

Stockpiling to Contain OPEC

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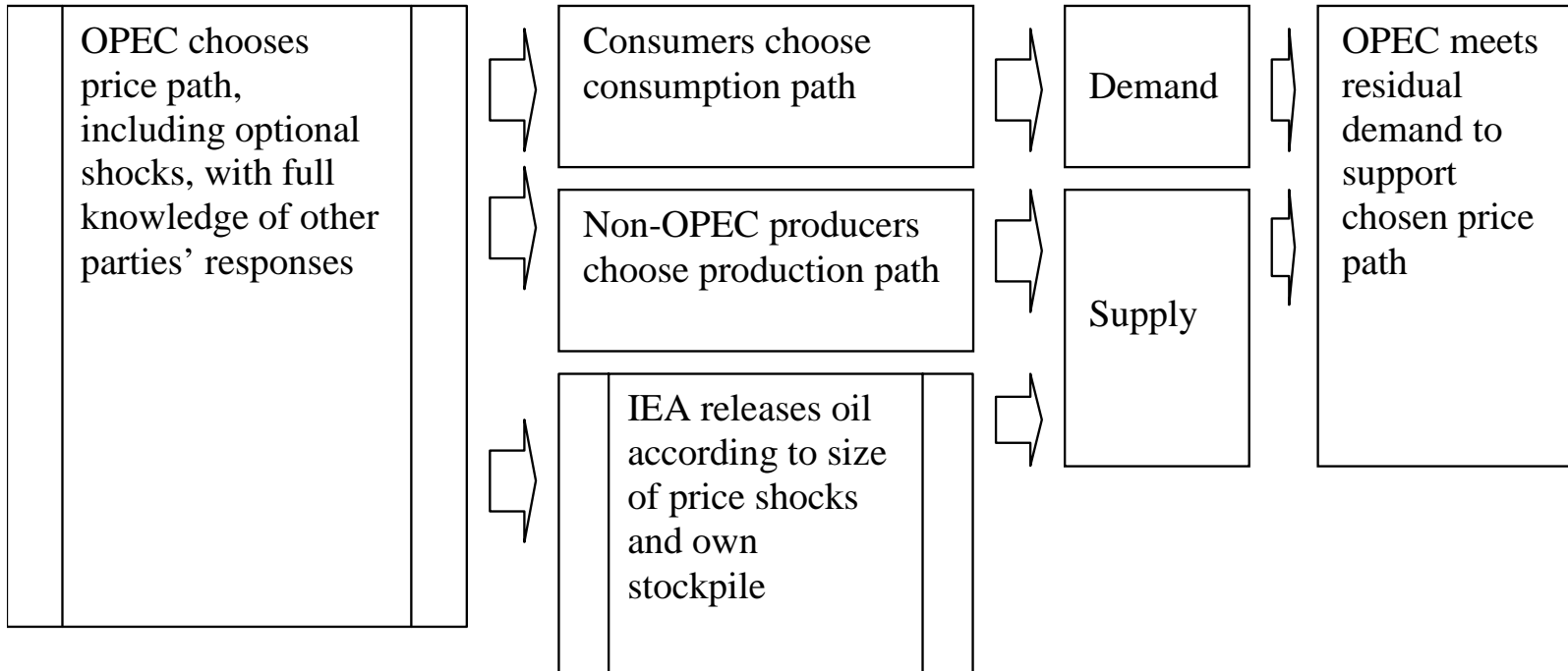
Overview

- Question: What is the optimal stockpile for the International Energy Agency (IEA) to hold for the purpose of containing price-shocks perpetrated by OPEC?
- Shocks are profitable to OPEC and detrimental to world GDP.
- This work simulates strategic interaction between IEA and OPEC.

Game Between IEA and OPEC

- One-shot game looking forward 60 years
- Consumers and non-OPEC producers are price-takers.
- IEA maximizes present-valued GDP over size of stockpile and price at which it intervenes in the market.
- OPEC maximizes present-valued profits over price-path.

