

Petrodollar Recycling, Oil Monopoly, and Carbon Taxes

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Motivation: Oil as an Essential Resource



- Oil market power:

	Share of prod. (2017)	Share of reserves (2017)
OPEC	43.7%	82%
OPEC+	64.9%	85%

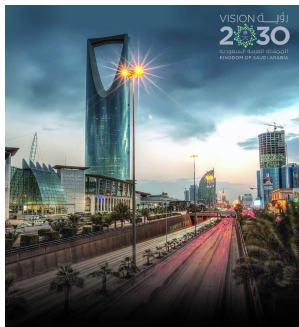
- High **complementarity** between key fossil resources like oil and capital in production. Interplay between markets.

⇒ General equilibrium ("GE") approach

- In "WP Marz and Pfeiffer (2015)" we examine GE oil supply behavior and identify new oil supply motives.

Source: <https://www.eia.gov/international/data/world>

Motivation: Two income streams of oil exporters



The Saudi gov't wants to

- "...make investments the source of Saudi government revenue, not oil" until 2030.
- establish a new **sovereign wealth fund** worth 2 Trillion \$ (→ Saudi Aramco IPO)

⇒ **A Two-Pillar Strategy.**

SWF Table

Research question

How does such a GE oil exporter with market power and two income streams **react to climate policy**?

Model

- A finite time horizon of two periods $t = 1, 2$
- Three markets: resource, capital, consumption goods
- Households: symmetric, homothetic consumption preferences

The resource exporting country E

- **Utility** maximizing resource monopolist (Stackelberg leader)
- No extraction costs
- Own endogenous capital assets, but no direct capital market power

The resource importing country I

- Competitively produces consumption goods (with oil R_t , capital K_t , and labor $L_t = 1$)

Model

General equilibrium conditional on any extraction path (R_1, R_2) for binding resource constraint

- Capital supply derives from endowments ($K_1 = s_{0E} + s_{0I}$) and household savings decisions ($K_2 = s_{1E} + s_{1I}$) in both countries.
- Factor demand derives from the competitive final goods production.
- The resource supply decision determines the resulting equilibrium outcomes of all variables.

⇒ Resource monopolist: Stackelberg leader.

GE Monopolist's Optimal Extraction

⇒ Enhanced general equilibrium version of the Hotelling Rule for a monopolist with full knowledge of the economic structure:

$$(1 + i_2) \left[p_1 + \frac{\partial p_1}{\partial R_1} R_1 + \frac{\partial i_1}{\partial R_1} s_{0E} \right] =$$
$$p_2 + \underbrace{\left(\frac{\partial p_2}{\partial R_2} + \frac{\partial p_2}{\partial K_2} \frac{dK_2}{dR_2} \right)}_{\frac{dp_2}{dR_2}} \cdot R_2 + \frac{di_2}{dR_2} \cdot s_{1E}$$

⇒ Conventional partial **own price effect** of resource supply.

GE Effects 1 - Resource Addiction Motive

$$(1 + i_2) \left[p_1 + \frac{\partial p_1}{\partial R_1} R_1 + \frac{\partial i_1}{\partial R_1} s_{0E} \right] =$$

$$p_2 + \underbrace{\left(\frac{\partial p_2}{\partial R_2} + \frac{\partial p_2}{\partial K_2} \frac{dK_2}{dR_2} \right)}_{\frac{dp_2}{dR_2}} \cdot R_2 + \frac{di_2}{dR_2} \cdot s_{1E}$$

- Supplying more cheap resource in the present increases savings and future resource demand
- Faster extraction (for $\frac{dK_2}{dR_2} < 0$). Conservationist bias of monopoly is dampened or reversed ("conservationist's friend", Solow (1974), Hotelling (1931)).

GE Effects 2 - Capital Asset Motive

$$(1 + i_2) \left[p_1 + \frac{\partial p_1}{\partial R_1} R_1 + \frac{\partial i_1}{\partial R_1} s_{0E} \right] = \\ p_2 + \frac{dp_2}{dR_2} \cdot R_2 + \frac{di_2}{dR_2} s_{1E}$$

- Complementarity effect of resource supply on own capital asset returns
- Effect on extraction depends on asset endowments, parameters. Conservationist bias can be increased, dampened, or reversed.

