Efficiency of National Oil Companies (NOCs)

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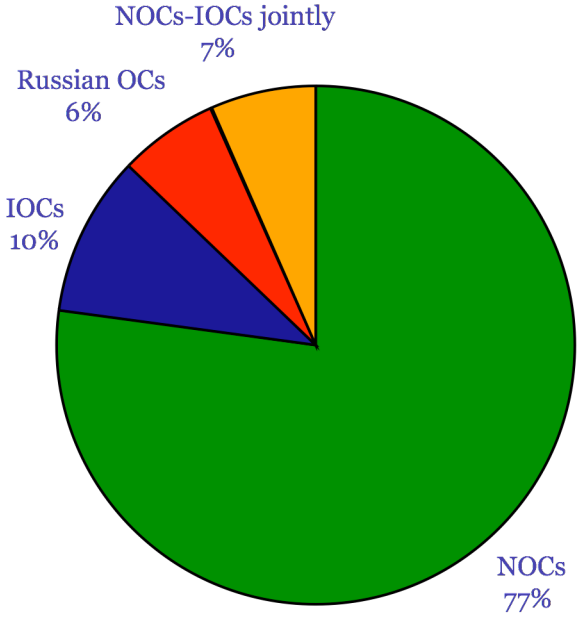
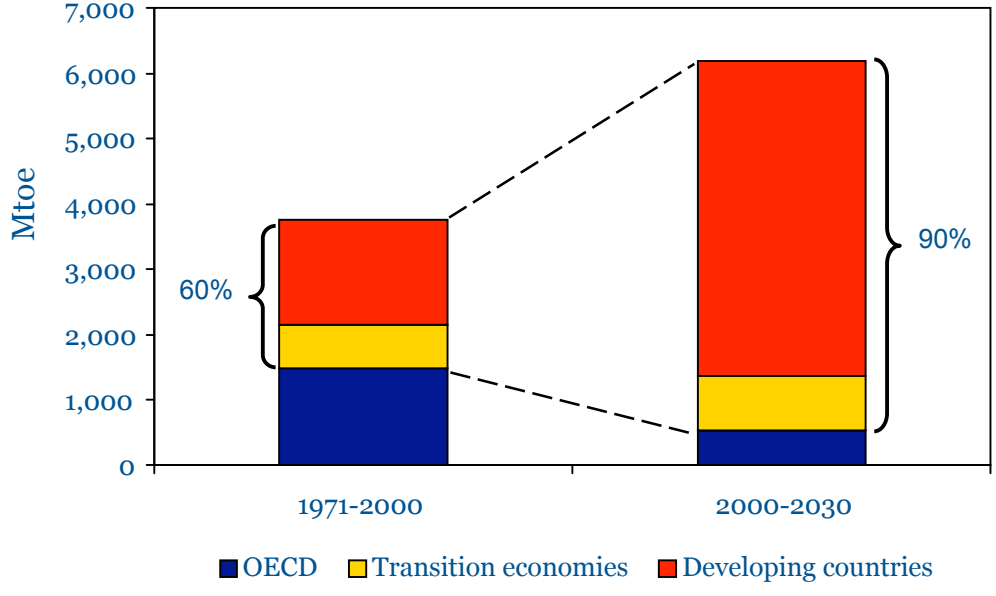
Motivation

Greater NOC role in global energy supply

Control of oil reserves, 2005



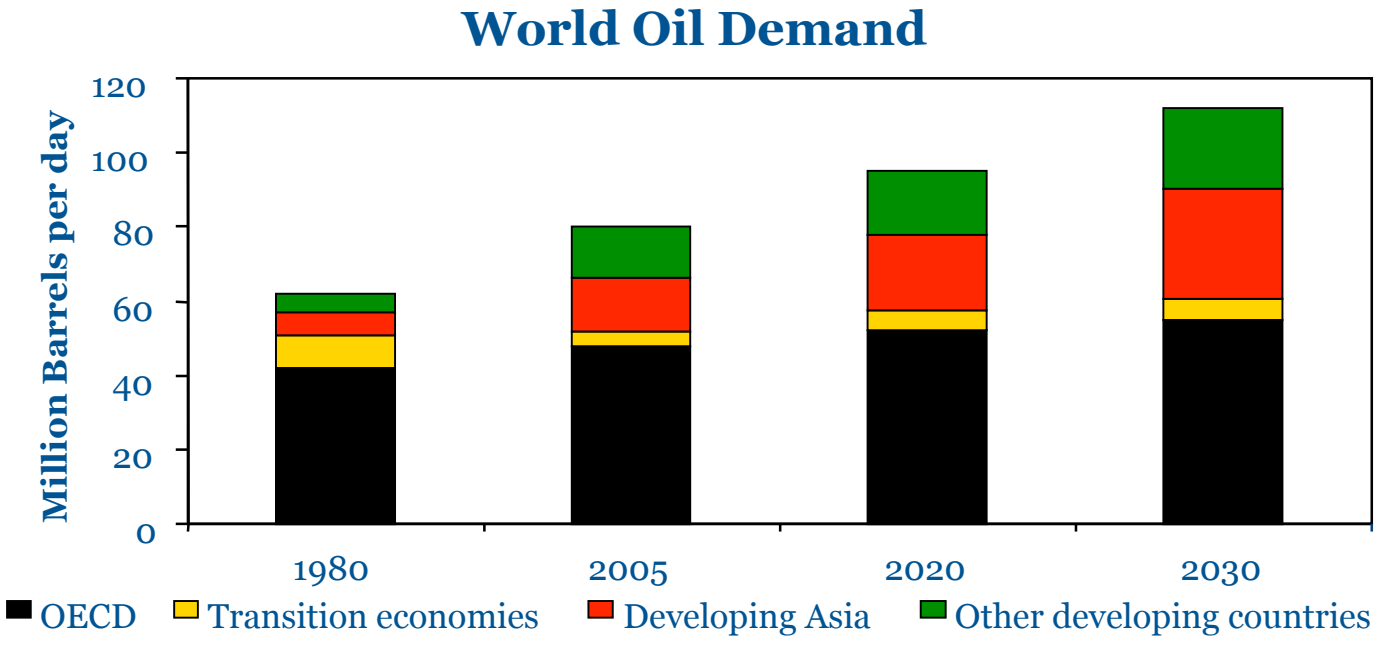
Increase in World Primary Energy Production