One-Shot Game at $t = 2005:11$



Price-Takers

- World Demand

$$D_t = -6.05604 - 0.02675P_t + 12.48769GDP_t - 0.235671t + 0.83554Dave_{t-1}$$

$$GDP_t = -0.0008312 - 0.00016 \left(\frac{dP_{t-1}^+}{GDP_{t-1}} \right) + 1.010725GDP_{t-1}$$

- Non-OPEC Supply

$$S_t = 1.00358 + 0.06468p_t - 0.00671CS_{t-1} + 0.10857t + 0.1741M_t + 0.92064S_{t-1}$$

OPEC

- Profits

$$PVP = \sum_{t=0}^T (P_t - C_t) \cdot Q_t(P) \cdot e^{-\rho t}$$

- Costs

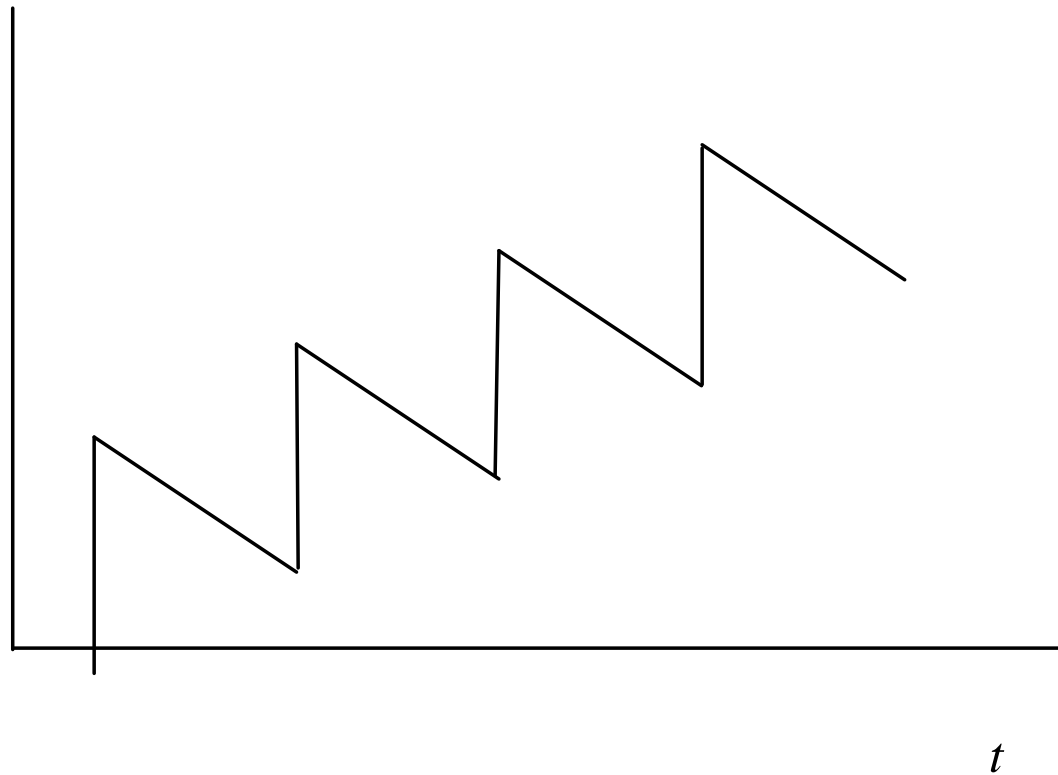
$$C_t = 12,783,287 Q_t^{0.3026} (R_t^p)^{-2.3356}$$

- Price

$$P_t = P_0 e^{gt} + shock \times \left(\left[\frac{t - phase}{length} \right]^+ + 1 \right) + mt$$

OPEC's Sawtooth Shockwave

$$shock \times \left(\left[\frac{t - phase}{length} \right]^+ + 1 \right) + mt$$



International Energy Agency

- Path of Intervention

$$I_t = SPRI \frac{\left(P_t - P_t^{smooth} \right) e^{-\rho t}}{\max_{\tau} \sum_{s=0}^{\tau} \left(P_s^b - P_s^{smoothb} \right) e^{-\rho s}}$$

where

$SPRI \equiv$ IEA stockpile at $t = 2005 : II$ (initially)

