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# *National Oil Company Efficiency: Theory and Evidence*

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## *Theoretical Model*



## *Economic model precepts*

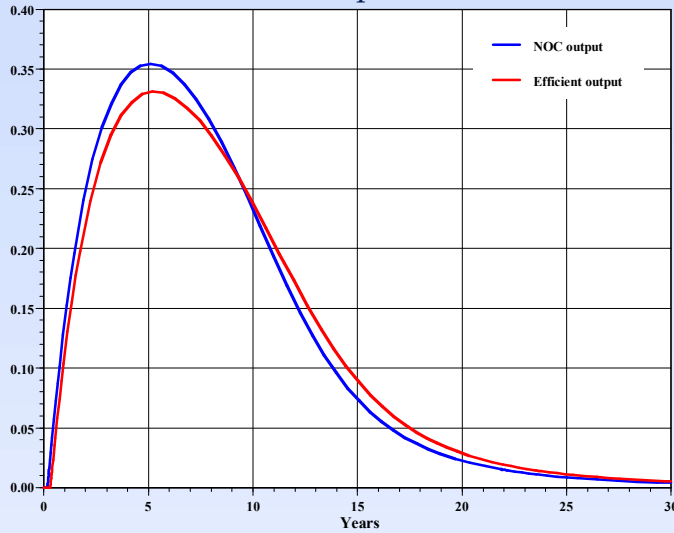
- *Intertemporal, optimizing* model of a National Oil Company (NOC)
- Contrast a NOC to a shareholder-owned firm
- Capture *systematic* effects from the NOC institutional arrangement
- Weaker monitoring of a NOC and differing political goals imply that in addition to commercial returns NOC management choices will reflect:
  - ◆ Increased employment in the firm of labor or other domestic inputs
  - ◆ Domestic consumer surplus from oil product sales
  - ◆ Pressure to increase current relative to future revenue – a high discount rate
- Without these concerns, the NOC optimization problem approaches that of a private monopoly firm
- In the *efficient* case:
  - ◆ Domestic oil consumers are neither taxed nor subsidized relative to other constituents, and
  - ◆ Domestic consumer surplus is weighed identically to NOC profits



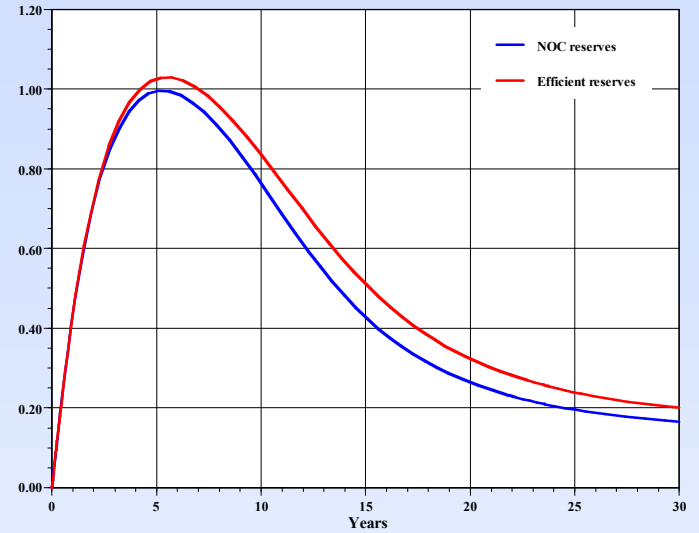
# NOC versus efficient case: output, inputs, cash flow