Source: International Energy Agency, *World Energy Outlook 2007*

- Through 2030, 90% of new energy production is expected to be from non-OECD nations where NOCs are more prevalent

Meeting growth in global oil demand



Source: International Energy Agency, *World Energy Outlook 2007*

- IEA projects that $2.2 trillion in new investment is needed in the next 30 years to meet rising world oil demand.

Baker Institute study of NOCs

- The study analyzes the strategy and objectives of NOCs
- Basic premise: NOCs will be important future sources of oil, but they must operate within political constraints not present in IOCs
- The study consists of:
  - An economic model a national oil company,
  - An empirical study of the operational efficiency of NOCs,
  - 13 case studies covering 15 state-owned oil companies,
  - A study of the impact of NOC operations abroad, and
  - A study of recent trends in investments by international oil companies (IOCs)
- This presentation focuses on the first three items
- The full study is available online under “Research” at www.rice.edu/energy

A Model of the Operation of a National Oil Company

Model precepts

- We developed an intertemporal optimizing model of the operation and development of an NOC
- We contrast an NOC's behavior with that of a shareholder-owned IOC
- Aims:
  - What are the systematic effects of being an NOC?
  - Are the systematic effects observable?
  - What are the consequences of national ownership?

Objectives of shareholder-owned corporations

- Usually taken to be profit maximization
  - But conflicts between shareholders and managers and shareholders and bondholders, as well as taxes, regulation and other government policies, can blunt this goal
- Nevertheless, many institutional features of shareholder-owned corporations appear to encourage managers to maximize shareholder wealth
  - Specific monitoring practices such as standard accounts and financial reports
  - Explicit performance-related compensation for managers
  - Increased firm leverage to increase the threat of bankruptcy or takeovers

Principal-agent issues in NOCs

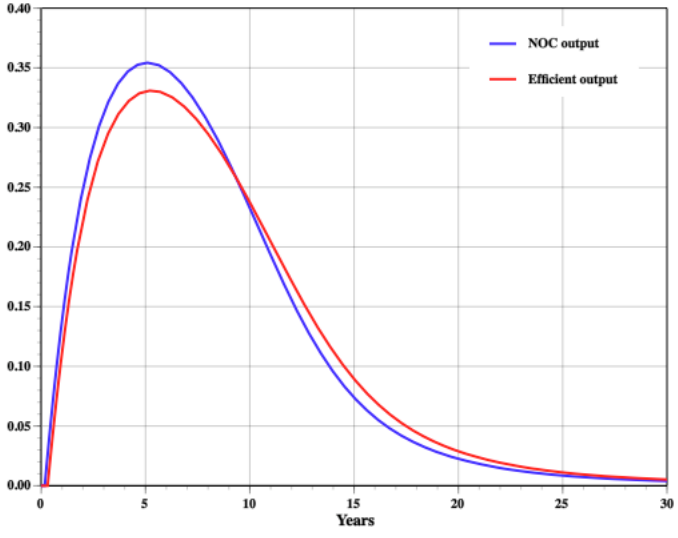
- Residual ownership claims are not traded and cannot be transferred, resulting in
  - Reduced information about manager performance,
  - Absence of a takeover threat, which reduces pressure on managers to perform, and
  - Reduced ability to compensate managers with performance related pay
- Firm debt guaranteed by government cannot bankrupt the firm
- Audited accounts or formal monitoring and control systems analogous to private corporations can be used but may not accurately reflect firm performance
- Politicians also may be interested in more than financial performance
- Managers of government-owned firms can be dismissed for poor performance
  - However, they may be given less credit if the firm does well
  - This asymmetry may make managers more risk averse

Modeling the objectives of an NOC

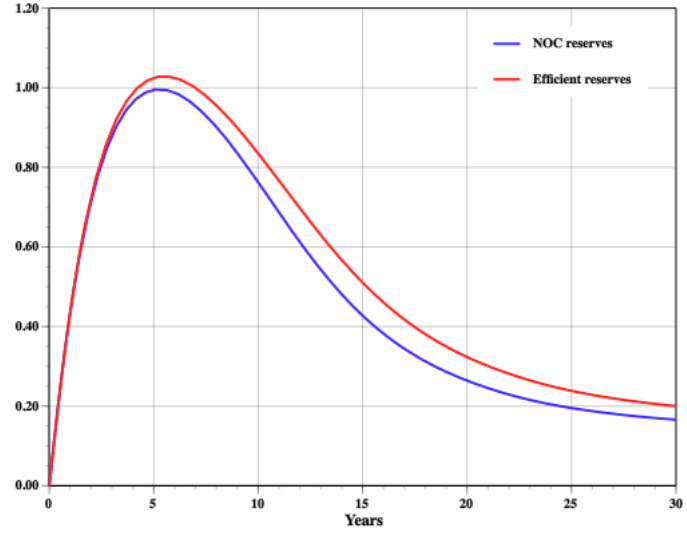
- Our model suggests that politicians will use an NOC to pursue goals other than economic efficiency:
  - Benefiting domestic consumers via subsidized prices
  - Enhancing political support by favoring domestic input suppliers (including employees)
  - Constraining investment to increase current revenue flowing to the Treasury
- If managers of government-owned firms are less constrained, they may also pursue objectives such as increased size (and budget) of the firm