$P_t^{smooth} \equiv$ price on path with shock IEA would tolerate

$P_t^b \equiv$ price on path OPEC chooses absent IEA threat

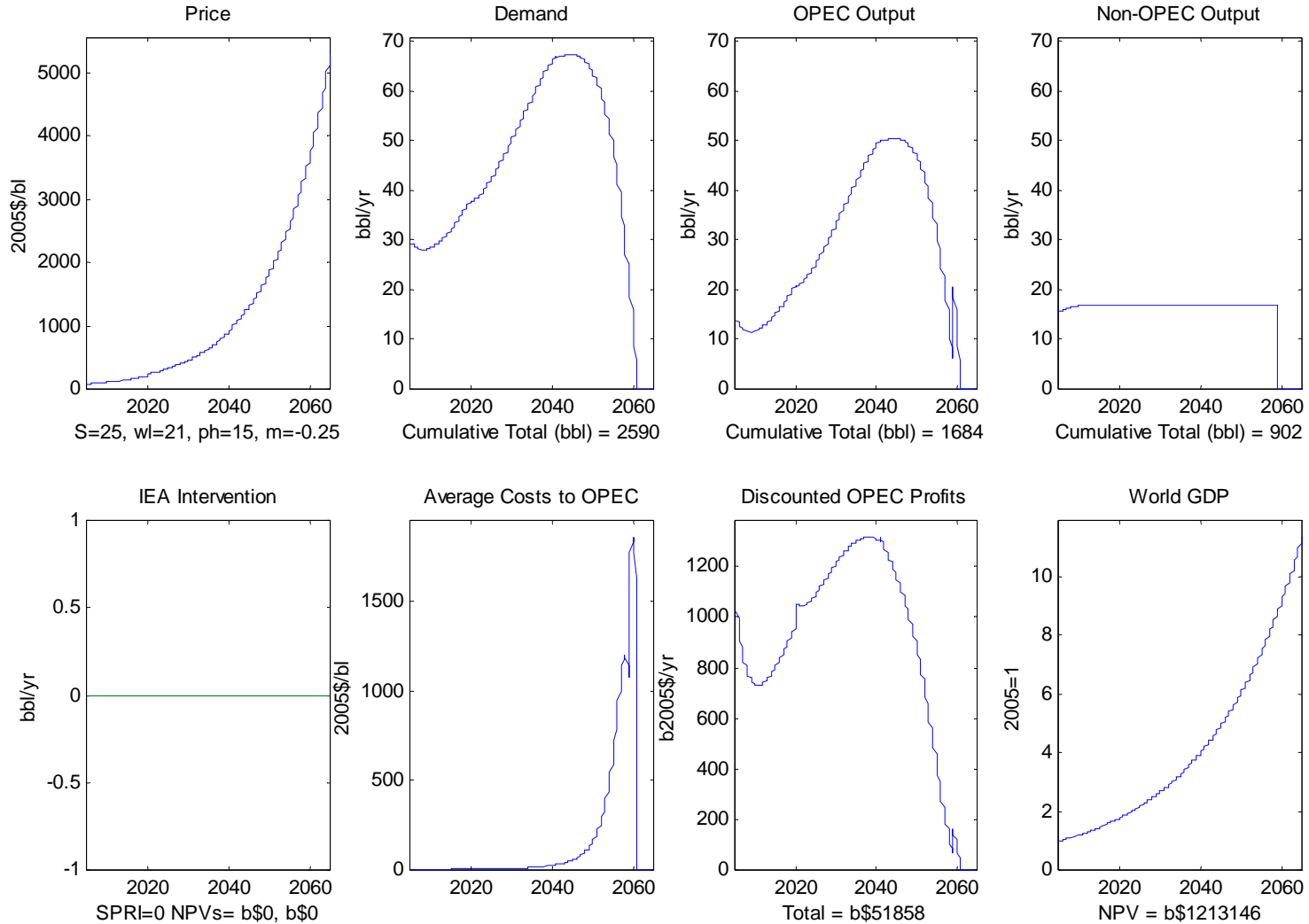
$P_t^{smoothb} \equiv$ same as P_t^b but with shock IEA would tolerate

- IEA exhausts stockpile if OPEC ignores IEA's threat.

