

Lecture 6: Oil/fracking and sovereign wealth funds

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Trinity, 2019

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Oil/fracking

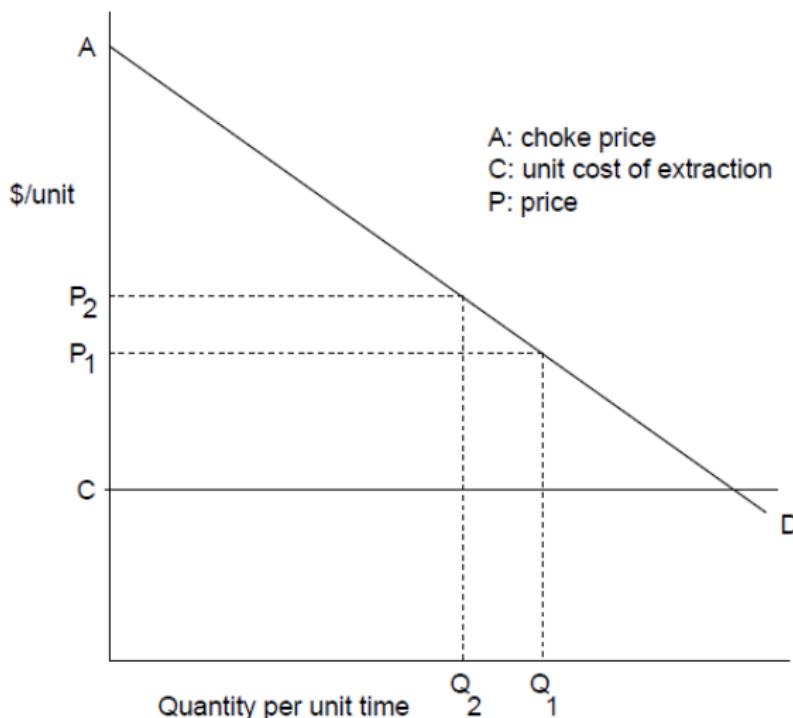
Non-renewables extraction

- Simple models of non-renewable resource extraction frequently based on the Hotelling (1931) model(s)
- Gives rise to (various forms of) Hotelling's rule, that the price of the non-renewable commodity should rise at the discount/interest rate under rent maximization by resource owners
- Here I follow *the (very nice) analysis* of Robert Deacon (UCSB) but you can find many treatments online

Non-renewables extraction - Hotelling

- Simple setup in competitive case
 - Commodity sells for P_t in period t
 - Constant cost of extraction per unit given by C
 - This implies unextracted units valued at $P_t - C$
 - Constant interest rate assumed, $r(t) = r \forall t$
 - The initial quantity to be tapped is R and call period of exhaustion, T
 - Note: T will depend on extraction policy, $Q(t)$
 - Assume a 'choke' price at which none of the quantity is demanded, A
 - Reflects a market demand curve

Non-renewables extraction - Hotelling



Demand curve for non-renewable commodity. Source: Deacon (lecture notes)

Non-renewables extraction - Hotelling

- Two optimality conditions with intuitive explanations
 - ① Production in any period should yield same present value profit per unit

$$\frac{P_t - C}{(1+r)^t}$$

- ② Last unit sold is at the choke price
 - If $P_T < A$: With leverage could obtain arbitrarily large return (recall the Krugman BoP model) or could buy and then resell last marginal unit - not an equilibrium
 - If $P_T \geq A$ before deposits exhausted: Would imply zero return on those resources ($< r$) - not an equilibrium

$$P_T = A$$

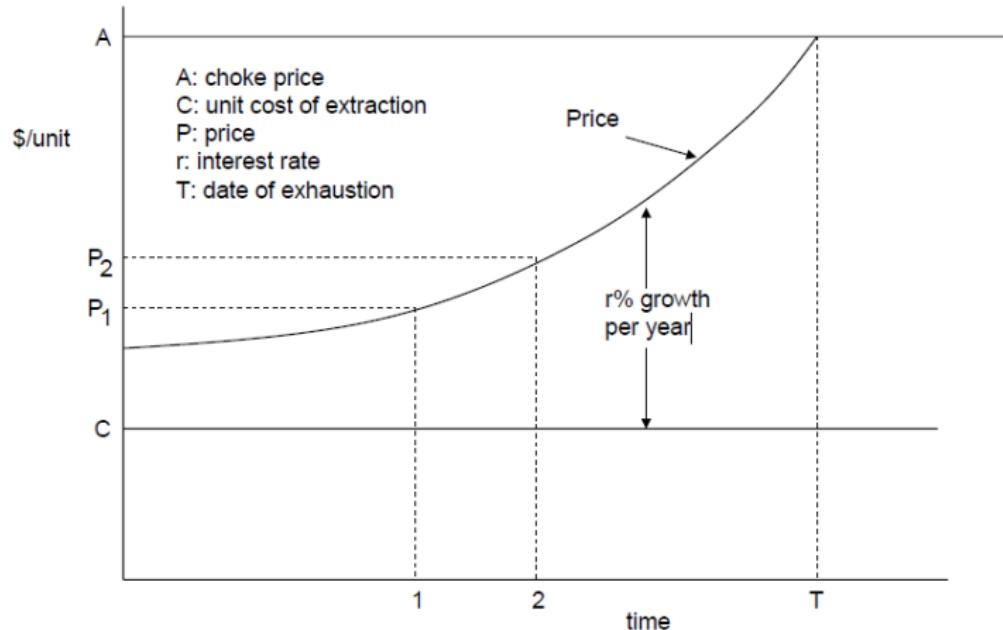
Non-renewables extraction - Hotelling

- 'PV' of profit from selling unit in $t = 0$ is $P_0 - C$
- Note, by the first condition

$$P_t - C = (P_0 - C)(1 + r)^t$$

- So price (adjusted for marginal cost) increases over time at the rate of interest

Non-renewables extraction - Hotelling



Competitive equilibrium - time path for price. Source: Deacon (*lecture notes*)

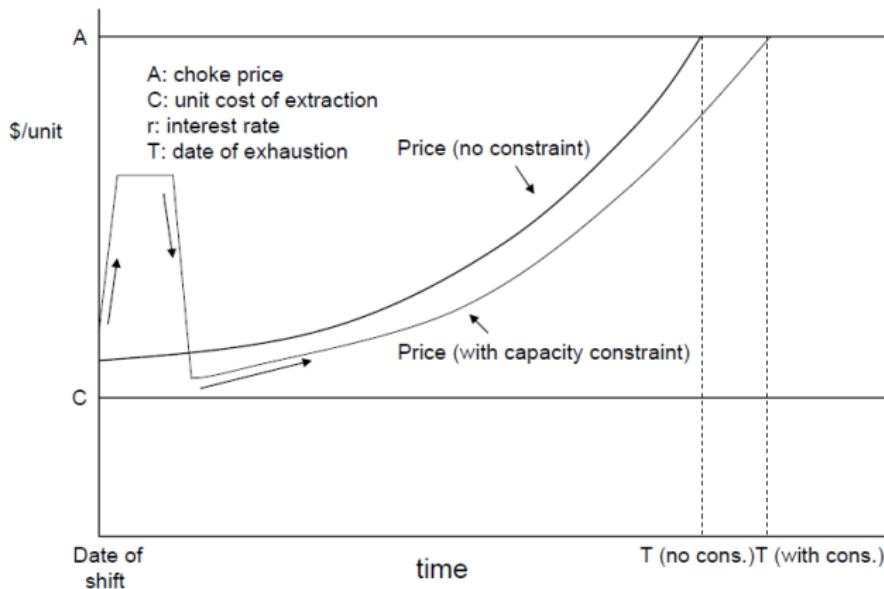
Non-renewables extraction - Hotelling

- Given the parameters of the problem (demand curve, initial stock, interest rate, choke price, cost of extraction) we have solved for price path
- Plug the price sequence into the demand curve to derive implied extraction rate
- But does the oil price behave like this? Answer: No.
- The model is enormously simplified (though still useful)
 - r , C and demand curve all will vary in the real world
 - We ignored exploration, alternative commodities, market power, uncertainty...
- Tweaking these assumptions provides useful intuition