NOC versus efficient firm

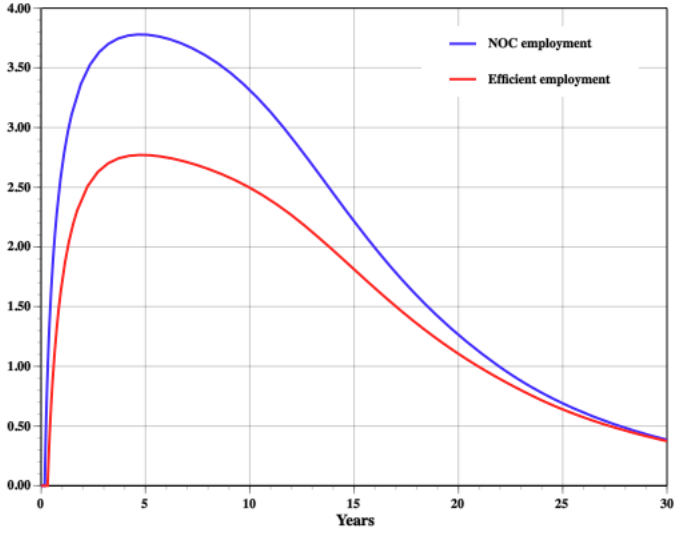
NOC and efficient production



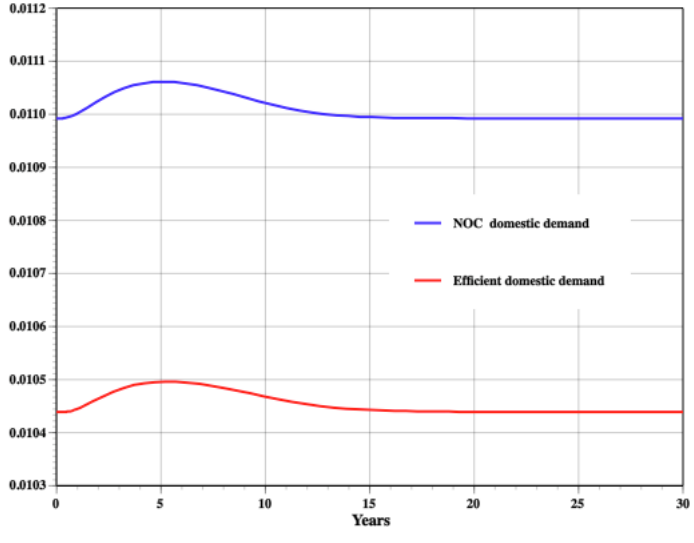
NOC and efficient reserves



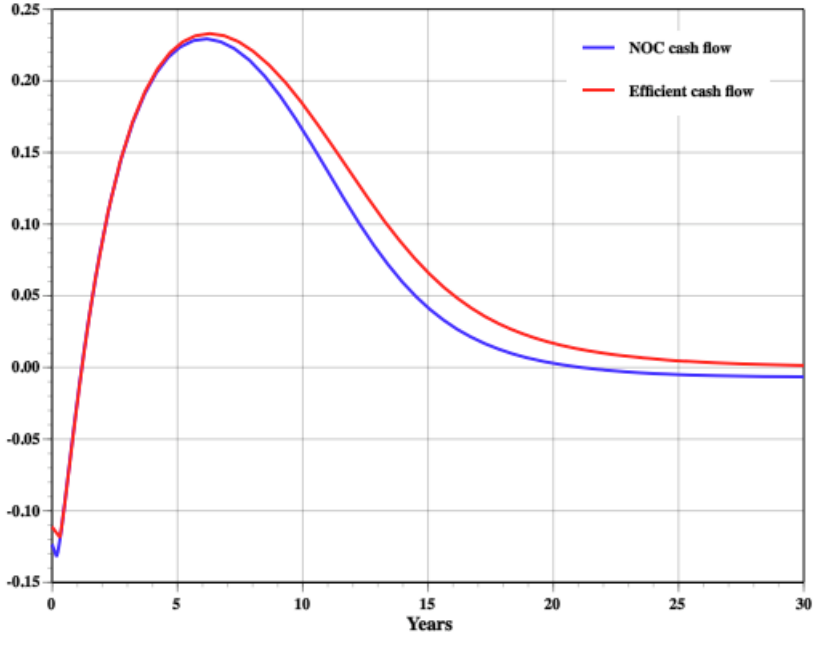
NOC and efficient employment



NOC and efficient domestic demand



Cash flows


0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
0
5
10
15
20
25
30
Years
NOC cash flow
Efficient cash flow

Summary remarks

- Many potential political influences on an NOC tend to push it in the same direction
- An increase in the political pressure to provide immediate funds to Treasury
  - Encourages employment, output and cash flow in the short run, but reduces them in the long run
  - Generally reduces proved reserves, except possibly in the first few years
- Any political or bureaucratic imperative to raise employment will lead to
  - Higher employment throughout the time horizon
  - Higher output, cash flow and reserves in the short run, but these are all lower in the longer term
- Forcing the NOC to subsidize domestic consumers
  - Shifts production from the future toward the present
  - Leads to greater employment in the initial time periods
  - While the firm is exporting, increased employment and output provide additional revenue to offset the losses associated with domestic sales
- The predictions of the model are consistent with NOCs being more focused on current output and cash flow and less focused on developing resources than private firms