- Output shifted forward, lower reserves & cash flow, higher employment

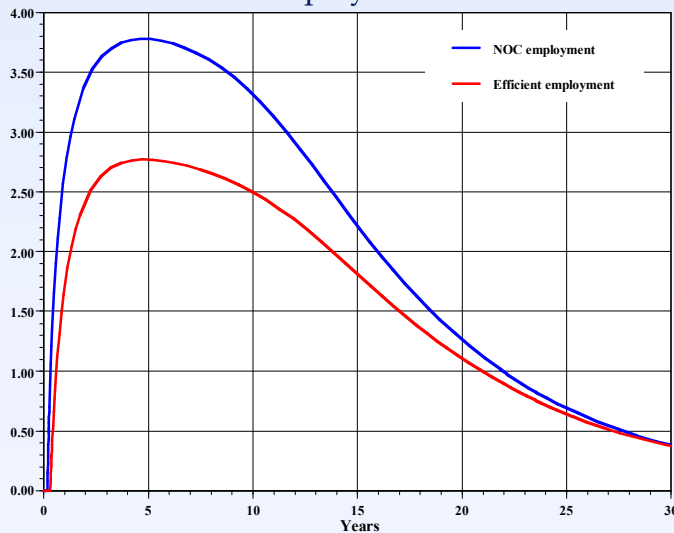
Output



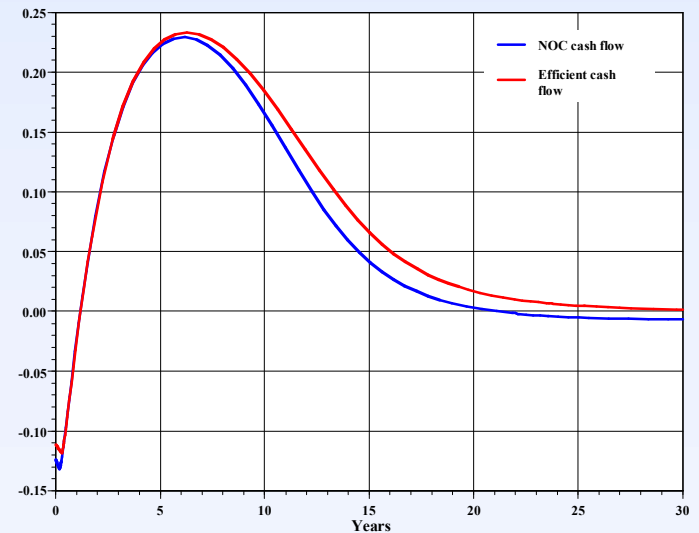
Reserves



Employment



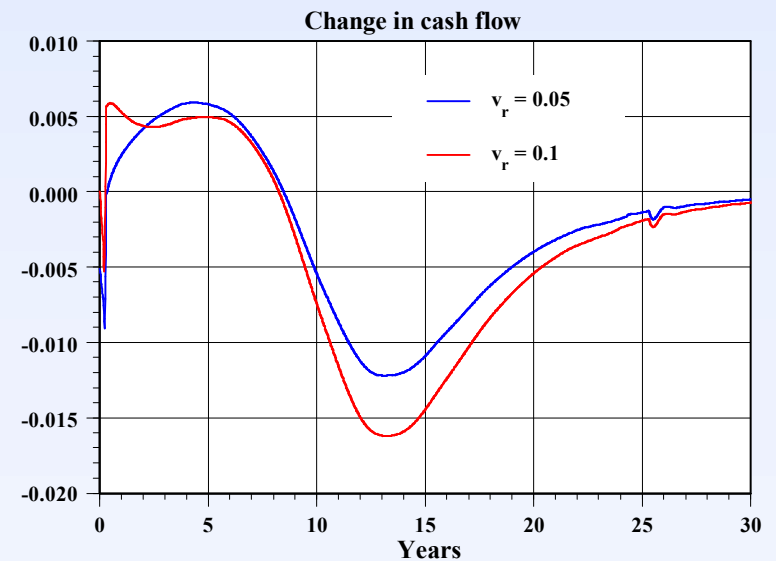
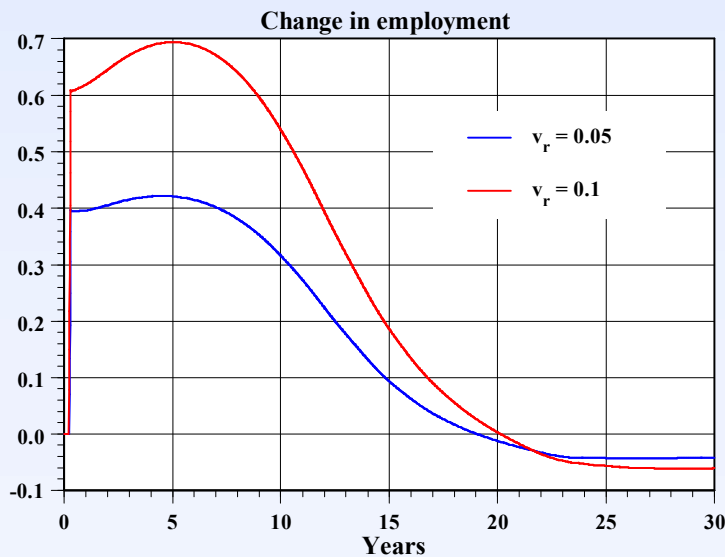
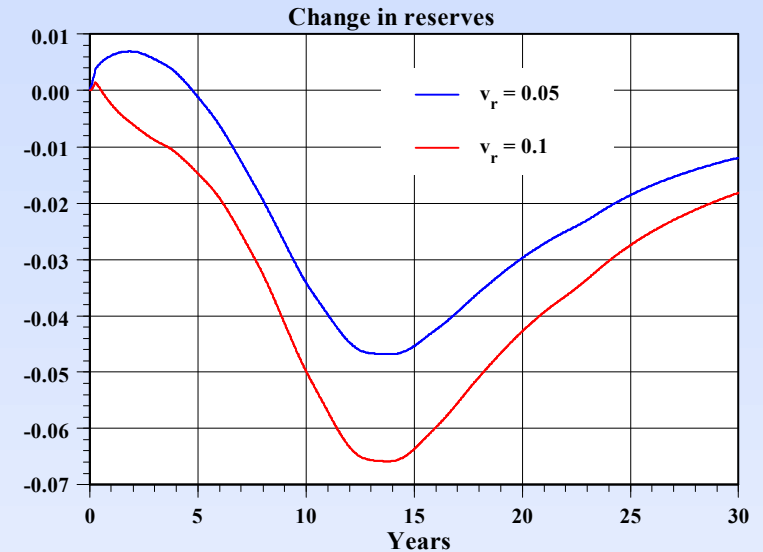
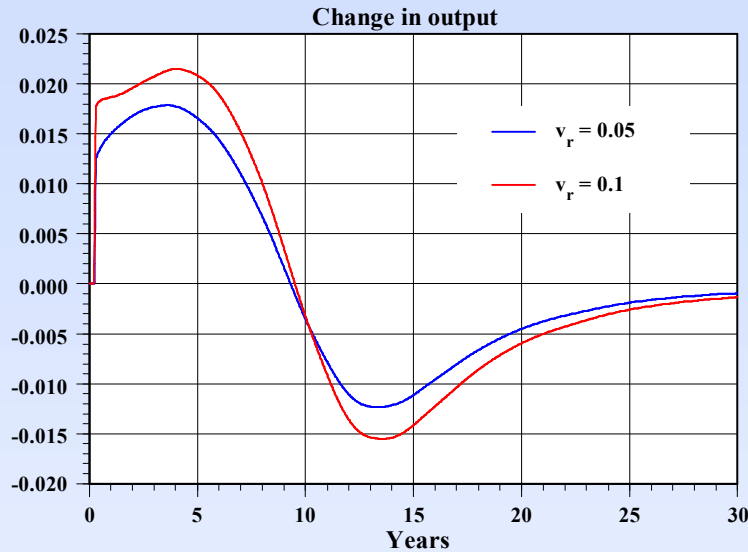
Cash Flow