Enriching basic Hotelling model

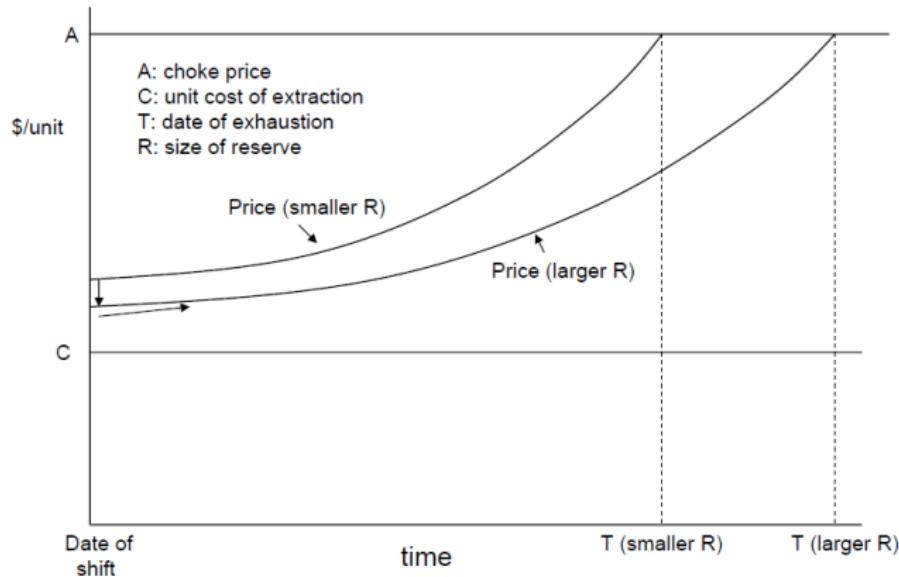
- Variation in C - imagine disruptions to supply chain or improved extraction technology
- Variation in R - imagine surprise discovery of reserves
- Variation in r - we observe this over the business cycle and at long horizons
 - Risk of extraction by other parties \Rightarrow premium on r
- Imperfect competition/monopoly - $MR_t - C$ (discounted) equal in all periods, not $P_t - C$
- Alternative commodities / qualities - Imagine different qualities of oil, or alternative resources
- Shifts in demand curve - Business cycle and trend (US? China? Self-driving cars?)

Enriching the basic Hotelling model - Cost variation



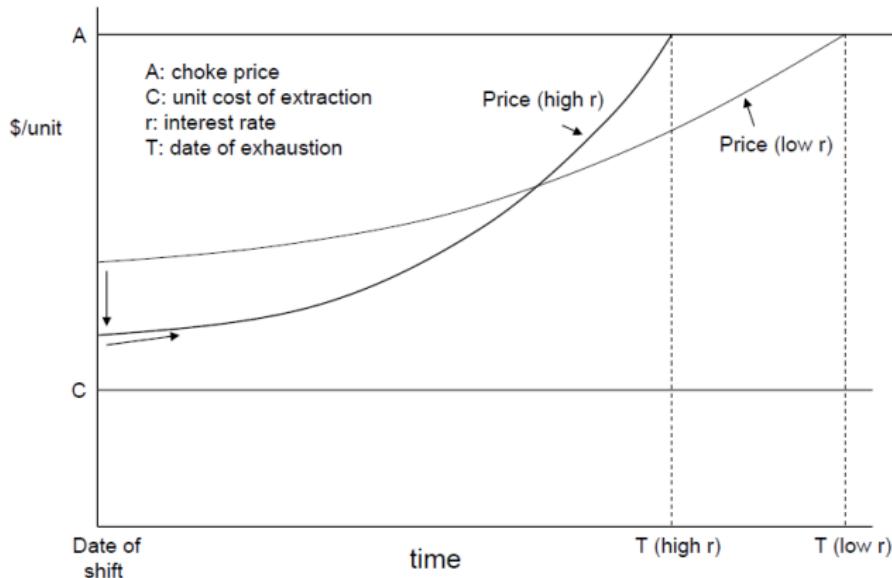
Temporary supply constraints / increase in extraction costs. Source:
Deacon (*lecture notes*)

Enriching the basic Hotelling model - Initial reserve / discovery



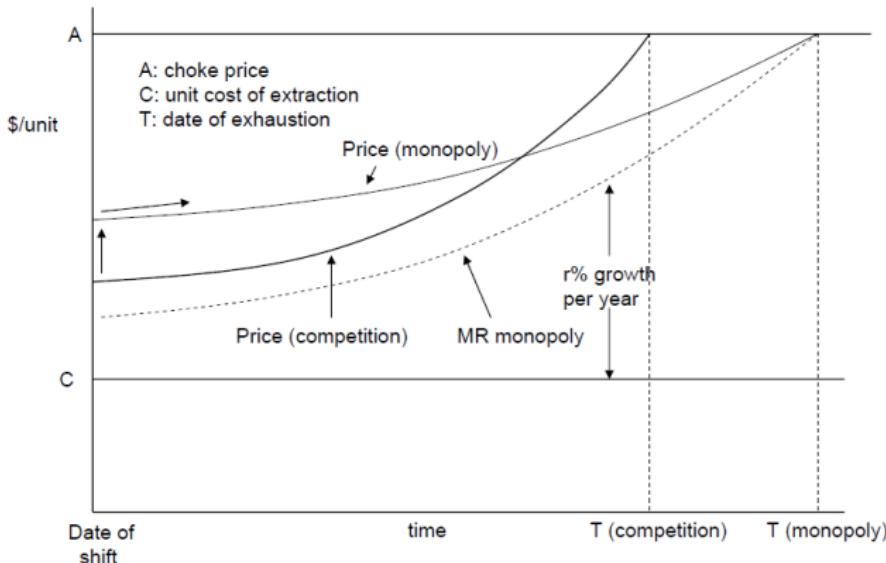
Shock to initial reserve / new discoveries. Source: Deacon (*lecture notes*)