Empirical Analysis

Data

- 78 firms over 2002-2004 (*Energy Intelligence* "Ranking the World's Oil Companies"):
  - revenue,
  - reserves of natural gas and crude oil,
  - employment,
  - production of natural gas and crude oil and crude oil products, and
  - government ownership share
- We examine relative efficiencies at producing *revenue*
- We allow for three inputs into the production of revenue:
  - employees
  - oil reserves and
  - natural gas reserves
- We do not include total assets as an input
  - Data on total assets is unavailable for many NOCs, especially OPEC members
  - Reserves capture most of the value of assets for these firms
  - Reserves are also likely to be measured more accurately than other assets
  - But, ignoring other assets makes vertically integrated firms look more efficient

Company	Revenue per Employee *$1,000/employee*	Revenue per Reserves *$/boe*	Government Ownership %	Country
		NOCs		
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	200	1.27	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
Norsk Hydro	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	1.51	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
Saudi Aramco	2,261	0.40	100%	Saudi Arabia
Sinopec	192	19.76	57%	China
Sonangol	755	1.37	100%	Angola
Sonatrach	688	0.93	100%	Algeria
Statoil	1,910	10.85	71%	Norway
TPAO	154	1.53	100%	Turkey
Average	***994.61***	***5.22***		
		Major IOCs		
BP	2,788	15.68	0%	UK
Chevron	2,606	12.78	0%	US
ConocoPhillips	3,368	14.03	0%	US
Exxon Mobil	3,148	12.26	0%	US
Shell	2,418	21.67	0%	Netherlands
Average	***2,865.48***	***15.28***		

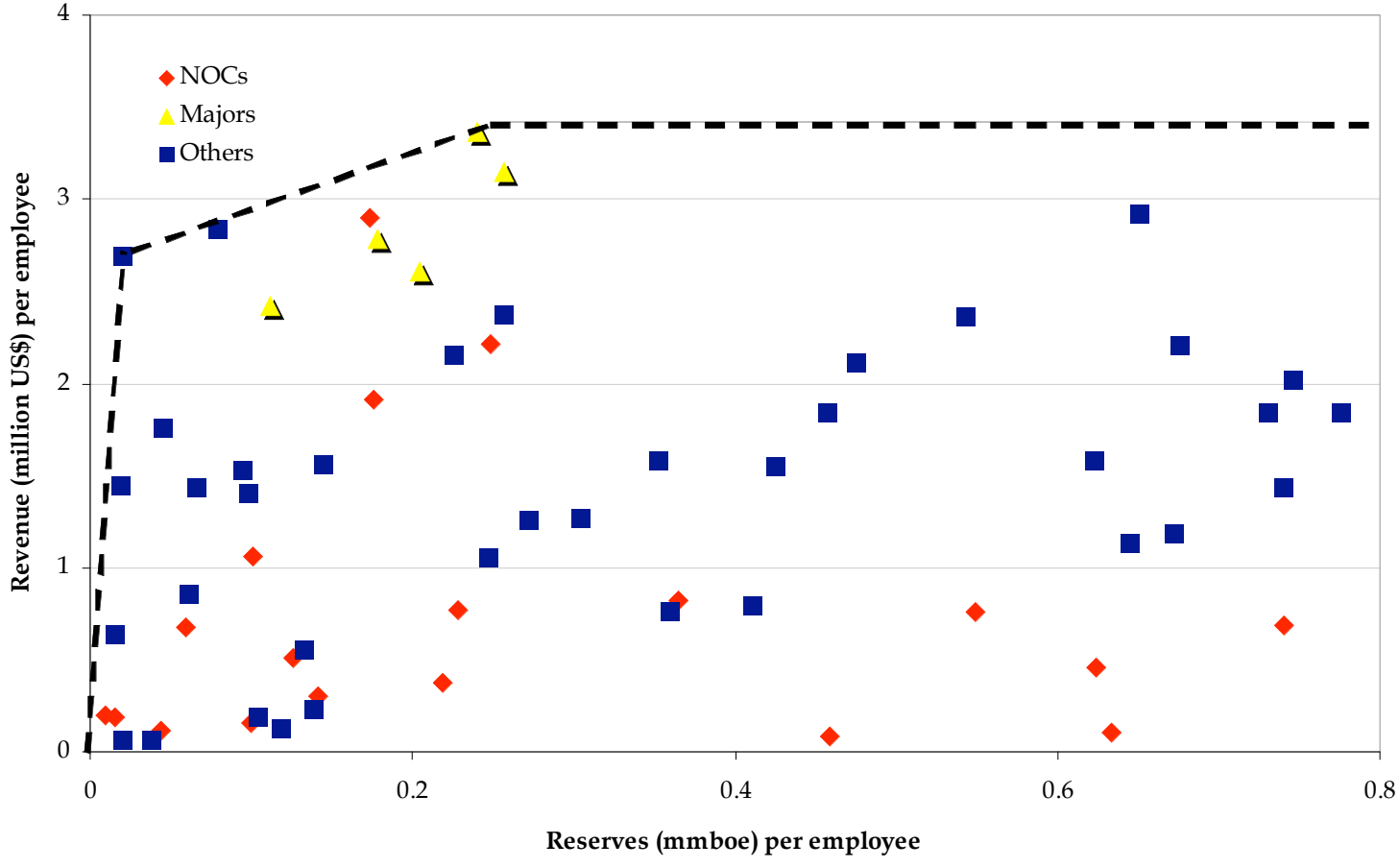
Company	Revenue per Employee *$1,000/employee*	Revenue per Reserves *$/boe*	Government Ownership %	Country
		Others		
Amerada Hess	1,532	16.07	0%	US
Anadarko	1,838	2.52	0%	US
Apache	2,019	2.71	0%	US
BG	1,547	3.64	0%	UK
Burlington	2,537	2.74	0%	US
Chesapeake Energy	1,577	3.22	0%	US
CNR	4,606	3.85	0%	Canada
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
Forest Oil	1,841	4.02	0%	US
Husky Energy	2,149	9.53	0%	Canada
Imperial	2,838	17.91	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
Nippon Oil	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
Repsol YPF	1,561	10.79	0%	Spain
Santos	789	1.92	0%	Australia
Sibneft	189	1.81	0%	Russia
Suncor	1,447	13.41	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
Average	***1,628.94***	***9.26***		