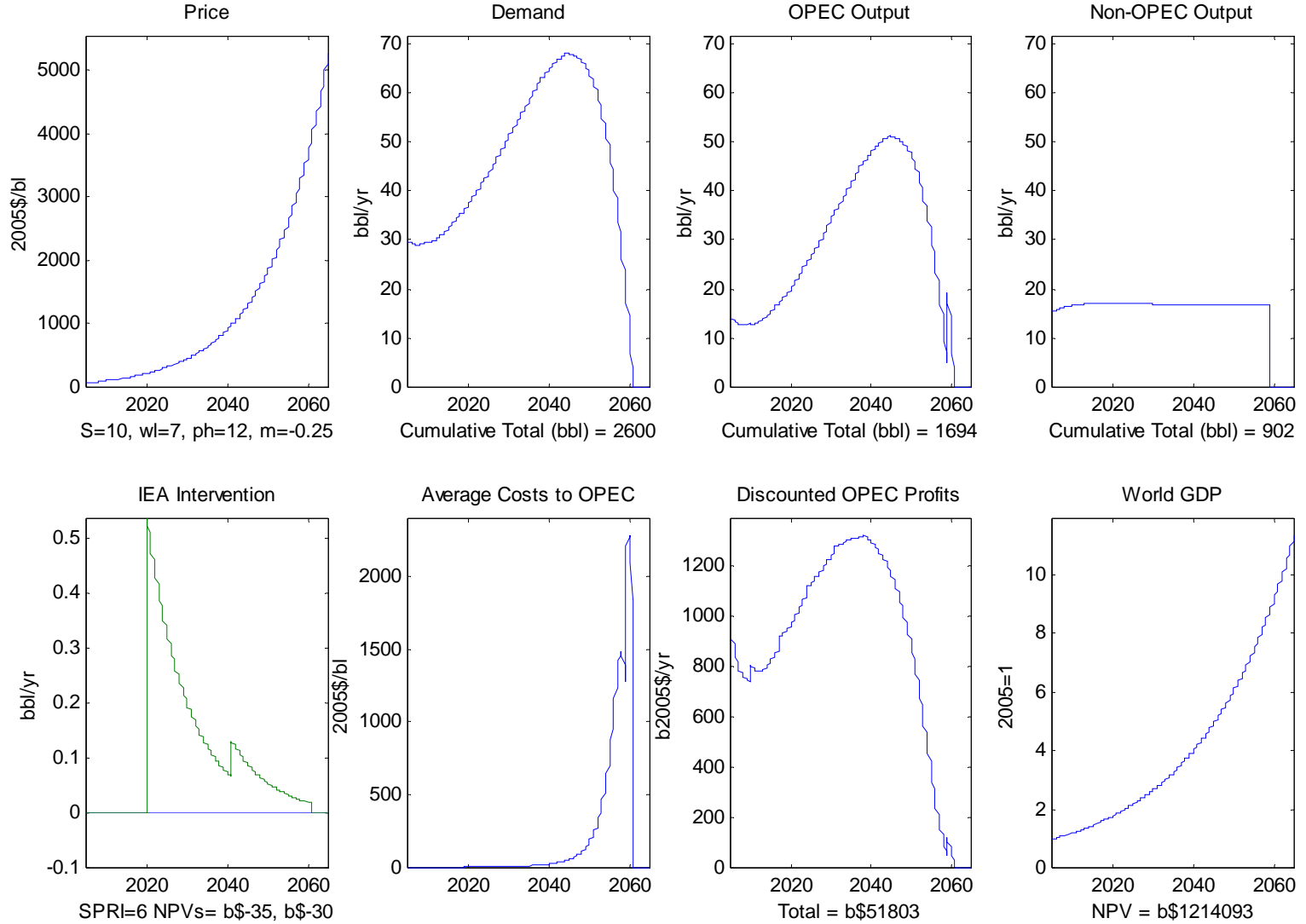
OPEC Output

$$Q_t(P) = D_t - S_t - I_t$$

Base Case w/o IEA Threat



Base Case with IEA Threat

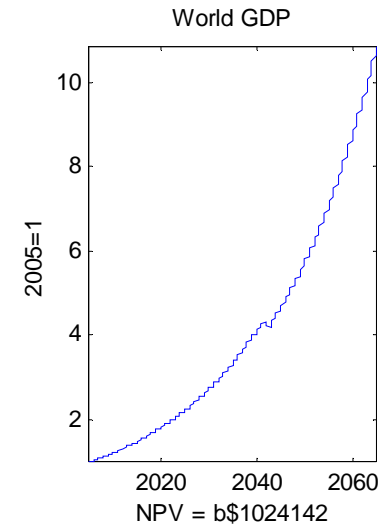
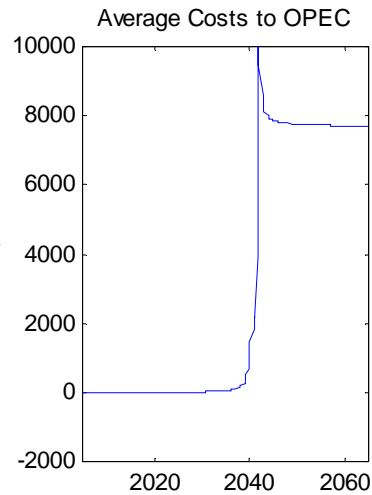