Enriching the basic Hotelling model - Different r



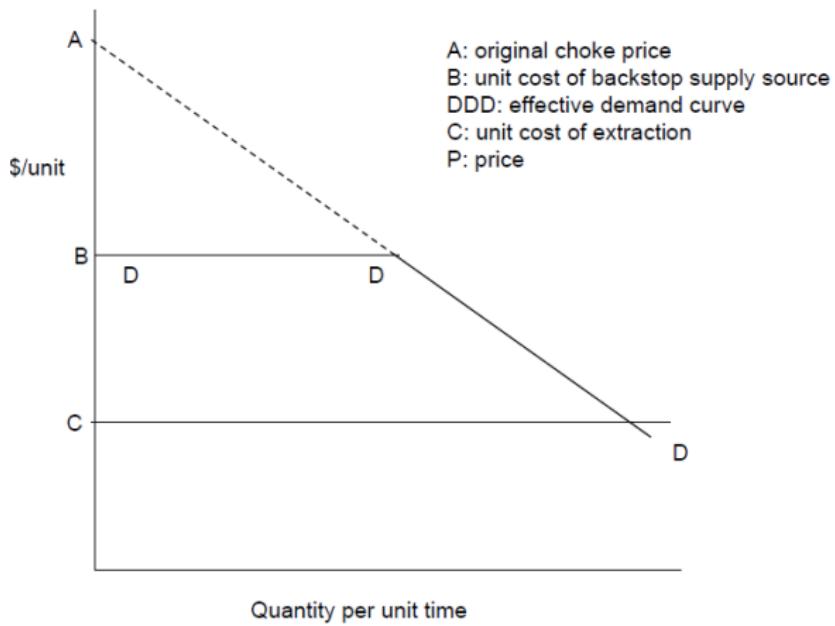
Implications of a different interest rate (or risk premium). Source: Deacon (*lecture notes*)

Enriching the basic Hotelling model - Monopoly



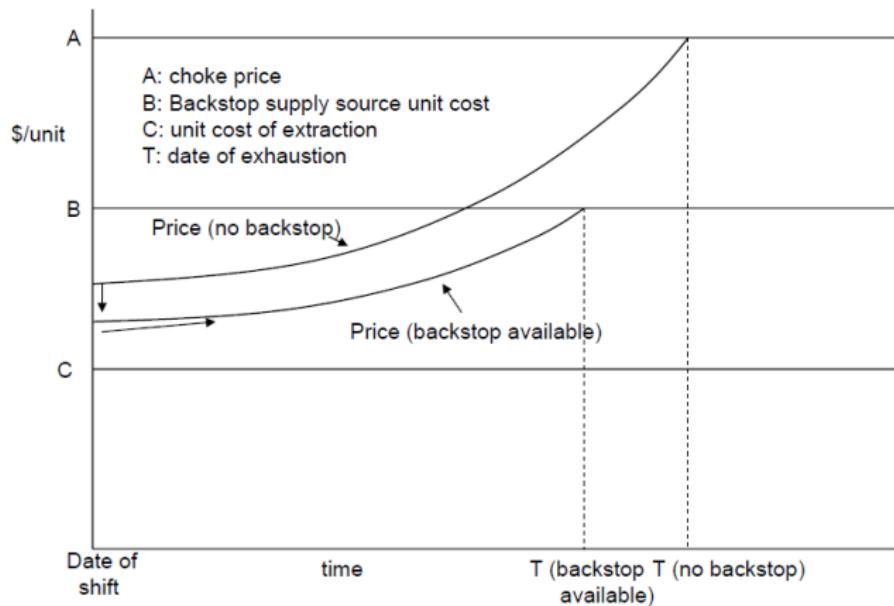
Monopoly power implies reduced supply (slower extraction). Source: Deacon (*lecture notes*)

Enriching the basic Hotelling model - Backstop/alternative commodities



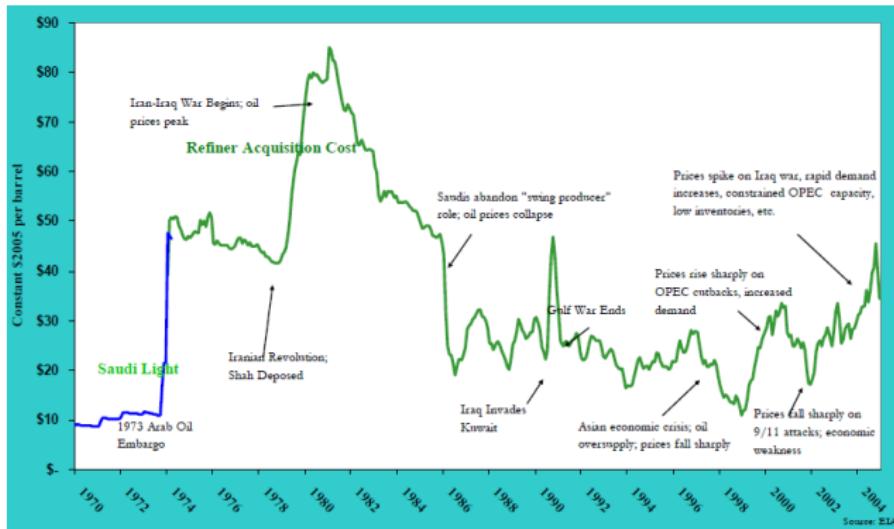
Backstop/alternative commodity supplied at certain price - effectively implies lower choke on first commodity. Source: Deacon (*lecture notes*)

Enriching the basic Hotelling model - Backstop/alternative commodities



Backstop/alternative commodity supplied at certain price - effectively implies lower choke on first commodity. Source: Deacon (*lecture notes*)

Oil prices don't follow smooth Hotelling path



Jagged path for oil prices partly reflects repeated shocks of the type discussed above. Source: Deacon (*lecture notes*)

Current issues in the oil market

- We will (briefly) discuss two issues of current interest
 - Hybrid/electric/self-driving cars etc.
 - Tight oil/fracking in North America

New technology and its implications for oil

The stone age came to an end not for a lack of stones, and the oil age will end, but not for a lack of oil.

- Sheikh Zaki Yamani (former Saudi oil minister)

New technology and its implications for oil

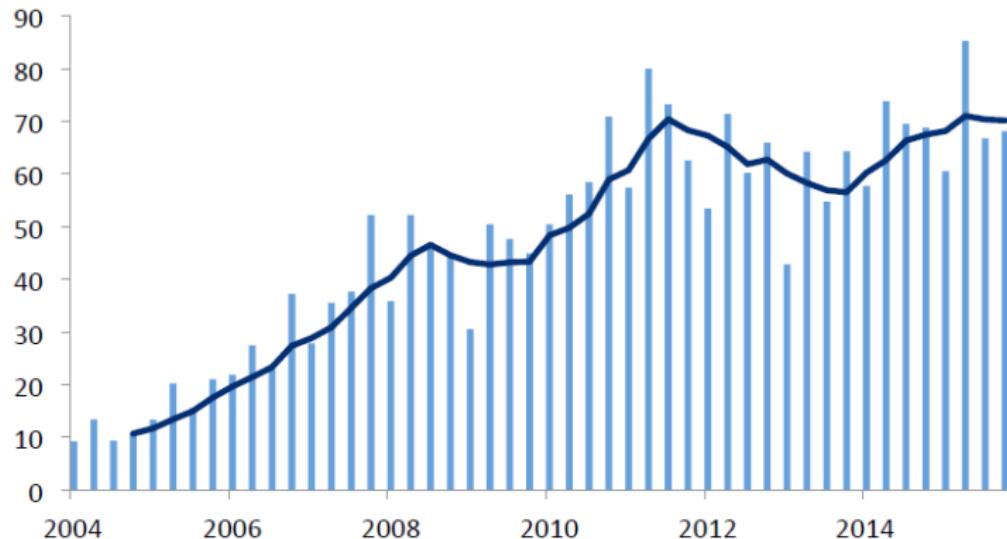
A hundred years ago, coal accounted for close to 80 percent of US energy consumption. Within 20 years, that share fell to one-half, and within 40 years to only one-fifth as oil displaced coal. This happened even though coal was cheaper than oil, because there was now real alternative to power motor vehicles, which quickly went from exotic luxury to the preferred means of personal transportation. Today, automobiles account for about 45% of oil consumption in the world