Methods

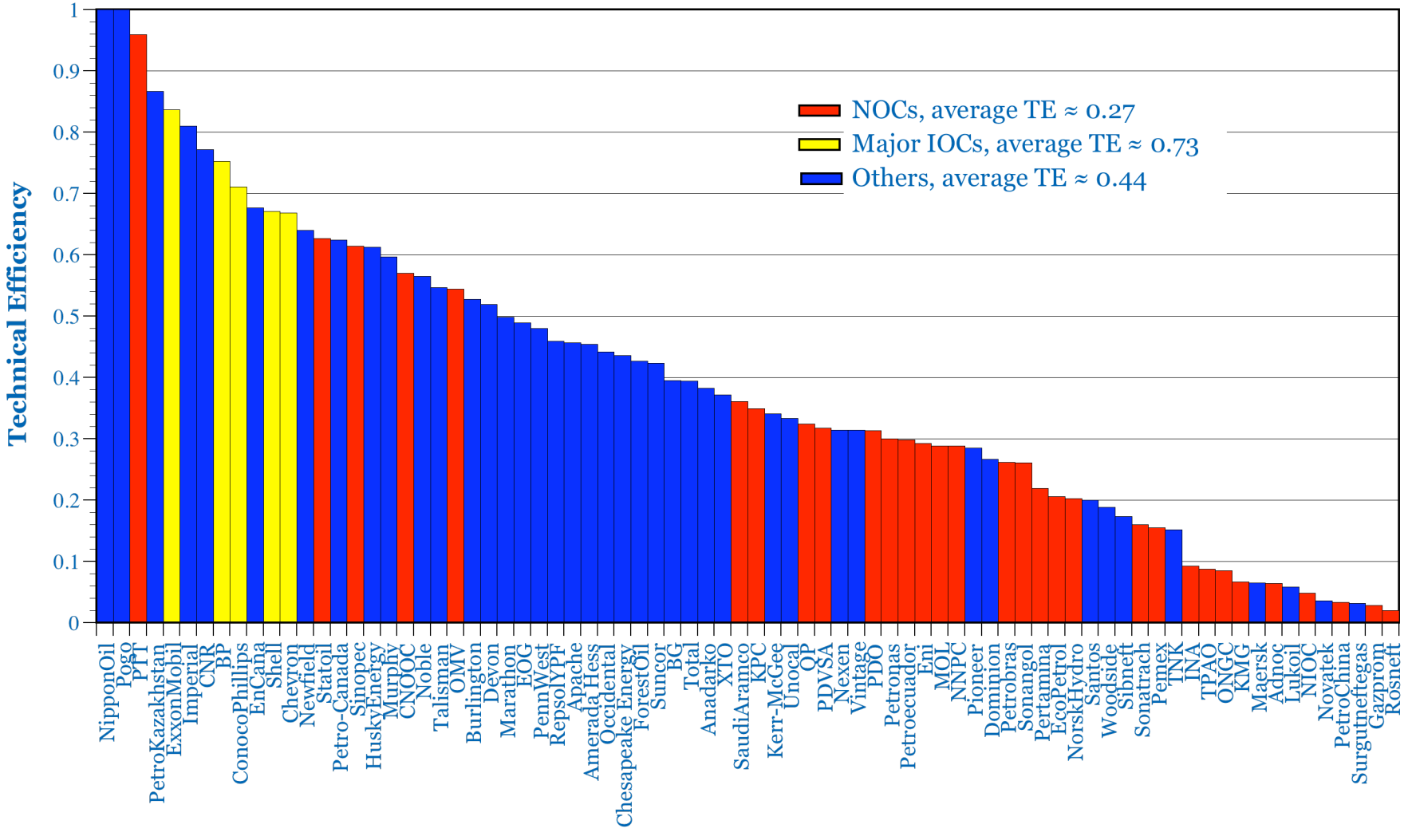
- We used two methods to formally measure efficiency – the non-parametric Data Envelopment Analysis (DEA) and a parametric Stochastic Frontier Approach (SFA)
- The two methods have different strengths and weaknesses:
  - SFA more directly reveals how different variables affect efficiency, allows for statistical noise including measurement error and provides a statistical measure of fit
  - But the assumed structural relationships or error distributions in SFA could be wrong
  - DEA requires no assumptions about functional form or error distributions
- DEA calculates the degree to which output is maximized for given inputs using linear programming to construct a piecewise-linear frontier of input-output bundles

Simplified representation of DEA

- To graph the data, normalize total reserves (in boe) and revenue on employees
- Calculate technical inefficiency in generating revenue using *vertical* distance of a firm from the frontier