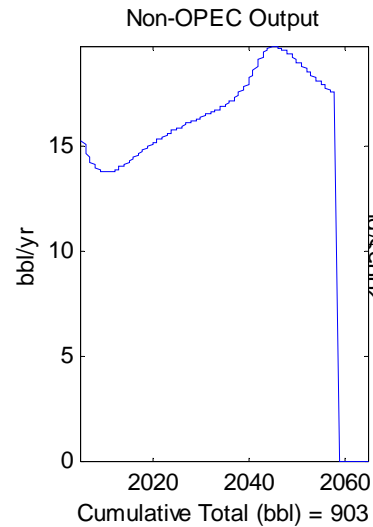
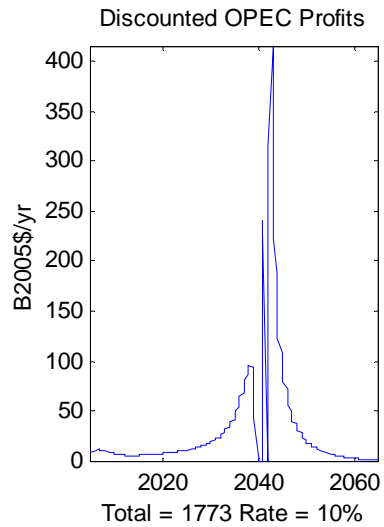
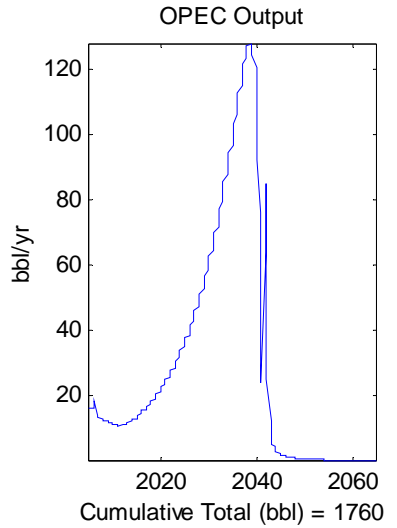
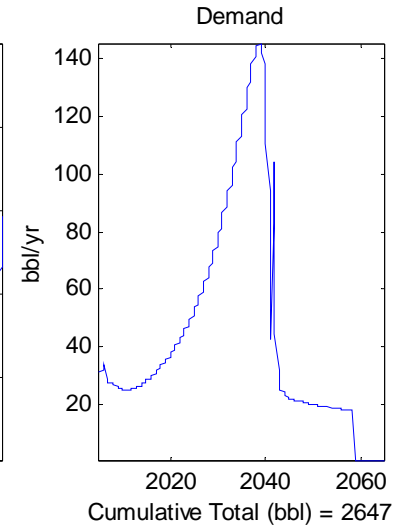
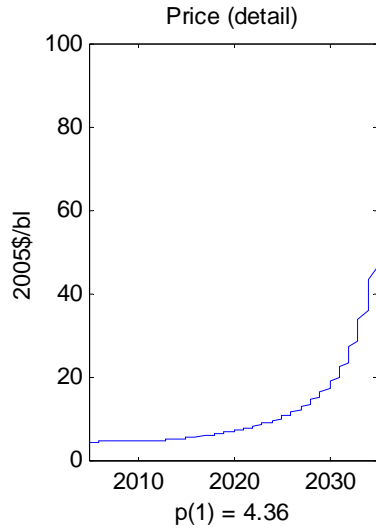
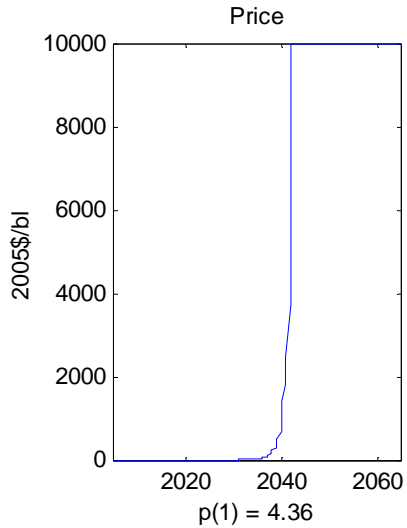