- Cherif, Hasanov and Husain (2017), IMF blog

New technology and its implications for oil

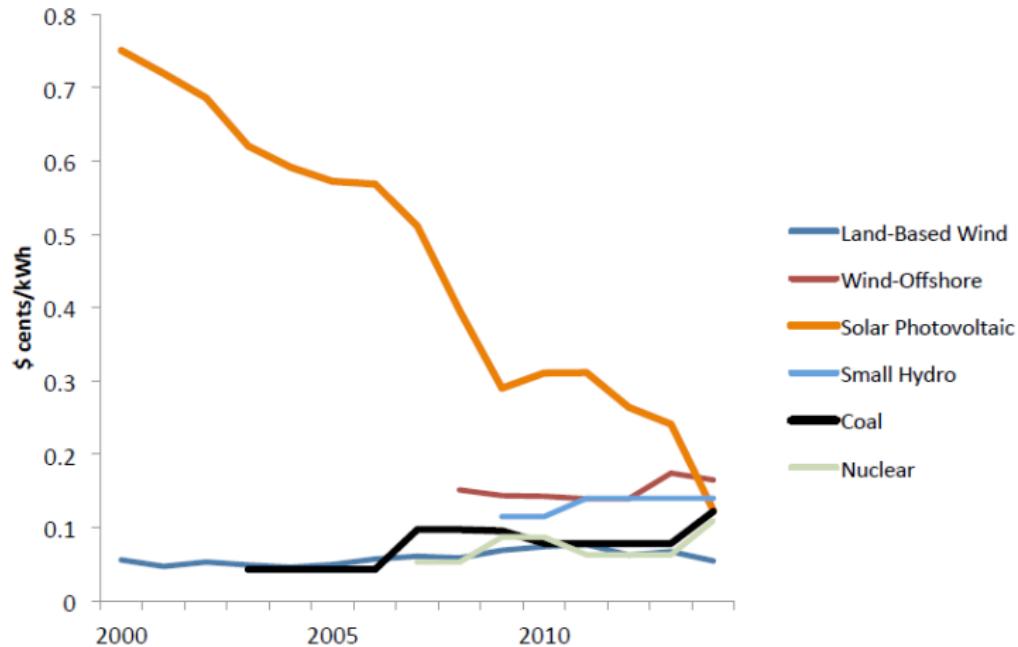
- Oil share in the electricity generation market only 20%, thus move to electric vehicles ⇒ negative shift in demand
- Alternative power sources (renewables) and battery technology also likely provide alternatives (shifting choke point?)
- Additional demand shifts likely to arise from ML/AI automated cars due to enormous efficiency gains (and reduction in car ownership)

Coming of a new age?



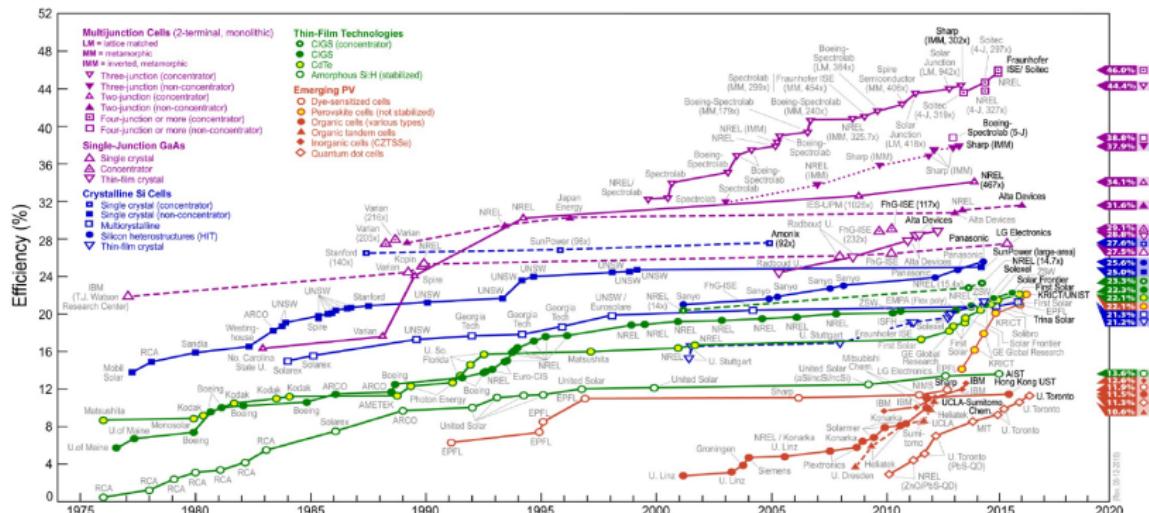
Investments in clean energy (\$bn). Source: World Economic Forum (2016)

Coming of a new age?



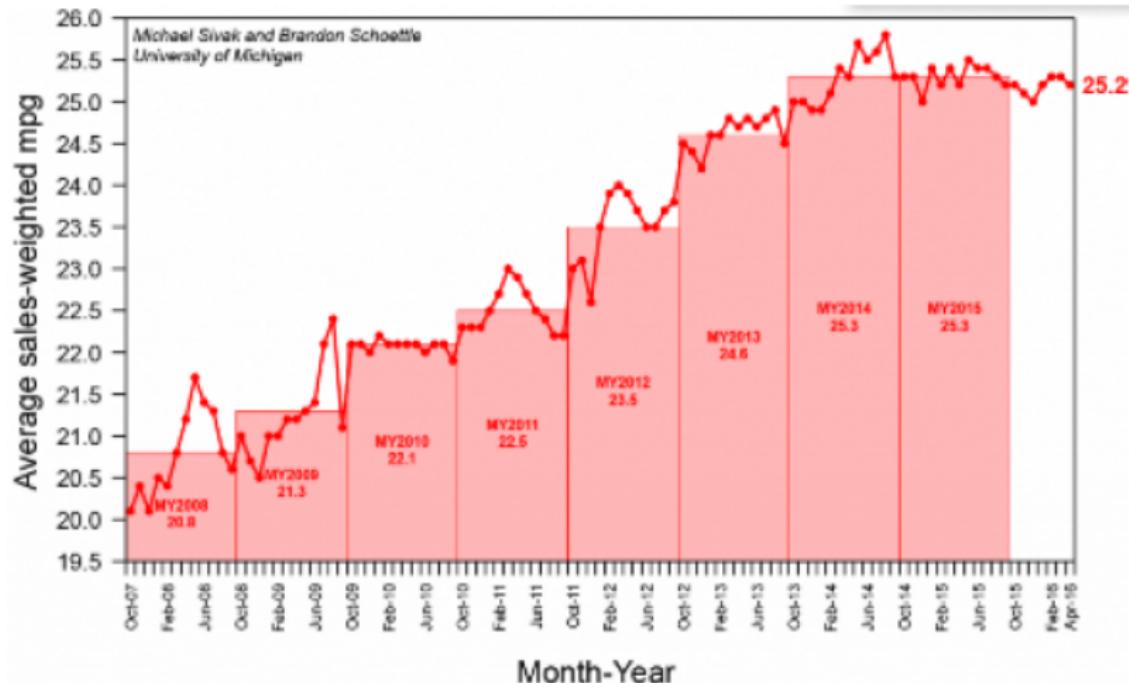
Levelized cost of energy (\$-cents per kWh, world average). Source: OpenEI, Transparent Cost Database; World Economic Forum (2016)

Coming of a new age?