# Effect of excess emphasis on current revenue

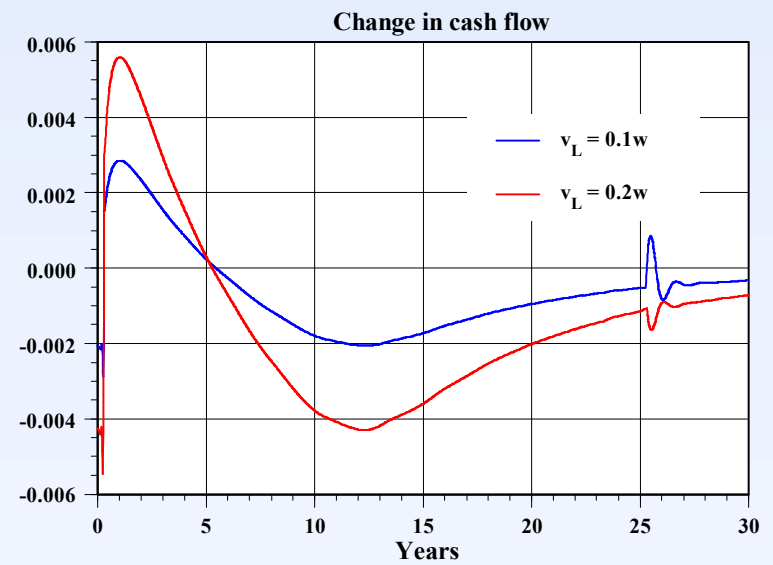
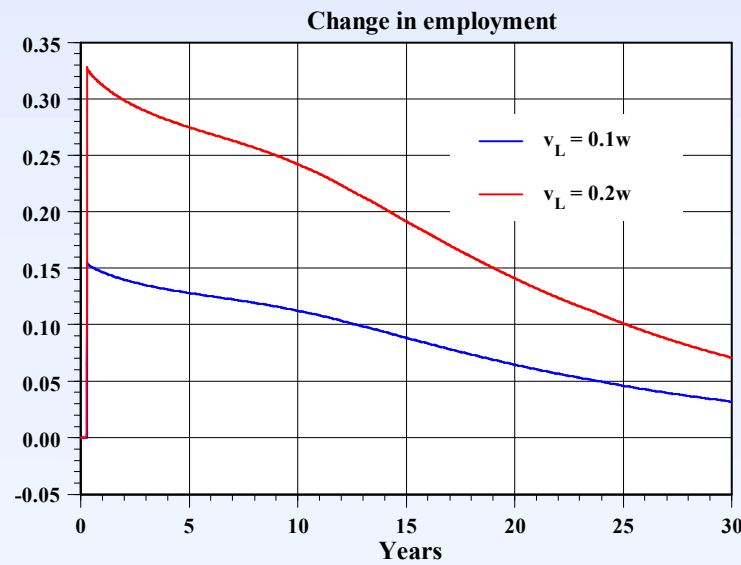
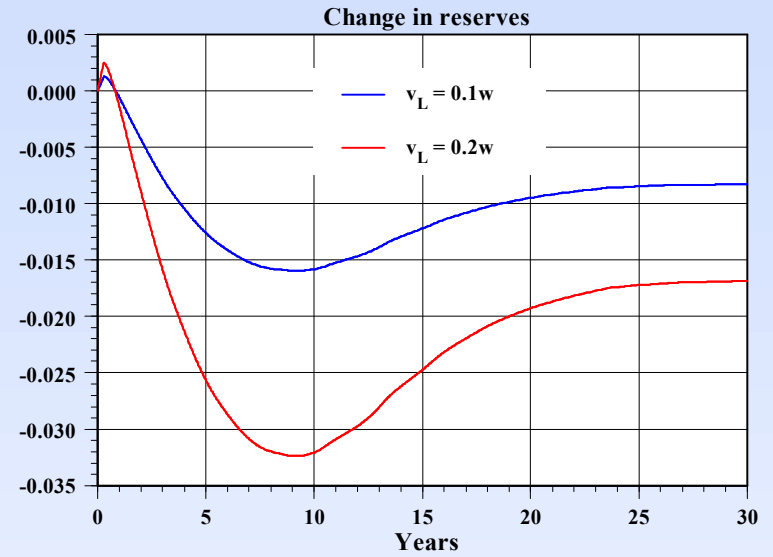
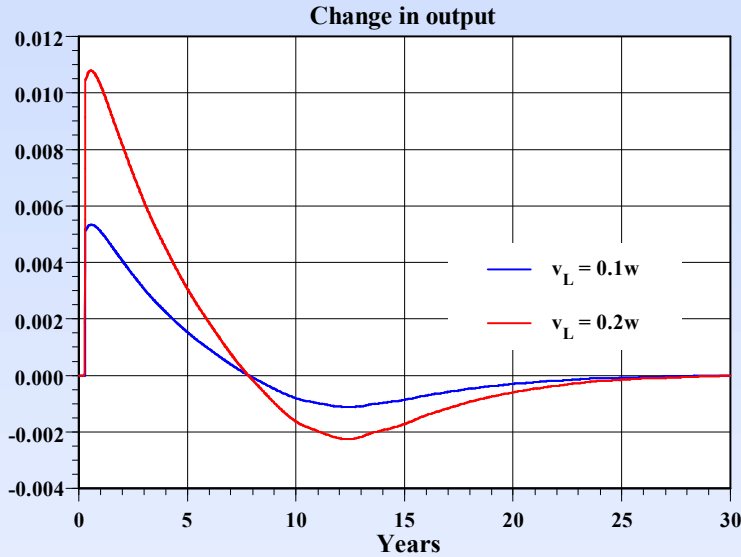
- Output & cash flow shifted forward, reduced investment in reserves, increased employment except in the long term





# Effect of increasing the employment incentive

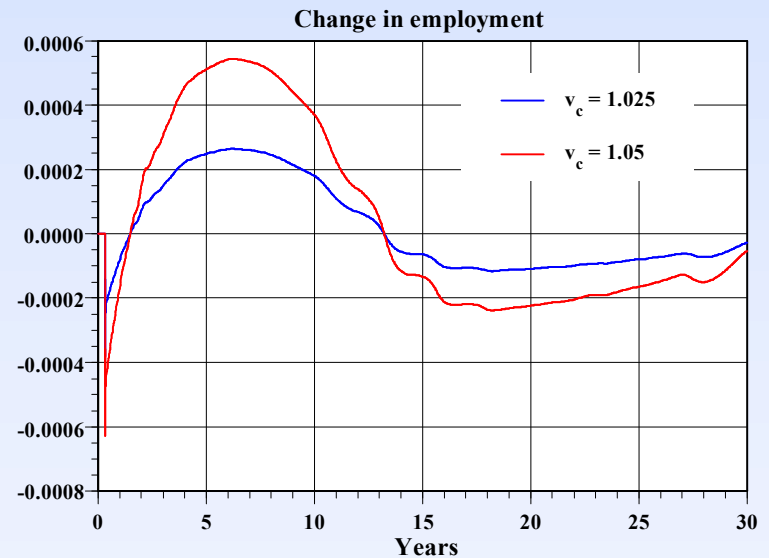
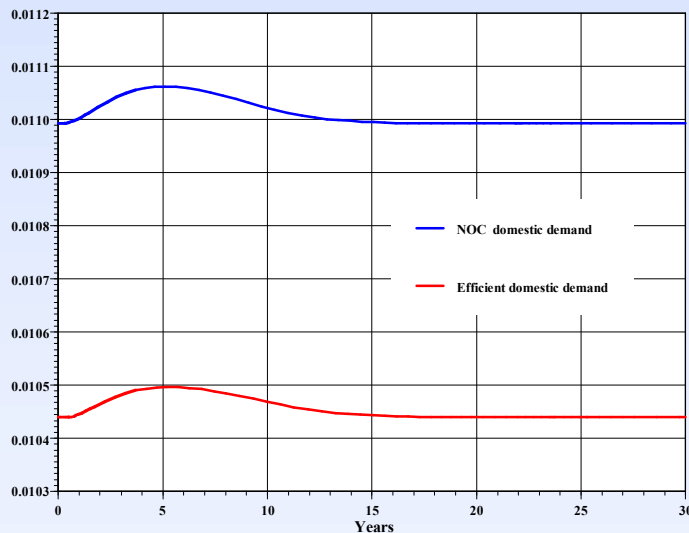
- Output & cash flow shifted forward, reduced investment in reserves, increased employment except in the long term