Sensitivities

A	B	C	D	E	F	G	H
Case	Shock that Triggers IEA Intervention	Change in NPV of OPEC's Profits	Private Incentive to Maintain Stockpile	Private Incentive to Punish OPEC	Gain in Present Valued World GDP	Net Benefits	<u>Benefits</u> <u>Costs</u>
	2005\$/bbl	b2005\$	b2005\$	b2005\$	b2005\$	b2005\$	
Base ^a	10	-55	-35	5	946	856	10.51
Current IEA Stockpile; 1.5 bbl	0	-19	-8	-2	276	249	10.22
High IEA Discount Rate; 8% real	10	-55	-249	110	794	490	2.61
Low IEA Discount Rate; 6% real	10	-55	355	-237	1162	1462	27.58
High OPEC Discount Rate; 11.5% real	30	-2	23	-61	169	190	96.00
Low OPEC Discount Rate; 8.5% real	5	-69	-122	43	838	647	4.39
High OPEC Costs; (25% above base)	5	-66	-34	5	660	560	6.60
Low OPEC Costs; (25% below base)	25	-2	21	-30	1076	1095	548.50
High OPEC Resources; 2100 bbl	10	-46	-34	6	218	138	2.73
Low OPEC Resources; 1500 bbl	35	-18	-5	-33	339	316	14.74
High Non-OPEC Resources; 1200 bbl	0	-71	-27	8	285	187	2.91
Low Non-OPEC Resources; 600 bbl	10	-87	-4	-10	848	757	9.32
High GDP Growth; 1.005 x trend	20	-11	118	-263	993	1100	101.00
Low GDP Growth; trend/1.005	0	-95	-99	75	1483	1289	7.64
NOPEC	NA	(50,085)	NA	NA	(189,004)	(239,089)	

^a IEA stockpile is 6 bbl; OPEC Resources 1800 bbl; non-OPEC 900 bbl; real IEA discount rate is 7%; OPEC's is 10%.

NOPEC



Conclusion

- A large negative externality exists in the world petroleum market in the form of macroeconomic effects of price shocks that are profitable to the oil cartel.
- The GDP-maximizing IEA stockpile is on the order of 6 bbl.
- Net benefits of storage intervention to counter OPEC's price shocks are in the hundreds of billions of dollars.