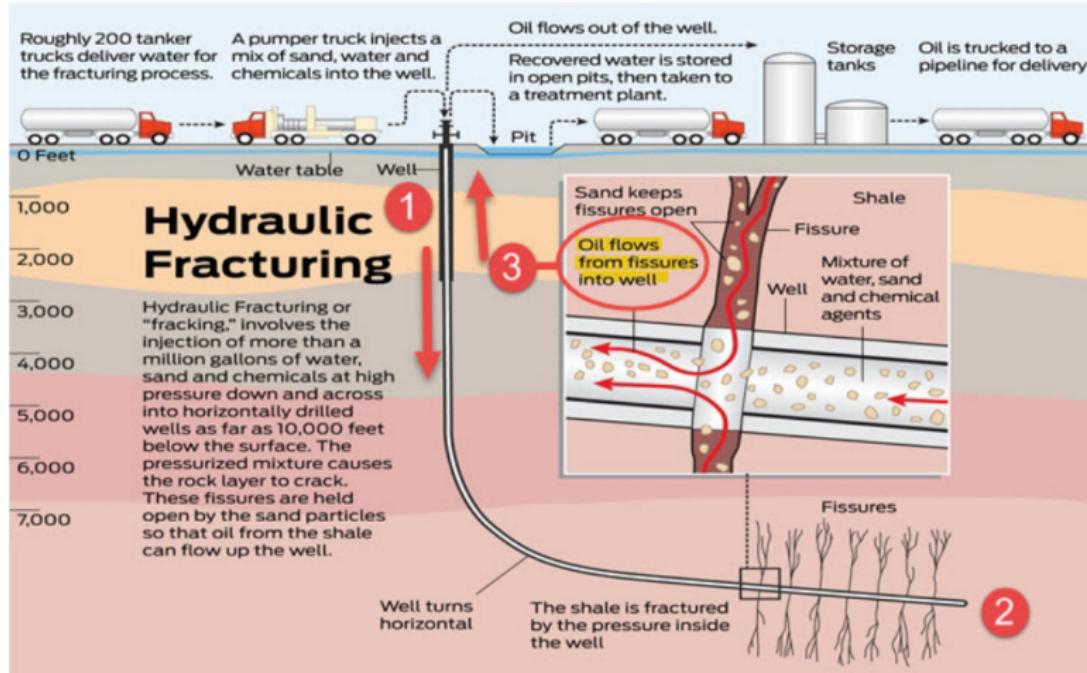
Best research cells efficiency. Source: National Renewable Energy Laboratory, Golden, CO; World Economic Forum (2016)

Coming of a new age?



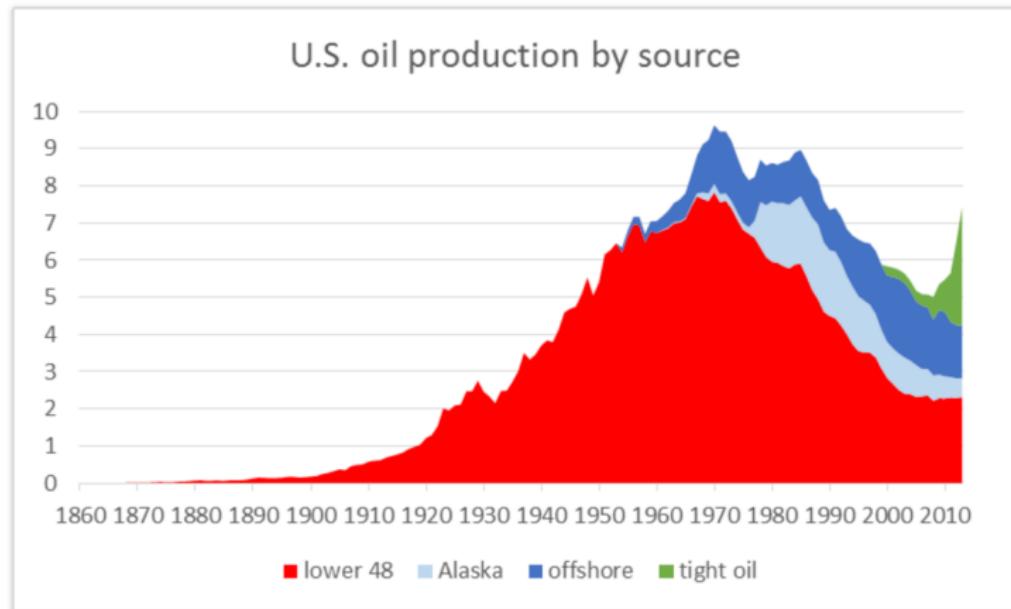
Dramatic mile-per-gallon improvements. Source: Hamilton (2014)

Fracking



Simplified schematic of a typical hydrolic fracking operation. Source: National Renewable Energy Laboratory, Golden, CO; Shale Stuff; Pro-Publica

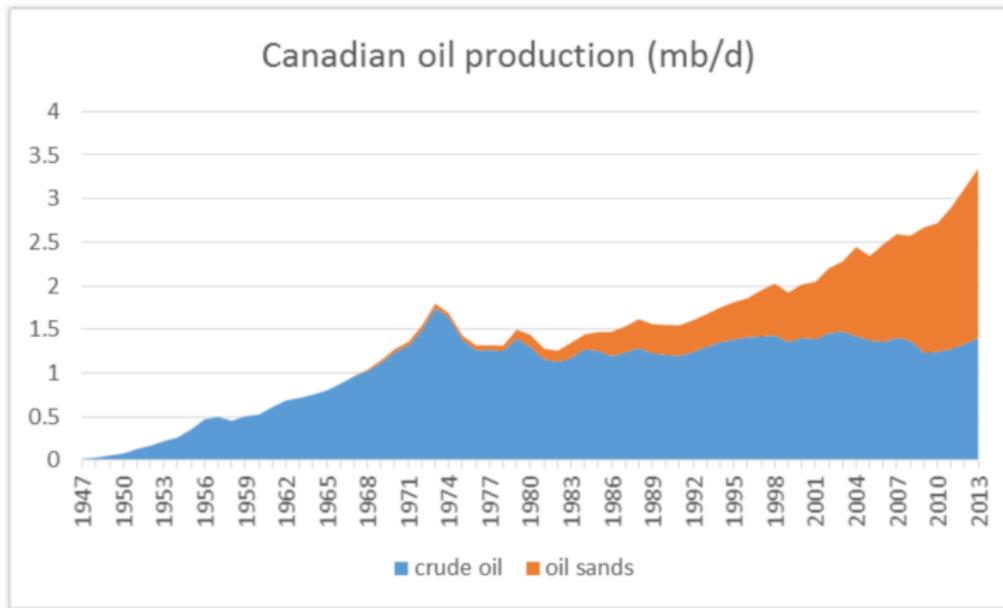
Explosion of extraction of 'tight oil'



U.S. field production of crude oil, by source, 1860-2013, in millions of barrels per day. Source: [Hamilton \(2014\)](#).