# *NOC versus efficient domestic consumption*

- The subsidy raises domestic consumption for the NOC
- Increasing the domestic subsidy also shifts employment forward relative to the efficient case, but the effects are small





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# *Empirical Analysis*





## *Data and methods*

- Sample of 80 firms over 2002-2004 (Energy Intelligence “Ranking the World’s Oil Companies”) with data on:
  - ◆ revenue,
  - ◆ reserves of natural gas and crude oil,
  - ◆ employment,
  - ◆ production of natural gas and crude oil and crude oil products, and
  - ◆ the government ownership share
- Used both non-parametric Data Envelopment Analysis (DEA) and a parametric Stochastic Frontier Approach (SFA)
- Motivated by the theoretical model we use revenue as the output measure
  - ◆ Political pressure is likely to force a NOC to subsidize domestic consumers
  - ◆ To the extent that NOC’s generate less revenue for given inputs we can conclude that their objectives differ from a private firm
- Also in accordance with the theoretical model, we allow for three inputs: employees, oil reserves and natural gas reserves



# Firms in the sample (statistics for 2004)

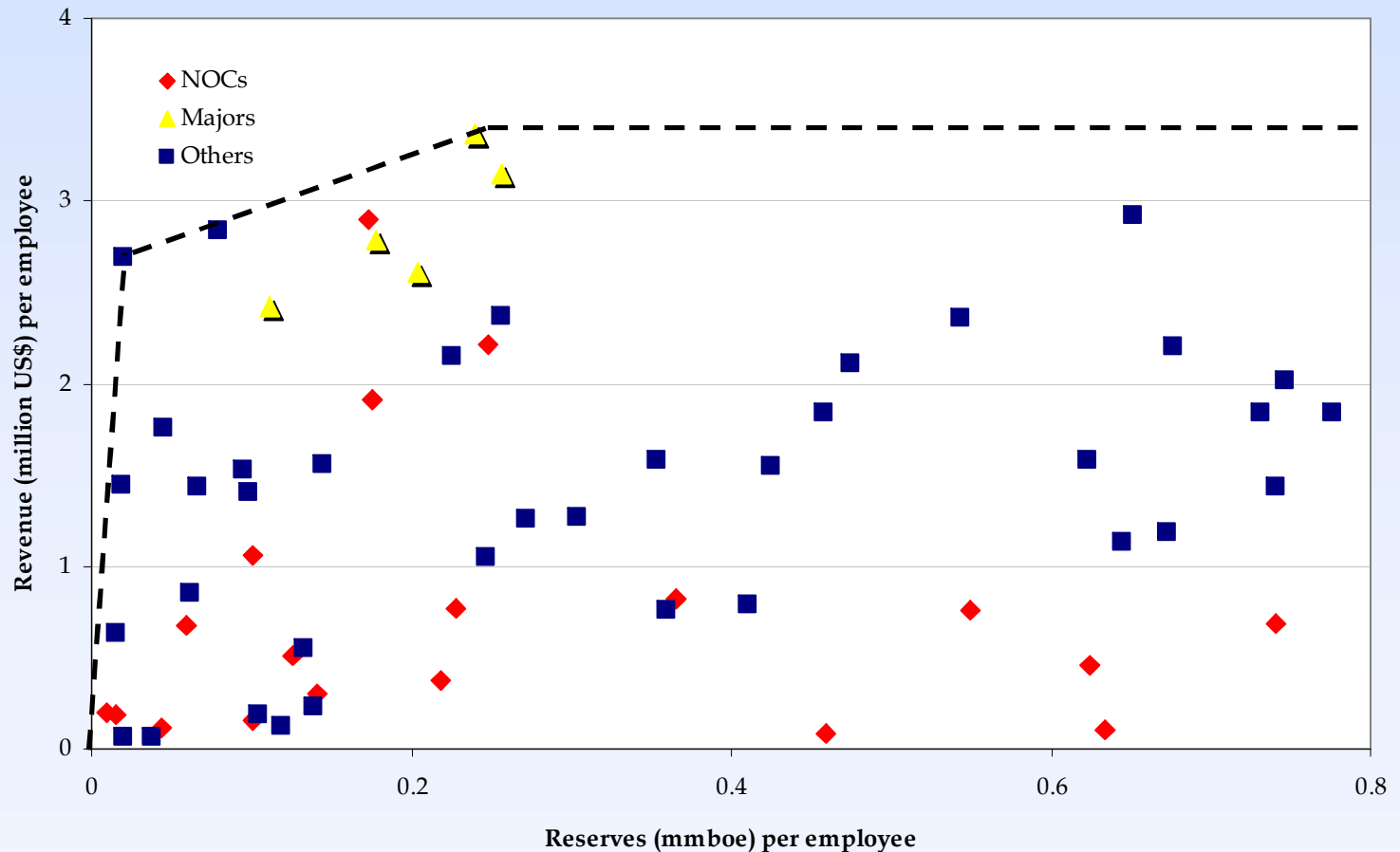
Company	Revenue per Employee \$/employee	Revenue per Reserves \$/boe	Government Ownership %	Country
<i>NOCs</i>				
Adnoc	205	0.20	100%	UAE
CNOOC	2,656	2.97	71%	China
EcoPetrol	824	2.26	100%	Colombia
Eni	1,056	10.50	30%	Italy
Gazprom	103	0.16	51%	Russia
INA	187	11.70	75%	Croatia
KMG	n/a	n/a	100%	Kazakhstan
KPC	1,650	0.34	100%	Kuwait
MOL	635	42.37	25%	Hungary
NIOC	283	0.11	100%	Iran
NNPC	1,460	0.56	100%	Nigeria
NorskHydro	673	11.37	44%	Norway
OMV	2,214	8.90	32%	Austria
ONGC	298	2.11	84%	India
PDO	1,591	0.98	60%	Oman
PDVSA	1,985	0.66	100%	Venezuela
Pemex	506	4.01	100%	Mexico
Pertamina	453	0.73	100%	Indonesia
Petrobras	773	3.39	32%	Brazil
PetroChina	111	2.52	90%	China
Petroecuador	1,026	1.25	100%	Ecuador
Petronas	1,202	1.45	100%	Malaysia
PTT	2,896	16.68	100%	Thailand
QP	1,800	0.10	100%	Qatar
Rosneft	86	0.19	100%	Russia
SaudiAramco	2,261	0.40	100%	Saudi Arabia
Sinopec	192	19.76	57%	China
Socar	n/a	n/a	100%	Azerbaijan
Sonangol	755	1.37	100%	Angola
Sonatrach	688	0.93	100%	Algeria
SPC	375	1.71	100%	Syriac
Statoil	1,910	10.85	71%	Norway
TPAO	154	1.53	100%	Turkey
<i>Average</i>	<i>1,000.27</i>	<i>5.23</i>		
<i>Major IOCs</i>				
BP	2,788	15.68	0%	UK
Chevron	2,606	12.78	0%	US
ConocoPhillips	3,368	14.03	0%	US
ExxonMobil	3,148	12.26	0%	US
Shell	2,418	21.67	0%	Netherlands
<i>Average</i>	<i>2,865.48</i>	<i>15.28</i>		