Average DEA scores over 2002-04



Model 1 Revenue TE, Inputs: Employees, Oil & Gas Reserves

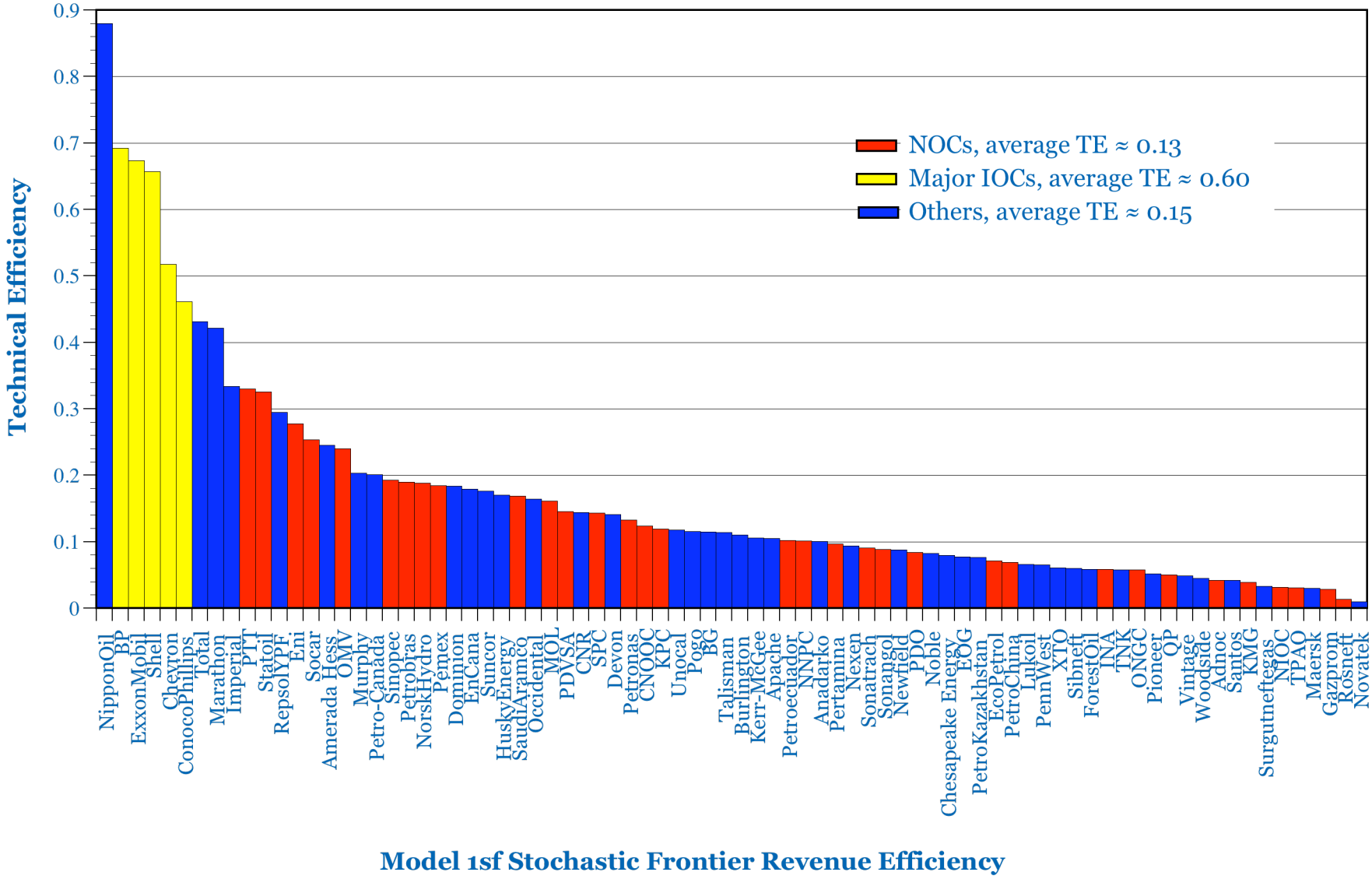
Stochastic frontier analysis

- SFA identifies inefficiency as part of a two-component error, where one component captures statistical noise and the other captures inefficiency
- The equation estimated using SFA is given as (standard errors in parentheses):

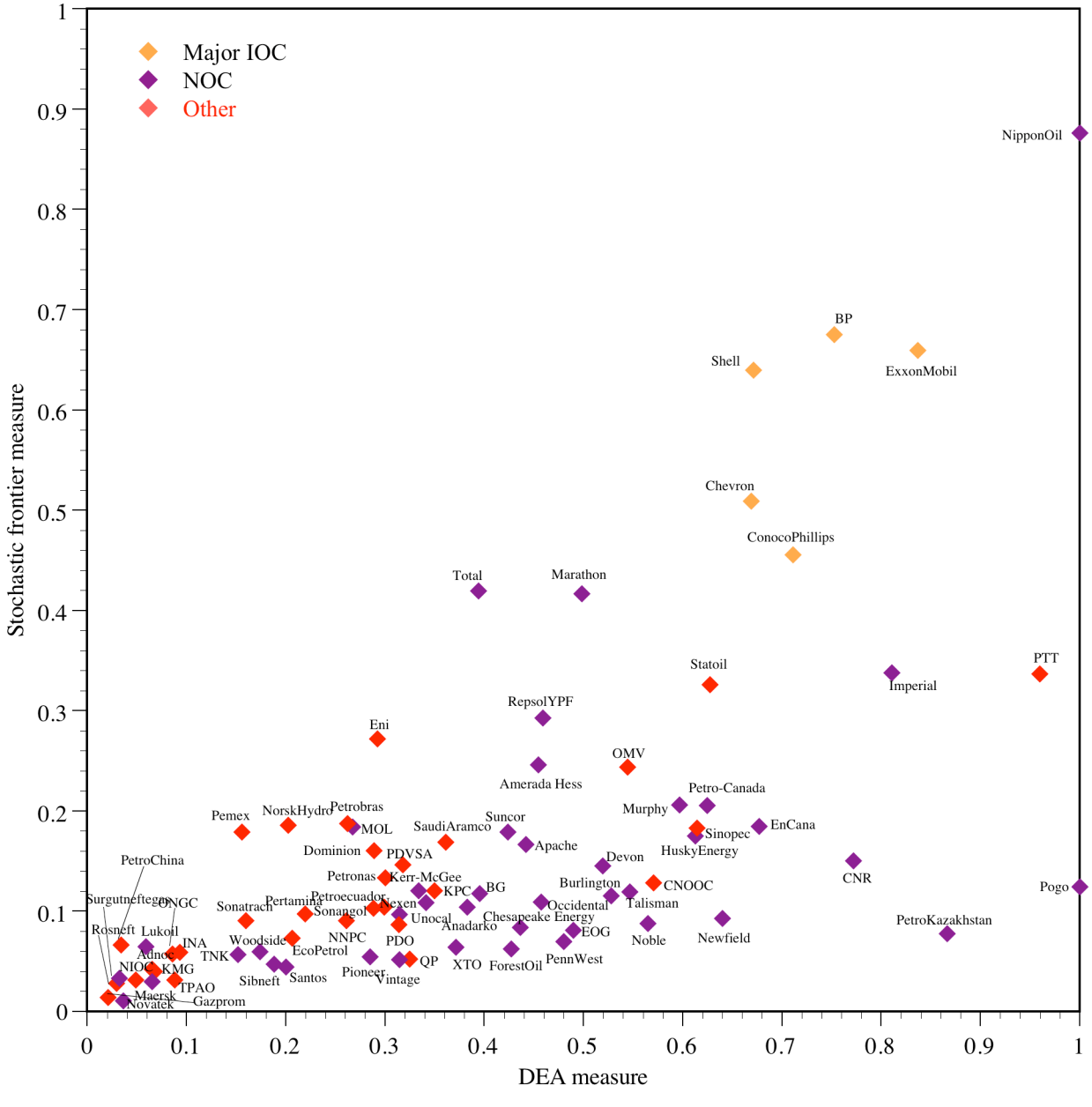
$$\ln Rev_{n,t} = \underset{(0.5928)}{4.8036} + \underset{(0.0636)}{0.3961}^{*} \ln L_{n,t} + \underset{(0.0608)}{0.1196}^{*} \ln OilRsv_{n,t} + \underset{(0.0547)}{0.1855}^{*} \ln NGRsv_{n,t}$$
$$+ \underset{(0.0249)}{0.2702}^{*} t_{2003} + \underset{(0.0251)}{0.4423}^{*} t_{2004} + v_{n,t} - u_{n}$$