Value-added carbon tax on oil imports τ_2 in period 2.

$$(1 + i_2) \left[p_1 + \frac{\partial p_1}{\partial R_1} R_1 + \frac{\partial i_1}{\partial R_1} s_{0E} \right] = \\ (1 - \tau_2) \left[p_2 + \frac{dp_2}{dR_2} \cdot R_2 \right] + \frac{di_2}{dR_2} s_{1E}$$

Climate Policy - Postponement of Extraction

Value-added carbon tax on oil imports τ_2 in period 2.

$$\frac{dR_1^*}{d\tau_2} = \frac{-\left(p_2 + \frac{dp_2}{dR_2} R_2\right) + \frac{di_2}{dR_2} \frac{\partial s_{1E}}{\partial \pi_{2E}} \frac{\partial \pi_{2E}}{\partial \tau_2}}{\frac{d[(1+i_2)MV_1]}{dR_2} - \frac{dMV_2^\tau}{dR_2}} \gtrless 0$$

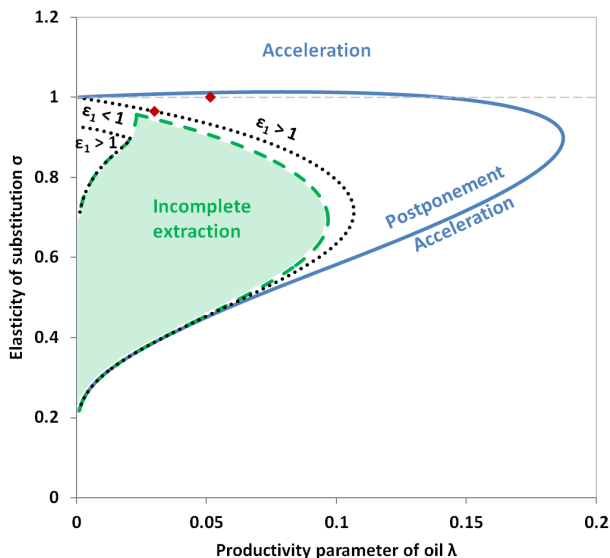
New channel for postponement of extraction

- Due to an increase in τ_2 , households in country E
 - suffer a loss in future resource income $\frac{\partial \pi_{2E}}{\partial \tau} < 0$
 - increase their savings as $\frac{\partial s_{1E}}{\partial \pi_{2E}} < 0$
- Larger asset holdings strengthen the second period's asset motive

⇒ Incentive to *postpone* extraction.

⇒ Tax effect monotonic in tax rate τ_2

Sign of Extraction Reaction



CES production:
 $\gamma = 0.5 - \lambda$
 labour: 0.5

Utility:
 $\beta = 0.3$
 $\eta = 2$

Endowments:
 $\bar{R} = 0.25$
 $s_{0E} = 7.66$
 $s_{0I} = 383$

Unit tax

Magnitude of Extraction Reaction

		τ	(A) PE comp.	(B) GE comp.	(C) PE mon.	(D) GE mon.	(E) GE mon. w/ assets
R_1	Ref	0	0.2001	0.2001	0.2499	0.2499	0.2222
		τ'	0.2011	0.2011	0.2499	0.2499	0.2193
	CD	0	0.2028	0.2028	0.2165	0.2165	0.2087
		τ'	0.2036	0.2035	0.2169	0.2168	0.2086
$\frac{\Delta R_1}{R_1}$	Ref		+0.546%	+0.523%	0%	0%	-1.283%
	CD		+0.366%	+0.344%	+0.186%	+0.157%	-0.055%

Table: Levels and changes of R_1 for a future ad valorem tax τ' that corresponds to $100 \frac{\$}{t_C}$ in different oil market structures for the reference calibration ("Ref") and the corresponding Cobb-Douglas case ("CD"): PE and GE competition and monopoly ((A)-(D)) and the full GE monopolist with asset motive (E).

Extensions

- With investment in exploration, cumulative extraction can decrease simultaneously to postponement

Cumul. ex.