Company	Revenue per Employee \$/employee	Revenue per Reserves \$/boe	Government Ownership %	Country
<i>Others</i>				
Amerada Hess	1,532	16.07	0%	US
Anadarko	1,838	2.52	0%	US
Apache	2,019	2.71	0%	US
BG	1,547	3.64	0%	UK
Burlington	2,537	2.74	0%	US
Chesapeake Energy	1,577	3.22	0%	US
CNR	4,606	3.85	0%	Canada
Devon	2,356	4.33	0%	US
Dominion	847	13.81	0%	US
EnCana	2,915	4.48	0%	Canada
EOG	1,844	2.38	0%	US
ForestOil	1,841	4.02	0%	US
HuskyEnergy	2,149	9.53	0%	Canada
Imperial	2,838	35.72	0%	Canada
Kerr-McGee	1,263	4.15	0%	US
Lukoil	233	1.68	0%	Russia
Maersk	60	2.90	0%	Denmark
Marathon	1,757	39.14	0%	US
Murphy	1,436	21.60	0%	US
Newfield	2,114	4.45	0%	US
Nexen	1,048	4.25	0%	Canada
NipponOil	2,690	131.74	0%	Japan
Noble	2,433	2.54	0%	US
Novatek	220	0.21	0%	Russia
Occidental	1,577	4.46	0%	US
PennWest	1,577	2.53	0%	Canada
Petro-Canada	2,370	9.24	0%	Canada
PetroKazakhstan	546	4.12	0%	Kazakhstan
Pioneer	1,183	1.76	0%	US
Pogo	5,088	4.38	0%	US
RepsolYPF	1,561	10.79	0%	Spain
Santos	789	1.92	0%	Australia
Sibneft	189	1.81	0%	Russia
Suncor	1,447	78.50	0%	Canada
Surgutneftegas	121	1.01	0%	Russia
Talisman	2,207	3.26	0%	Canada
TNK	63	1.66	0%	Russia
Total	1,406	14.33	0%	France
Unocal	1,259	4.63	0%	US
Vintage	1,136	1.76	0%	US
Woodside	758	2.11	0%	Australia
XTO	1,437	1.94	0%	US
<i>Average</i>	<i>1,628.94</i>	<i>11.24</i>		



## Simplified representation of DEA

- To graph the data in two dimensions, reserves are converted to barrels of oil equivalent and normalized, along with revenue, on the number of employees
- Technical inefficiency in generating revenue from these inputs can be calculated using the *vertical* distance of a firm from the frontier

