural Resource Tax Revenues/Natural Resource GDP	-0.038	-0.154**
	0.054	0.063
r2		
N	424	466

*All prices are in logs. Additional controls include natural resource prices (suppressed)

Benchmarking the efficiency of oil tax systems

We attempted benchmarking the efficiency of LA oil tax systems in two ways:

(1) Recovering the country fixed effects coefficients in the equation for active rigs

(2) Using DEA (Data Envelope Analysis) techniques with:

- active rigs as output and as inputs:
- reserves (or recent additions to reserves)
- (the inverse of) tax ratios

Table 10. Benchmarking oil tax systems efficiency. Coefficients of fixed effect terms

	Eq 1 in Table 3		Eq 2 in Table 3		Eq 4 in Table 3	
	Explanatory Variables are oil prices, standard deviation of oil prices, reserves, change in reserves and natural resource tax revenue/oil production (-1)		Explanatory Variables are standard deviation of oil prices, reserves, change in reserves and natural resource tax revenue/oil production (-1), WBGI - Government Effectiveness index X natural resource tax revenue/oil production		Explanatory Variables are standard deviation of oil prices, reserves, change in reserves and natural resource tax revenue/oil production (-1), WBGI - Government Effectiveness index X natural resource tax revenue/oil production, OPEC X future oil prices, OPEC X future rigs	
Countries	FE Term 1	Rank	FE Term 2	Rank	FE Term 4	Rank
AGO*	-1.057	19	-1.246	19	-1.210	19
ARE*	0.544	8	0.733	8	0.444	9
BOL [1/]	-1.886	21	-2.038	21	-1.795	21
COG	-2.223	23	-2.421	23	-2.178	23
COL	-0.043	13	-0.084	13	0.063	11
DZA*	0.723	7	0.549	9	0.520	8
ECU	-0.904	18	-0.940	18	-0.787	18
GAB	-2.050	22	-2.101	22	-1.937	22
IDN	1.237	5	1.185	5	1.189	4
IRN*	1.338	4	1.273	4	1.038	6
KWT*	0.202	10	0.260	10	0.006	12
LBY*	0.123	11	-0.060	12	-0.164	13
MEX*	1.969	2	2.111	1	2.066	1
NGA*	-0.103	14	-0.268	15	-0.342	15
NOR	0.331	9	0.896	7	0.781	7
OMN*	0.807	6	1.023	6	1.059	5
QAT*	-0.454	15	-0.106	14	-0.212	14
SAU*	1.576	3	1.683	3	1.476	3
SYR*	0.053	12	-0.003	11	0.168	10
TTO [2/]	-1.696	20	-1.528	20	-1.339	20
VEN*	2.037	1	1.939	2	1.765	2
VNM [3/]	-0.902	17	-0.929	17	-0.700	17
YEM [4/]	-0.724	16	-0.795	16	-0.652	16

http://iisdb.stanford.edu/res/2251/NOC_study_prospectus.pdf 1/http://en.wikipedia.org/wiki/YPFB 2/http://en.wikipedia.org/wiki/Petrotrin

3/ http://en.wikipedia.org/wiki/Petrovietnam 4/ http://www.eia.gov/cabs/Yemen/Full.html

Table 11. Benchmarking. DEA scores and ranks.
Inverse tax ratios, average outstanding reserves, net additions to reserves and reserves in 2000 as inputs

Sample	2000-2008		2000-2008		2000-2008	
Input	(1) Average reserves (2) Natural Resource Tax Revenues/ Natural Resource Production (Inverse)		(1) Δ reserves (2) Natural Resource Tax Revenues/ Natural Resource Production (Inverse)		(1) Δ reserves (2) Natural Resource Tax Revenues/ Natural Resource Production (Inverse) (3) Reserves in 2000	
Output	Rigs		Rigs		Rigs	
Countries	rank	theta	rank	theta	rank	theta
AGO	20	0.092	20	0.025	21	0.099
ARE	17	0.125	9	0.125	17	0.125
BOL	7	0.560	21	0.025	7	0.566
COG	19	0.095	22	0.011	22	0.097
COL	5	0.799	12	0.090	1	1.000
DZA	10	0.377	6	0.226	9	0.468
ECU	14	0.236	19	0.032	11	0.379
GAB	23	0.079	23	0.010	23	0.089
IDN	1	1.000	7	0.204	1	1.000
IRN	15	0.229	5	0.229	16	0.229
KWT	18	0.108	10	0.108	19	0.108
LBY	21	0.092	11	0.092	20	0.107
MEX	1	1.000	1	1.000	1	1.000
NGA	22	0.082	14	0.082	18	0.117
NOR	11	0.361	8	0.177	12	0.364
OMN	1	1.000	3	0.401	1	1.000
QAT	16	0.135	16	0.075	15	0.314
SAU	12	0.348	4	0.348	14	0.348
SYR	6	0.729	13	0.083	6	0.752
TTO	9	0.422	18	0.034	8	0.512
VEN	8	0.457	2	0.457	10	0.457
VNM	1	1.000	17	0.066	1	1.000
YEM	13	0.328	15	0.081	13	0.351

*Δ reserves was calculated for the period between 2000-2007 for all countries except for Bolivia (2002-2007) and Iran (2000-2005)

*Reserves in 2000 was calculated for all countries except for Bolivia (2002)

5. Main Conclusions

Main Conclusions

1. Average tax ratios have significant effects on oil and mineral investment and production:
   - On average, a 10% increase in the tax ratio reduces the number of active rigs in the following year between 2.25 to 2.29% (OLS estimates) or between 2.66% and 4.14% (IV estimations) depending on the definition of the tax ratio
   - A 10% increase in the tax ratio reduces future production by about 4% to 6% in oil producing countries. In the joint estimation for oil and mineral rich countries the effect is small in OLS estimations (0.5%) but quite high 8.75% in IV GMM systems estimations
   - The effect of tax ratios on oil production happen ONLY through the level of active rigs (eg, through investment)

E. g., the trade-offs are large!

Other conclusions I

1. The interaction of WB indexes of quality of institutions (especially the index of quality of government effectiveness) and tax ratios have positive, though weak effects, on oil investment.

2. This suggests that countries with better institutions do tend to have better quality (or stability) of oil taxes, though the effect does not seem large (compared to that of the average tax ratio) perhaps indicating some “tax quality convergence”.

3. The results of the attempted benchmarking suggests that a critical variable that must be included in the models is the dominance of a State owned enterprise: these are obviously less sensitive than private firms to tax ratios in their investment behaviour

Other conclusions II

Control variables have, in general, the expected effects:

- Actual and future prices affect investment significantly . Actual prices have additional, though weaker, effects on current production
- Price volatility has in general significant negative effects on investment
- Recent additions to reserves have significant effects on investment and production. Older reserves have weaker effects on production
- Interest rates do not appear to have significant effects in oil investment (very high profitability?)
- OPEP countries investment react less to prices, but significantly to expected global production capacity, as expected