- Competitive fringe: Weaker postponement, closer to perfect competition ("Green Paradox"), but switch to postponement more probable for higher carbon tax.

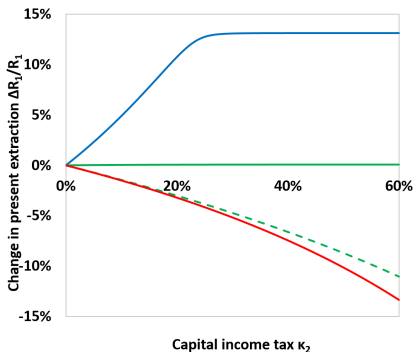
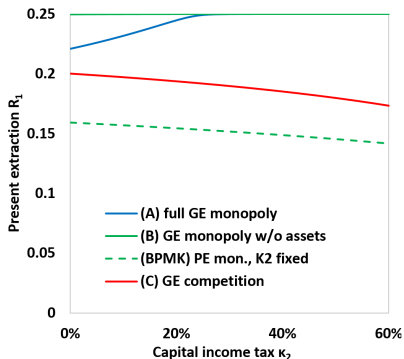
Fringe

Extension: Capital Income Tax

- Tax κ_2 on income from capital assets held by oil exporting countries in the importing countries.
- Discussed by Sinn (2008) and van der Ploeg (2016) as an alternative to a carbon tax, that is supposed to slow down extraction.
- In GE setup with oil market power, however, effect is generally ambiguous.

Extension: Capital Income Tax

- For reference calibration: unwanted acceleration of extraction:



Conclusion

- Expected climate policy triggers adjustment of oil extraction *and* savings directly.
 - In the monopolist's portfolio of oil and capital income this (together with the capital asset motive) provides an incentive to postpone extraction.
- ⇒ Reduction of present extraction by 1.3% for an ad-valorem tax which corresponds to $100\$/t_{CO_2}$ in reference calibration.
- ⇒ Weaker for lower market power.
- Very long-term perspective. Technological change will affect the role of oil. But due to the intertemporal nature of the problem, the asset motive will continue to play a role.

Appendix

Motivation: Market Power

Why Resource Market Power? Think of the oil market and the position of OPEC...

Table: Oil production and liquids by source (million barrel/day)

	1990	2013	New Policies		450 Scenario	
			2020	2040	2020	2040
...						
World	65.6	87.3	93.4	100.7	90.9	69.4
OPEC share	36%	42%	40%	49%	40%	48%
Crude oil	59.6	68.6	68	66.4	66.6	45.4
NGLs	5.6	12.5	14.6	18.2	13.8	13.3
Unconventional	0.4	6.1	2.5	3.2	2.5	2.6

Source: IEA (2014), World Energy Outlook 2014, Table 3.5, p. 115;

Wealth of oil exporters: Sovereign Wealth Funds

	Country	in billion [\$]
1.	United Arab Emirates	1299
2.	Norway	922
3.	Saudi Arabia	697
4.	Kuwait	524
5.	Qatar	320
	...	...
	Total Oil and Gas Related	4,170
	Total SWF	7,327

Source: <http://www.swfinstitute.org/fund-rankings/>, 06/2017.

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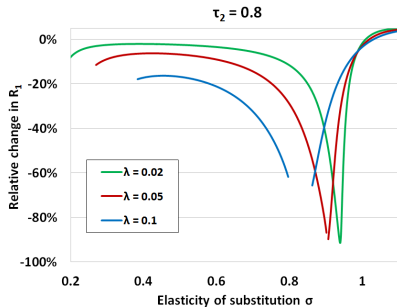
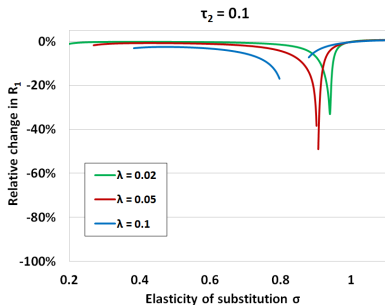
Postponement of Extraction

$$\frac{dR_2^*}{d\tau_2} = \frac{-\left(p_2 + \frac{dp_2}{dR_2} R_2\right) + \frac{di_2}{dR_2} \frac{\partial s_{1E}}{\partial \pi_{2E}} \frac{\partial \pi_{2E}}{\partial \tau_2}}{\frac{d[(1+i_2)MV_1]}{dR_2} - \frac{dMV_2^\tau}{dR_2}} \gtrless 0$$