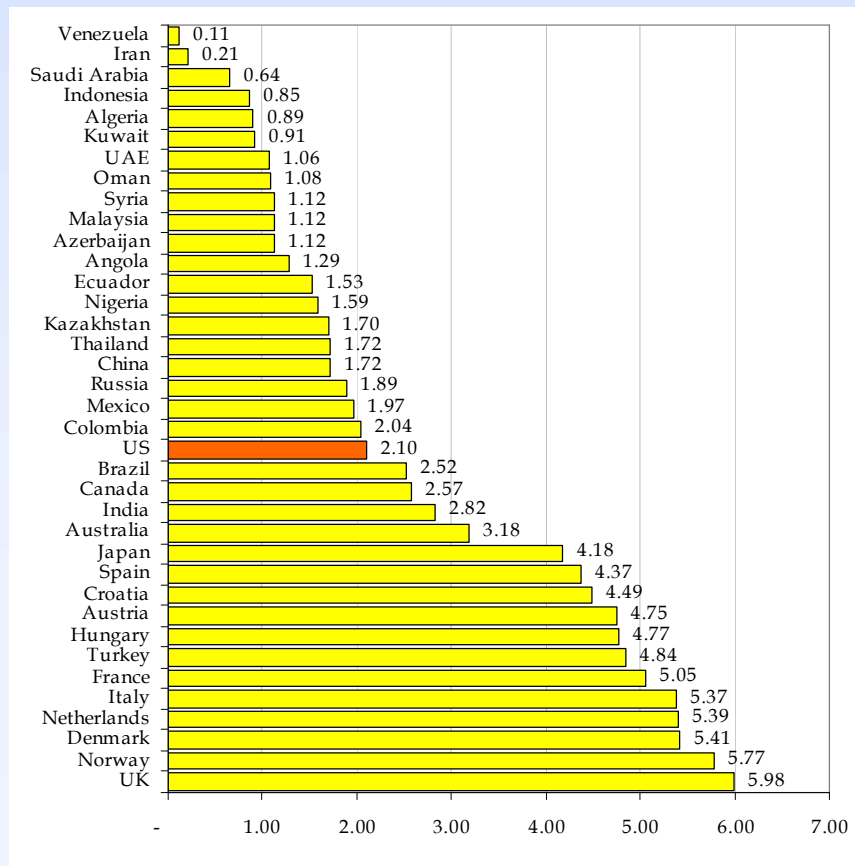




# Other variables in the analysis

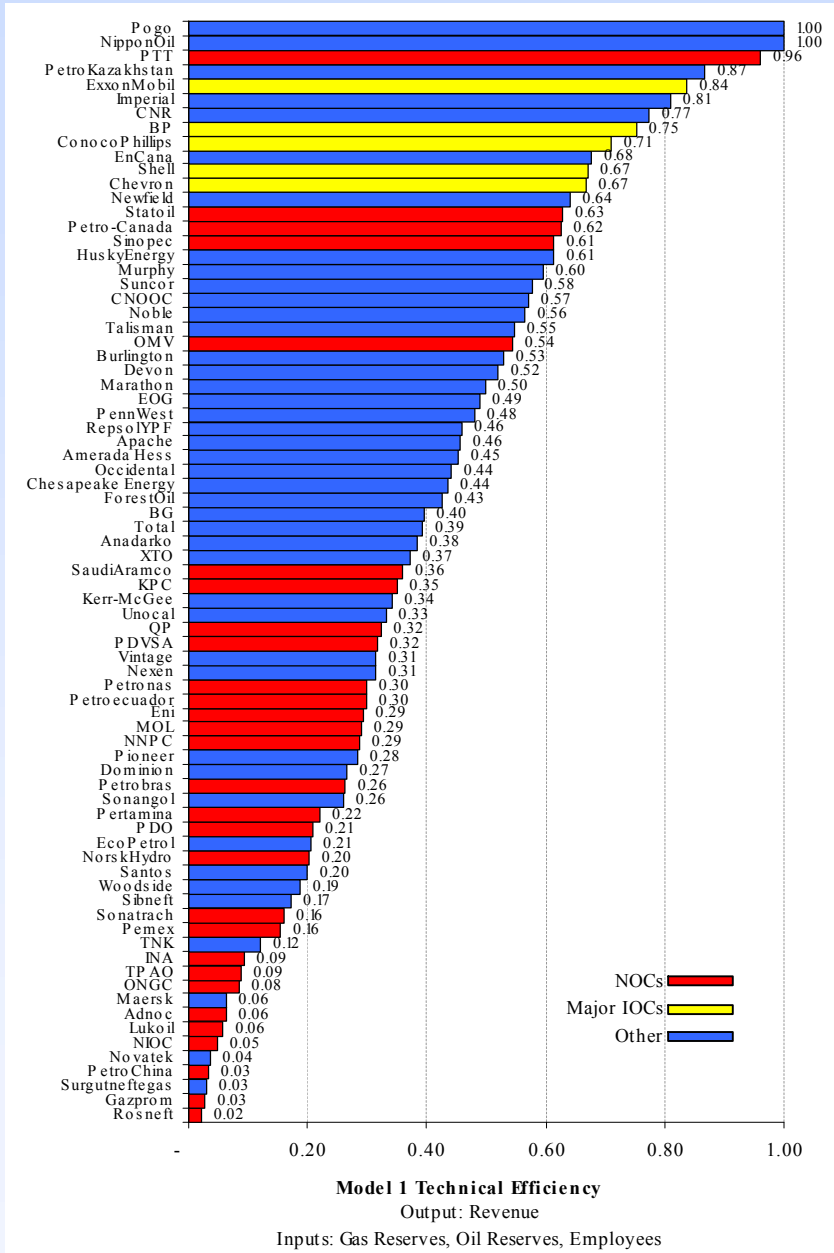
- *Vertical integration* could influence estimated technical efficiency:
  - ◆ A vertically integrated firm captures the value added by the internal sale of crude oil to its refining unit
  - ◆ Without measuring capital employed in the refining, transporting and marketing, a vertically integrated firm would *appear* to be relatively efficient at generating revenue from employees and reserves alone
- *Government ownership share* is a key variable for our hypothesis:
  - ◆ Theory implies higher government ownership should give lower efficiency at generating revenue
  - ◆ *Excess employment* should be a key mechanism for this measured technical inefficiency
  - ◆ *Two-tier pricing* is another reason a NOC may generate less revenue

Average pump prices 2004

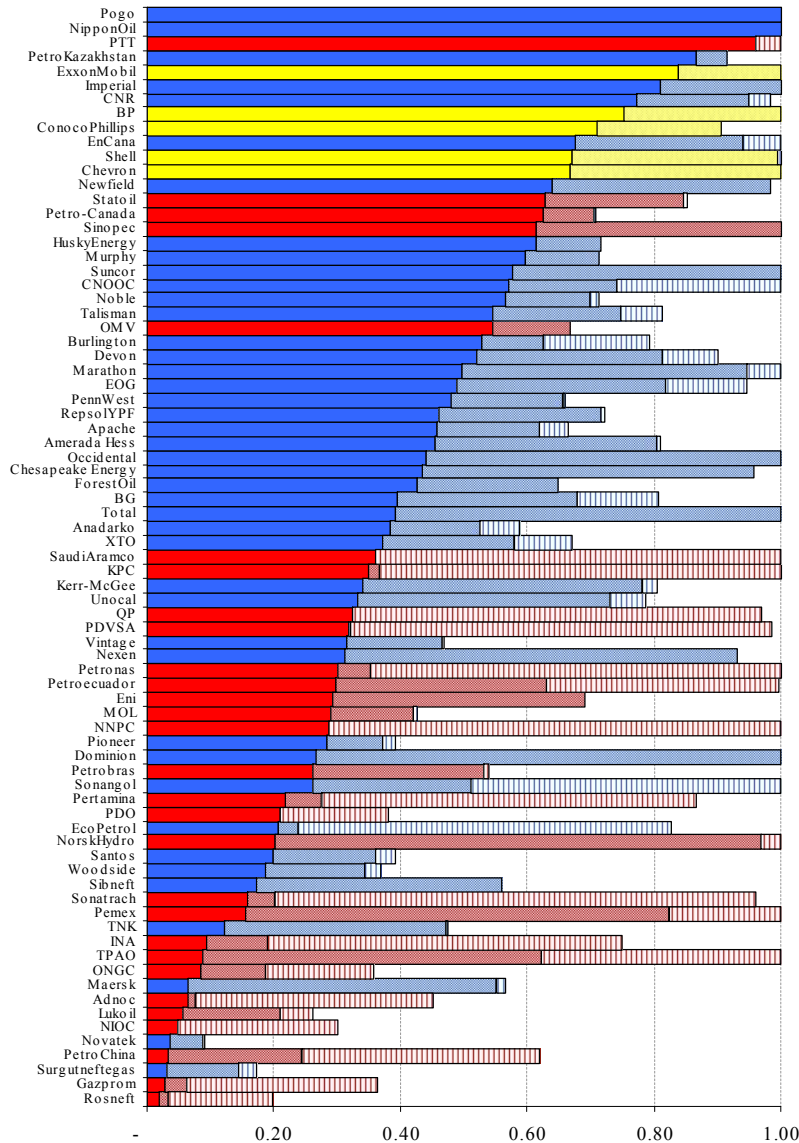




# Average DEA scores over 2002-04



- Five major IOC's are clustered near the frontier
- NOC's tend to be clustered near the bottom
- NOCs average TE  $\approx$  0.27
- Sample average TE  $\approx$  0.40
- Five major IOCs TE  $\approx$  0.73



**Model 1, 2 and 3 Technical Efficiency**  
 Output: Revenue  
 Inputs: Model 1 - Gas Reserves, Oil Reserves, Employees  
 Model 2 - Model 1 plus Vertical Integration  
 Model 3 - Model 2 plus Government Share

# Structural & institutional adjustments

If we include:

- ◆ a vertical integration measure (petroleum product sales divided by total liquids production)
- ◆ and government ownership share

as “inputs” more firms appear to be on the revised frontier



# Stochastic frontier estimation

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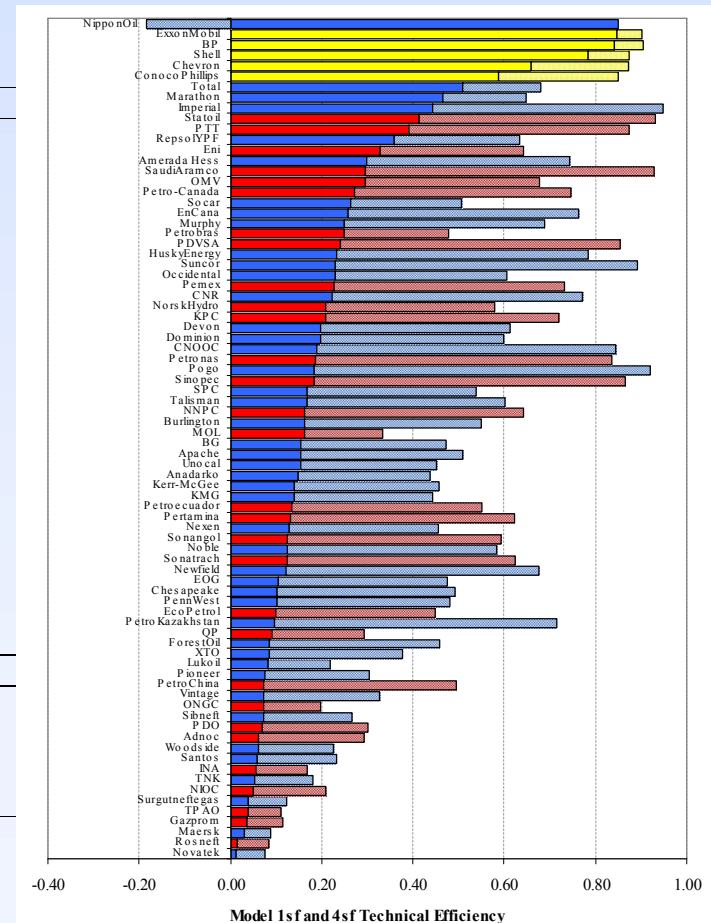
- Estimated TE is now assumed constant over the three year period
  - ◆ Include yearly effects to allow especially for varying oil and gas prices by year
  - ◆ Year effects are not necessary in DEA analysis since TE is calculated for each year separately
- Model 2sf includes vertical integration and government share (like DEA model 3)
- Model 3sf includes a dummy for 2-tier pricing
- Model 4sf includes an employment-government share interaction

Table 4 Š Panel estimation of stochastic frontier<sup>a</sup>

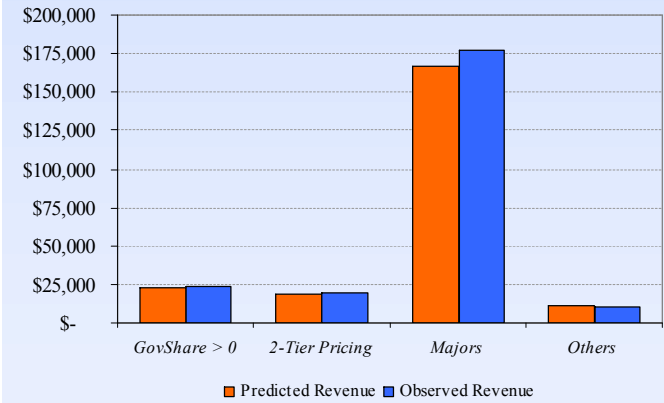
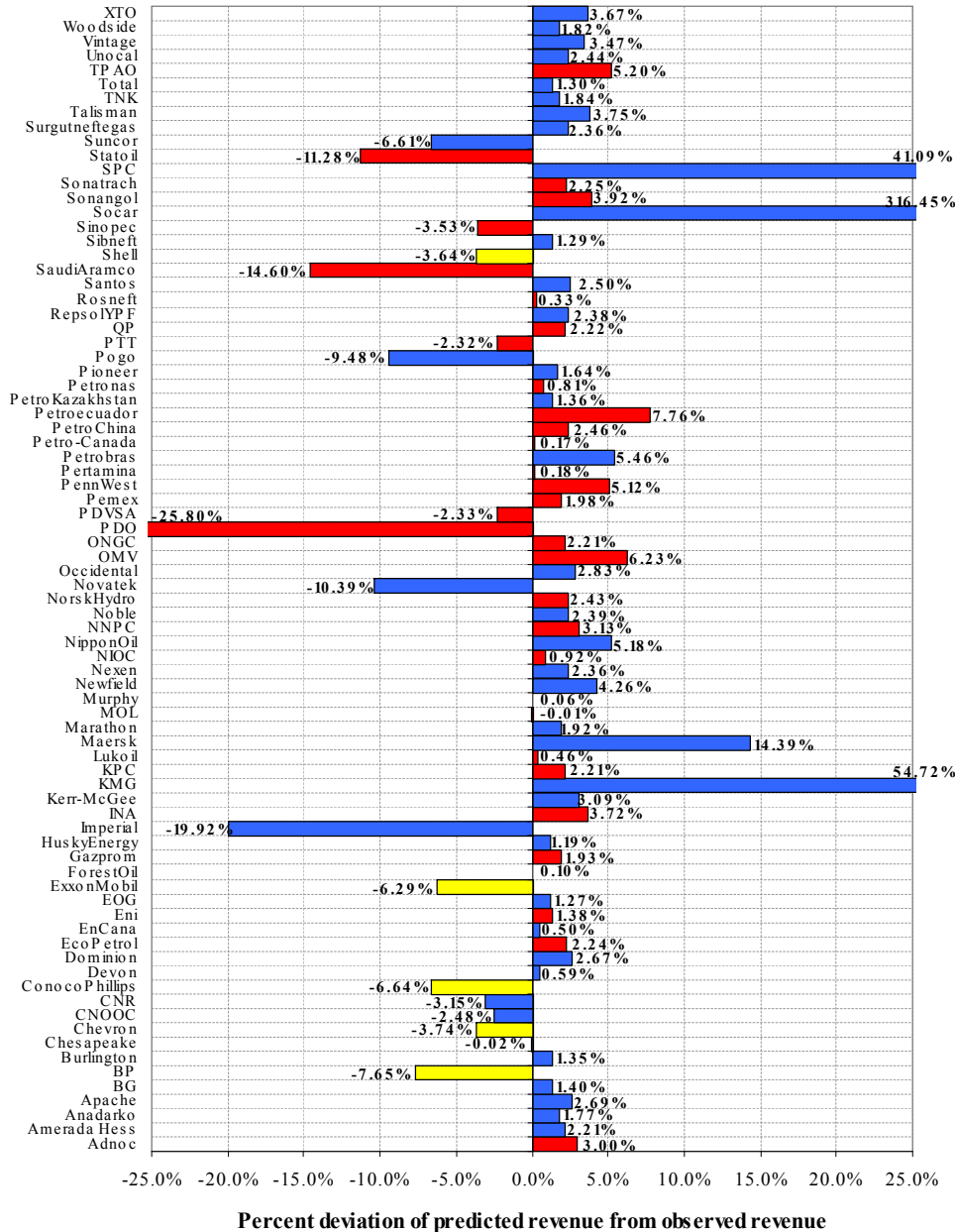
	Model 1sf	Model 2sf	Model 3sf	Model 4sf
$\ln L$	0.4847*** 0.0666	0.6459*** 0.0504	0.5648*** 0.0637	0.6077*** 0.0362
$\ln OilRsv$	0.0463 0.0415	0.0666 0.0462	0.1188*** 0.0459	0.1524*** 0.0396
$\ln NGRsv$	0.1695*** 0.0493	0.2091*** 0.0485	0.2069*** 0.0471	0.2035*** 0.0415
$GovShare$		-0.5970*** 0.1398	-0.3109** 0.1607	2.7912*** 0.8316
$VertInt$		0.0737*** 0.0203	0.0969*** 0.0198	0.0824*** 0.0198
$2TierP$			-0.5435*** 0.1570	-0.6654***
$GovShare * \ln L$				-0.3099*** 0.0824
$year2003$	0.3022*** 0.0307	0.2950*** 0.0325	0.2877*** 0.0331	0.2872*** 0.0335
$year2004$	0.4767*** 0.0312	0.4626*** 0.0330	0.4633***	0.4652*** 0.0339
$constant$	4.3644*** 0.6561	1.5483*** 0.3474	1.9375*** 0.4860	1.2476*** 0.2894
$\chi^2(d)$	451.33	1112.72	992.72	1643.43
$d$	5	7	8	9
$Log Likelihood$	-111.300	-100.041	-94.109	-87.427
$\# Observations$	236	236	236	236