Dramatic recent expansion of tight oil extraction. Source: Hamilton (2014)

Explosion of extraction of 'tight oil'



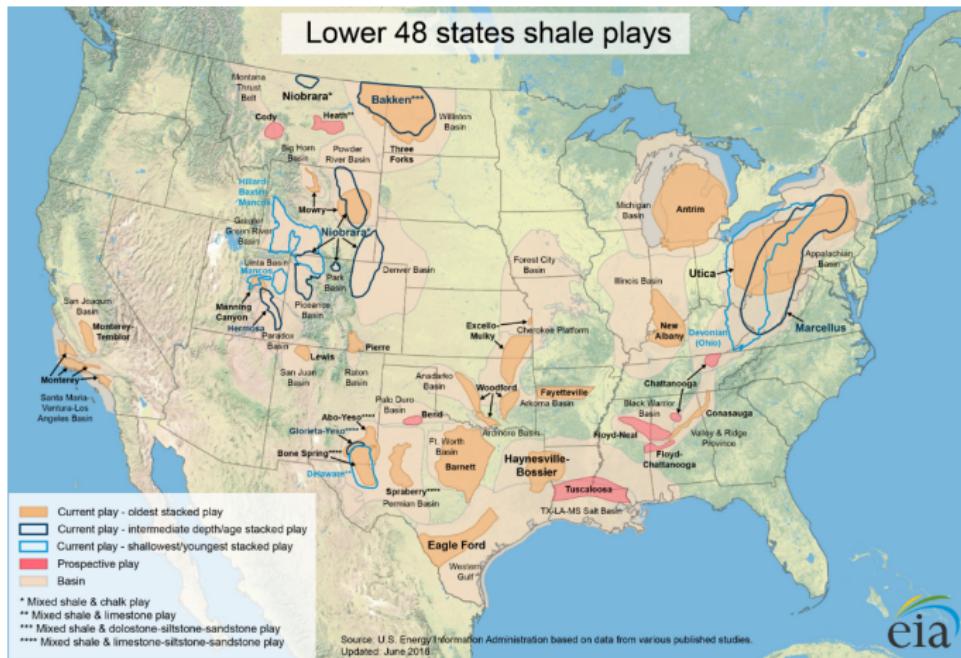
Canadian production of crude oil, 1947-2013, in mb/d. Blue: Conventional crude plus lease condensate. Orange: oil sands. Data source: [Canadian Association of Petroleum Producers](#).

Canadian oil sands production has also accelerated in recent years.
Source: Hamilton (2014)

Tight oil - reasons for recent growth

- Oil price growth in 2000's (recall first lecture)
 - Largely driven by China's emergence
 - Stimulated research to find cheaper resources
 - But also made (more) economical the then costly oil sands and tight oil plays

Explosion of extraction of 'tight oil'



Lower 48 states (U.S.) shale plays. Source: EIA

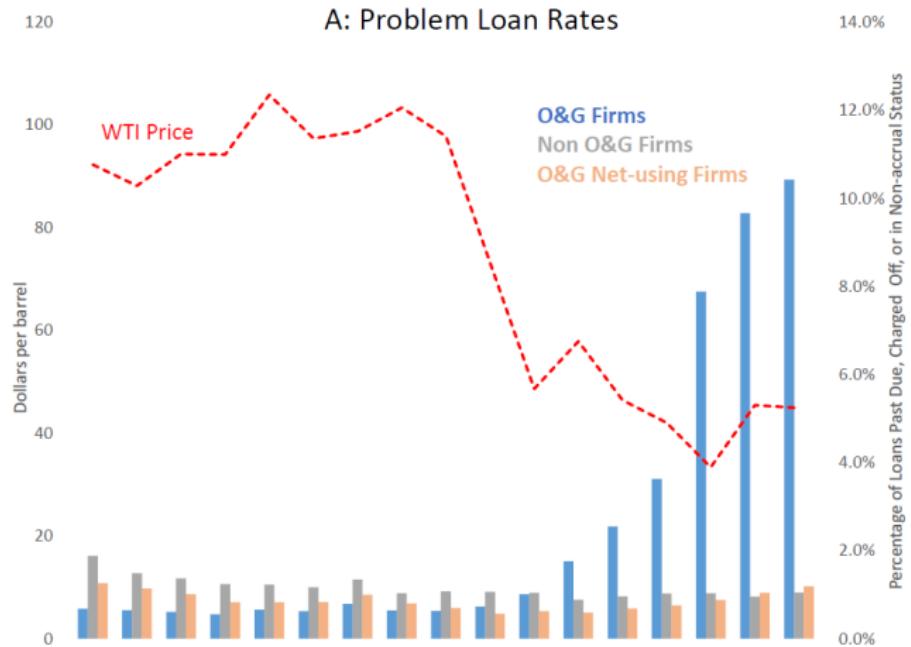
Explosion of extraction of 'tight oil'



Source: [Business Insider](#).

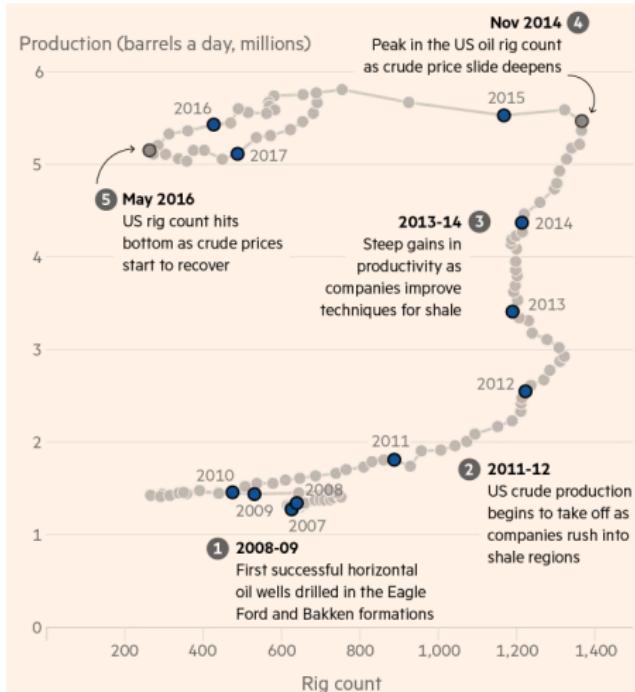
Break-even rates (at which plays become ‘profitable’) and reserves.
Source: Hamilton (2014); Business Insider; Wood Mackenzie

Oil price decline of 2014



Oil price decline and stresses in O&G-related credit. Source: Bidder *et al* (2018)

Efficiency gains in extraction



Production and rig counts in the U.S. shale oil boom. Source: FT (2017)

U.S. as a marginal producer at lower breakevens

Independent companies exploring shale in aggregate act like a precision valve in the oil supply machine, increasing output as prices rise and decreasing it when they fall...

Analysts have been slashing their oil price forecasts and examining the sensitivity of shale production to lower prices. Every dollar-per-barrel move adds or subtracts 100,000 b/d from next year's US crude supply, argues Bank of America Merrill Lynch. "Within a \$20 band, you get an almost 2m b/d swing," says Francisco Blanch, the bank's global head of commodities research...

Occidental Petroleum, the largest Permian operator, says it can increase production by 5-8 per cent with oil prices at \$50 a barrel and keep it steady at \$40. "We believe that we need to be prepared for a \$40 environment," Vicki Hollub, chief executive, told a conference last month...