- Estimated TE is assumed constant over the three year period
  - Include yearly effects to allow especially for varying oil and gas prices by year
  - Year effects are unnecessary in DEA since TE is calculated separately for each year
- Each coefficient has the expected sign

Stochastic frontier efficiency measures



Model 1sf Stochastic Frontier Revenue Efficiency



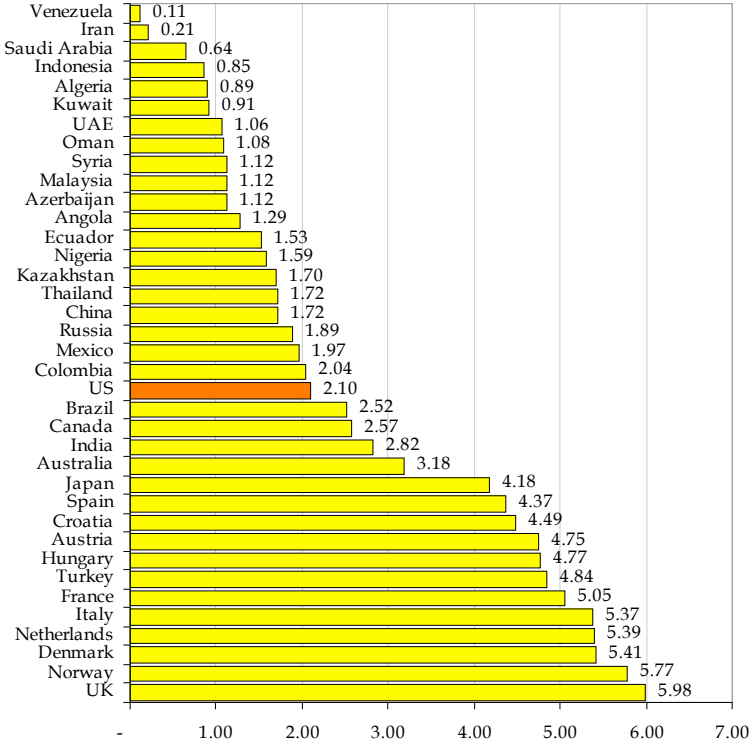
Spearman rank order correlation = 0.6974

$$RevEff_{DEA,n} = \underset{(0.0327)}{0.2247} + \underset{(0.1450)}{1.0523} * RevEff_{SFA,n}$$

Explaining measured inefficiencies

- *VertInt* = petroleum product sales divided by total liquids production
- *GovShare* = Government ownership share
- *TierP* = Two-tier pricing, defined based on average retail prices relative to US

Average pump prices 2004



DEA measured inefficiencies

- Obtained the following Tobit panel regression results

$$RevEff_{DEA,n} = \underset{(0.0318)}{0.4183} + \underset{(0.0110)}{0.0519} * VertInt - \underset{(0.0540)}{0.2429} * GovShare$$

Modified SFA frontiers and errors

- Basic model allowing inefficiency term to depend on *VertInt* and *GovShare*

$$\ln Rev_{n,t} = \underset{(0.6052)}{4.8297} + \underset{(0.0427)}{0.2872}^{*} \ln L_{n,t} + \underset{(0.0552)}{0.3976}^{*} \ln OilRsv_{n,t} + \underset{(0.0342)}{0.1176}^{*} \ln NGRsv_{n,t}$$
$$+ \underset{(0.1125)}{0.2630}^{*} t_{2003} + \underset{(0.1447)}{0.4248}^{*} t_{2004} + v_{n,t} - u_{n,t}$$
$$u_{n,t} = \underset{(0.5338)}{2.6681} - \underset{(0.0299)}{0.3279}^{*} VertInt_{n,t} + \underset{(0.1245)}{0.8648}^{*} GovShare_{n,t}$$