<sup>a</sup> Estimated standard errors included beneath each coefficient estimate.

\* - statistically significant at the 1% level; \*\* - statistically significant at the 5% level; \*\*\* - statistically significant at the 10% level



# Other indications of model adequacy



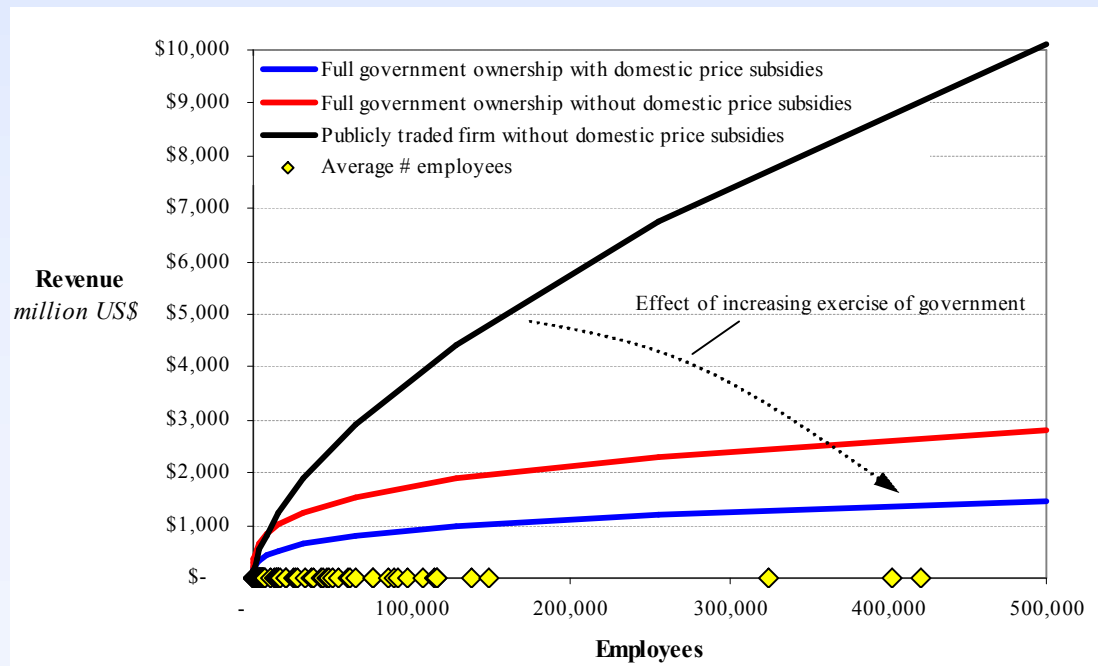
Percent deviation of predicted revenue from observed revenue





# Interpreting the stochastic frontier results

- Vertically integrated firms generate more revenue from inputs of employees and reserves
- Government ownership reduces the ability of the firm to generate revenue
- Domestic price subsidies are one reason government share may reduce revenue
  - ◆ However, since the government share still has a negative effect, this is not the only reason
  - ◆ The positive and significant coefficient on oil reserves in models 3sf and 4sf suggest that accounting for domestic subsidies gives a better model of the determinants of TE in generating revenue
- Since the model implies many consequences of government control should lead to over-employment, we allow for a government share-employment interaction
  - ◆ The negative coefficient on the interaction implies that the productivity of labor in generating revenue is lower the higher is government ownership
  - ◆ Furthermore, the overall effect of government ownership remains negative (controlling for 2-tier pricing) for firms with a positive government share





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## *Conclusion*



## *Summary remarks*

- The theoretical model implies that government ownership of a NOC will redistribute revenue via over-employment and under-investment in reserves and by subsidizing domestic consumption
  - ◆ Many of the influences reinforced each other in their effects
- Evidence confirmed that increased government ownership makes the firm less effective at producing revenue from employment and reserves
- We further found specific evidence that:
  - ◆ Over-employment was a strong common feature of government-owned firms
  - ◆ Domestic price subsidies negatively affect a NOC's ability to generate revenue
- The relative technical inefficiencies of NOC's, which are observed when one considers only commercial objectives, are largely the result of governments exercising control over the distribution of rents
- The forgone revenue will, however, reduce government spending on other items or require higher taxes
  - ◆ Product subsidies or over-employment in a NOC are generally inefficient compared to taxes and transfers as a way of redistributing income
  - ◆ They are poorly targeted as transfers, and more inefficient than a broadly-based tax as a means of raising revenue