- FT.com, July 2017, <https://on.ft.com/2Zmj2nj> or, for subscribers, <https://on.ft.com/2Wy8SxY>

Implications for OPEC

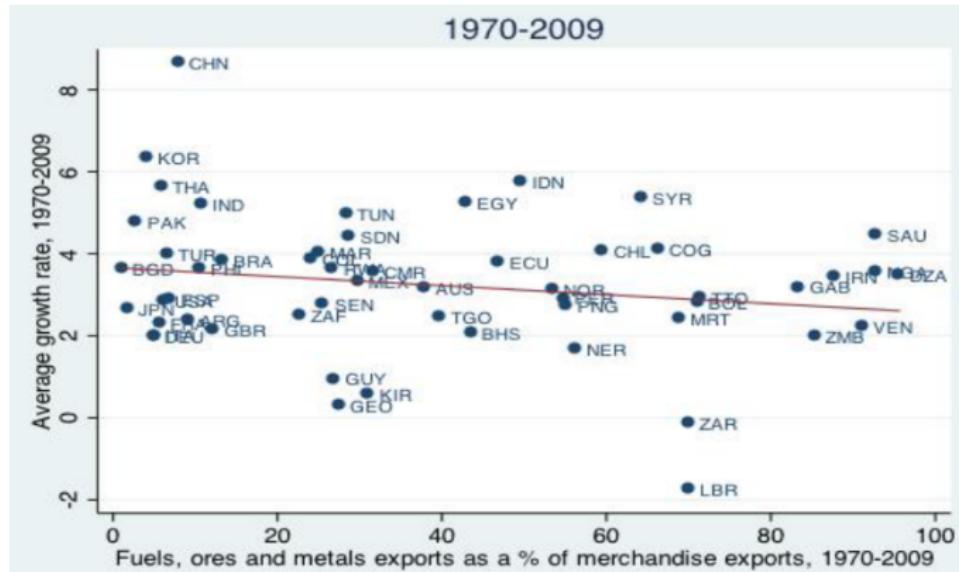
- Commonly thought that part of the 2014 price decline was an attempt by ME oil producers to drive U.S. producers out of business
 - i.e. did not cut production to defend price level
- Caused temporary damage but likely also spurred innovation
- As such, for immediate future (though maybe not long term), North American production helps limit price upside
 - Note also the lifting of the (U.S.) ban on U.S. exports of oil, 2015 (see Brent and WTI price convergence)
- Fundamentally, a huge technological leap has been made, undermining power of OPEC in short term (though some would argue that its ability to control prices has never been that precise)
- People do question how long economically viable extraction of tight oil will continue (pressure drops fairly quickly after rig established)

Sovereign Wealth Funds

Sovereign wealth funds - background

- Sovereign wealth funds are an important group of investors
 - Approximately \$8tn AUM and growing rapidly (compare to \$8tn of foreign reserves and \$3.2tn for hedge funds)
 - Arise from CA surpluses ⇒ accumulation of NFA where governments retain control of the foreign assets acquired
 - Increasingly diversifying their holdings into alternative asset classes (real estate, private equity...)
 - Prominent involvement in funding banks during GFC (or not funding - see Korean SWF in Lehman debacle)
 - Long horizon/illiquid investments (contrast with central bank holdings that are typically highly liquid / currency - foreign reserves)
 - Deep pocketed, low/no leverage
- We will quickly discuss some background justifications for SWF...

Natural resource ‘curse’



Natural resource dependence (as measured by concentration in exports) and growth. Source: Frankel (2012); World Bank *World Development Indicators*

Natural resource 'curse'

- Natural resource 'curse' discussed in Frankel (2012)
- Little benefit arises from rich stores of natural resources - and possibly negative impact
- Examples of struggling 'well endowed'
 - Africa, Middle East, Latin America
- Examples of successes without natural resources
 - Japan, Korea, China (though rare earth?)
- Typically an issue for small / developing countries
 - Natural to imagine them as being price takers in the commodity market
- Note that there is significant debate over whether the phenomenon exists and/or is a proxy for deeper causes
 - Causality very difficult to establish

Natural resource 'curse'

- Various reasons proposed...
 - Long term trends in prices
 - But if anything resource prices have trended up over time
 - Commodity price volatility (esp. oil and natural gas)
 - Necessitates constant reallocation of factors with associated costs
 - Crowding out of manufacturing (and growth industries)
 - Not entirely clear where market failure is
 - Possibly government involvement in commodity extraction retards modernization
 - Governance failure
 - Rents from resources induces socially destructive rent seeking
 - Once secured, access to rents can substitute for tax revenues
 - Less of an incentive - especially if undemocratic - to promote private enterprise/tax base
 - May retard the development of democracy (no taxation so no representation)

Natural resource 'curse'

- Various reasons proposed (cont.)
 - Social failure / 'anarchy'
 - Short termism - failure to assign property rights to future generations
 - Can lead to excessively rapid extraction and spending of the fruits
 - Election cycles may induce governments to promote excessively fast extraction
 - Word of the week: *Usufruct*
 - Enforcement of property rights difficult ('tragedy of the commons')

Natural resource 'curse'

- Various reasons proposed (cont.)
 - 'Dutch disease'
 - Stems from a substantial price increase in the commodity exported
 - Leads to real appreciation (via flexible exchange rate and/or inflation)
 - Increase in spending - especially by government (pro-cyclical stimulus)
 - Increase in relative price of non-traded goods and resource/expenditure switching away from 'manufacturing'
 - Possibly a current account deficit and increased external debt burden
 - Note: As with many of these 'reasons' the literature seems a bit sketchy on the mechanism/causality - seems somewhat anecdotal and far from inevitable
 - Simple models feature commodity sector, traded (e.g. manufacturing) non-commodity sector and non-traded sector
 - Resources move to booming commodity sector and extra spending drives up price of non-traded
 - RER appreciation and resources pulled away from traded non-commodity sector
 - It's often left implicit why this should be a market failure (maybe learning by doing in manufacturing and a general sense that manufacturing is 'more worthwhile')

Alternative to CB foreign reserves

- Many SWF are funded by proceeds from exporting commodities
- Others are financed by excess currency reserves resulting from CA surpluses
- A certain (can be large) amount of reserves will be used by CB to offset currency fluctuations / defend pegs or managed floats
 - Recall earlier lectures on exchange rate regimes and BoP crises
 - Particularly applies among Asian countries
- But the very liquid assets typically held for these purposes are very low yielding
- Once a desired currency reserve buffer has been reached it is wasteful not to seek higher returns (and to diversify) from less liquid assets
 - For example, China Investment Corporation set up to manage some of its (enormous) foreign reserves

Largest sovereign wealth funds

Table 1
Leading Sovereign Wealth Funds

Country	Fund Name	Assets (billions of dollars)	Inception	Origin of wealth
UAE – Abu Dhabi	Abu Dhabi Investment Authority	627	1976	Oil
Norway	Government Pension Fund – Global	593	1990	Oil
China	SAFE Investment Company	568	1997	Non-commodity
Saudi Arabia	SAMA Foreign Holdings	533	N/A	Oil
China	China Investment Corporation	440	2007	Non-commodity
Kuwait	Kuwait Investment Authority	296	1953	Oil
China – Hong Kong	Hong Kong Monetary Authority Investment	293	1993	Non-commodity
Singapore	Government of Singapore Investment Corporation	248	1981	Non-commodity
Singapore	Temasek Holdings	158	1974	Non-commodity
Russia	National Welfare Fund	150	2008	Oil
China	National Social Security Fund	135	2000	Non-commodity
Qatar	Qatar Investment Authority	100	2005	Oil
Australia	Australian Future Fund	80	2006	Non-commodity
UAE – Dubai	Investment Corporation of Dubai	70	2006	Oil
UAE – Abu Dhabi	International Petroleum Investment Company	65	1984	Oil
Libya	Libyan Investment Authority	65	2006	Oil
Kazakhstan	Kazakhstan National Fund	58	2000	Oil
Algeria	Revenue Regulation Fund	57	2000	Oil
UAE – Abu Dhabi	Mubadala Development Company	48	2002	Oil
South Korea	Korea Investment Corporation	43	2005	Non-commodity

Note: This information about the 20 largest sovereign wealth funds is compiled from the Sovereign Wealth Fund Institute, <http://www.swfinstitute.org/fund-rankings/> (accessed July 21, 2012).