Postponement Channel No. 2 - Inelastic Oil Demand and Capital Asset Motive:

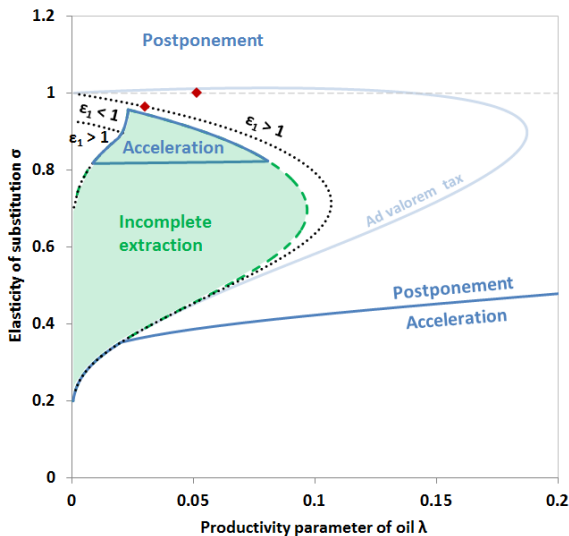
- Marginal oil revenue can be negative ($MR_2 < 0$, suboptimal in pure resource terms) with a strong future capital asset motive
 - The oil income component negatively contributes to the overall positive marginal resource value ($MV_2 > 0$)
 - In contrast to the standard case: Raising the second period resource tax *increases* the overall value of future resource supply
- Incentive to *postpone* extraction.

Magnitude of Extraction Postponement

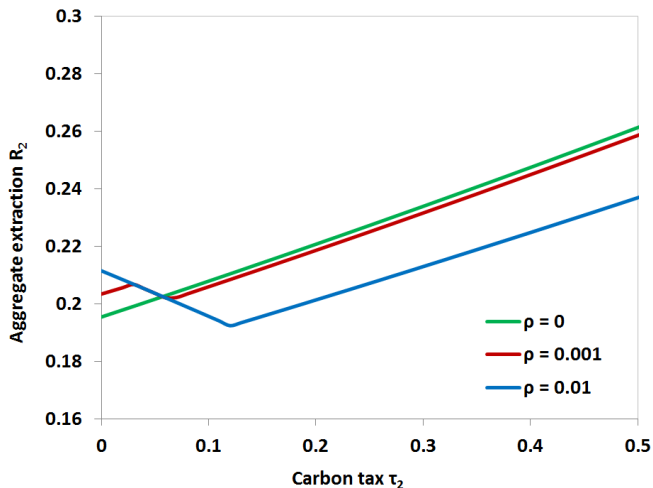


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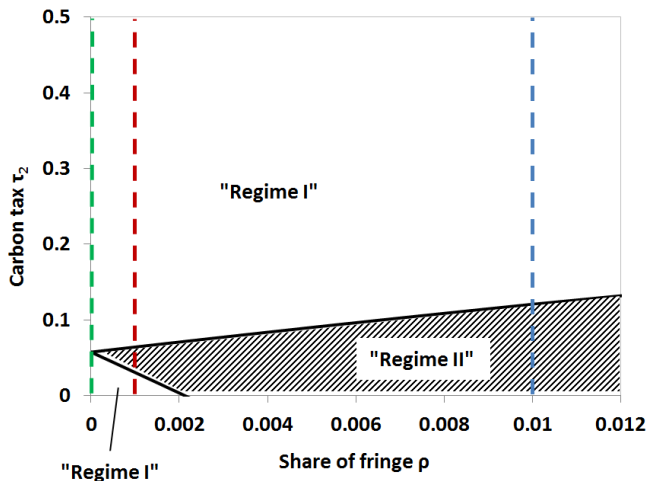
Prevalence of Postponement for a Unit Tax



Extension: Competitive Fringe



Extension: Competitive Fringe



Extension: Competitive Fringe