- Looking specifically at the factors suggested by the theoretical model

$$\ln Rev_{n,t} = \underset{(0.2443)}{3.5744} + \underset{(0.0249)}{0.4598}^{*} \ln L_{n,t} - \underset{(0.0183)}{0.3002}^{*} \left(\ln L_{n,t} * GovShare_{n,t} \right) + \underset{(0.0350)}{0.3763}^{*} \ln OilRsv_{n,t}$$
$$+ \underset{(0.0279)}{0.1185}^{*} \ln NGRsv_{n,t} + \underset{(0.0989)}{0.2407}^{*} t_{2003} + \underset{(0.1050)}{0.4101}^{*} t_{2004} + v_{n,t} - u_{n,t}$$
$$u_{n,t} = \underset{(0.1851)}{2.5041} - \underset{(0.0113)}{0.1828}^{*} VertInt_{n,t} + \underset{(0.0982)}{1.4250}^{*} TierP_{n,t} - \underset{(0.1828)}{3.1847}^{*} GovShare_{n,t}$$

Interpreting the stochastic frontier results

- Vertically integrated firms generate more revenue for given inputs of employees and reserves
  - Prior to controlling for it, firms with large downstream activities (eg Nippon Oil) will tend to have a less negative *u* and so will appear more efficient
- Government ownership reduces the ability of the firm to generate revenue, controlling also for the effect of vertical integration
- Domestic price subsidies are one reason government share may reduce revenue
- The negative coefficient on the government share-employment interaction implies higher government ownership reduces labor productivity

Why might NOCs exist?

- A private firm may exploit domestic consumers if it is a domestic monopoly
- Resource development may be associated with wider economic development and a private firm might neglect these wider social benefits
- Government wants to redistribute rent from resource exploitation
  - Other mechanisms (other than nationalization) may be unavailable
    - The tax collection system may be weak
    - There may not be a royalty or lease auction system
    - The government may have a history of not adhering to prior agreements
  - The government wants to use rents to favor particular political constituencies and needs more control to do so
- According to the "paradox of plenty," resource rents may invite more intervention
  - Petroleum revenue may
    - weaken government fiscal discipline,
    - postpone needed structural change,
    - lead to a tendency to rely on the state for resolution of problems

Case Studies

Case Study Selection

- Origin
  - pre-1960s
  - 1960s to early 1970s
  - 1980s
  - 1990s to present
- Organizational structure
  - state monopolies
  - partially privatized NOCs
  - fully privatized NOCs
- Size of reserves and production
- Geography and trading partner flexibility
- Autonomy from national government
- Range of business models

CNOOC, China*

CNPC, China

Iraq Oil Ministry

Kazmuniagaz, Kazakhstan

LUKOIL, Russia**

NIOC, Iran

NNPC, Nigeria

ONGC, India*

PDVSA, Venezuela

Pertamina, Indonesia

Petronas, Malaysia

Rosneft, Russia

Saudi Aramco, Saudi Arabia

Sinopec, China*

Statoil, Norway*

* denotes partially privatized.
**LUKOIL is fully privatized.

Objectives found in the case study examples

- NOCs further national goals other than the maximization of return on capital to shareholders, including:
  - Oil wealth redistribution to society at large,
  - Wealth creation for the nation,
  - Industrialization and economic development,
  - Energy security, including assurance of domestic fuel supply and security of demand for producing nations,
  - Foreign and strategic policy and alliance building, and
  - Participation in national level politics.
- But the non-economic priorities interfere with these firms' abilities to:
  - Maximize the value of oil resources,
  - Replace reserves,
  - Expand production in line with market opportunity, and
  - Meet performance goals in line with best practices in international industry

Some Implications

Can the NOCs meet demand?

- Can the NOCs develop the vast resources under their control in a timely manner given the constraints imposed by political influences?
  - Many NOCs have falling oil exports due to domestic subsidies, and stagnant production resulting from government interference, corruption, inefficiency, and diversion of capital to social spending
  - Importing nations may need to reduce their vulnerability to changes in NOC investment
- Consuming nations need to consider the benefits and challenges of having NOCs seek security of demand and other benefits of vertical integration by buying into downstream markets
- For consuming nations, a desirable policy will be to promote free trade and utilize multilateral frameworks to press NOCs to adopt institutional structures to:
  - Enhance their efficiency,
  - Promote market competition, and
  - Curb interference in commercial investment decisions by their national government

Potential paths to NOC reform

- Can social welfare and revenue maximization be better balanced by adopting some institutional elements of private sector firms to enhance NOC performance?
  - These institutional structures include:
    - Competition in the home industry
    - Competition in international exploration and refining
    - More strict monitoring through generally accepted accounting and financial reporting
    - At least partial privatization or bond issues in major international markets
    - Autonomous board of directors and professional management
  - These institutional structures encourage NOC managers to
    - Minimize the commercial impact of pursuit of non-commercial objectives,
    - Focus on core business activities, and
    - Reduce corruption and wasteful spending
- The strategy of vertical integration has multiple benefits for a NOC
  - By entering into the downstream market, a NOC is able to capture the value added from production and sale of finished products
  - It enhances security of demand by providing market access, especially if it is able to invest in downstream assets in key consuming regions
  - It helps the NOC diversify and mitigate risk
  - Upstream/downstream asset swaps are a promising avenue for IOC/NOC partnering and collaboration.

Implications for E&C contractors

- Inefficiency of NOCs would appear to create opportunities for sub-contracting to more efficient operators
- However, governments would be likely to impose conditions to retain employment, fiscal revenue and revenue for domestic subsidies
- There is a certain rationality to the current institutional arrangements even though they do appear to be inefficient
- There also is a potential problem of "sleeping with elephants":
  - A small contractor might get "squashed" when the contracting NOC or government controls the "rules of the game" in addition to commercial interest