Largest sovereign wealth funds, type and inception (as of 2012) Source:
Bernstein, Lerner and Schoar (2013); Sovereign Wealth Fund Institute

Largest sovereign wealth funds

Norway's Sovereign Wealth Fund Hits \$1 Trillion

Largest sovereign wealth funds by assets under management in 2017*



* As of September 19, 2017

@StatistaCharts Source: The Sovereign Wealth Fund Institute

statista

Largest sovereign wealth funds (as of 2017) Source: Sovereign Wealth Fund Institute

Largest sovereign wealth funds

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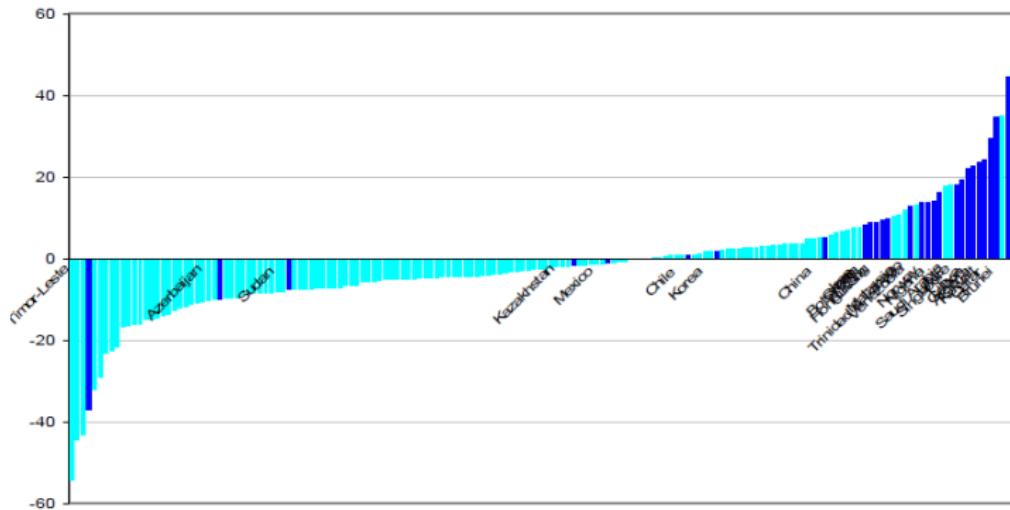
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@StatistaCharts Source: The Sovereign Wealth Fund Institute

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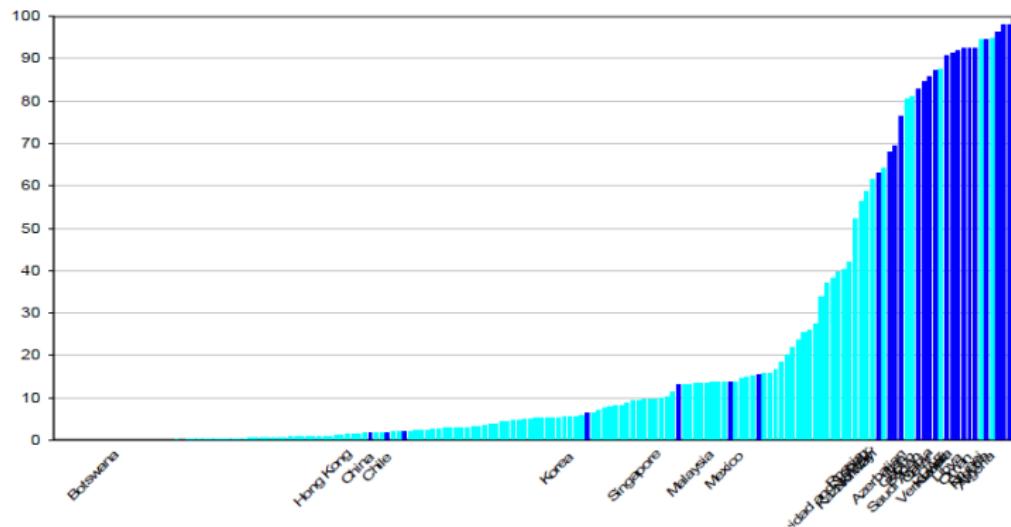
Largest sovereign wealth funds (as of 2017) Source: Sovereign Wealth Fund Institute

SWF prevalence among CA surplus countries



Current account surpluses as share of GDP, 2002-2006 (countries with SWF in dark blue) Source: Aizenmann and Glick (2008)

SWF prevalence among commodity exporters



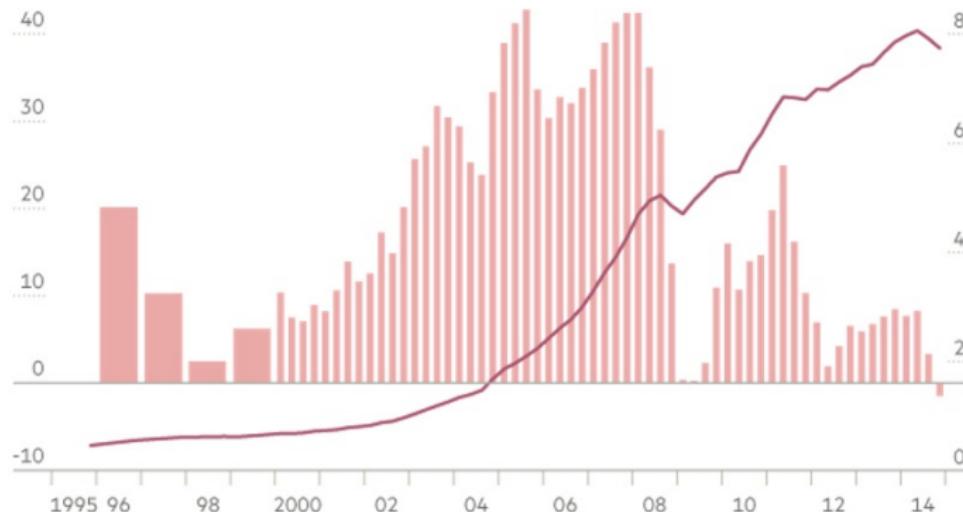
Fuel exports as share of total merchandise exports, 2006 (countries with SWF in dark blue) Source: Aizenmann and Glick (2008)

Enormous accumulation of foreign reserves in recent years

Emerging and developing foreign exchange reserves

Annual
% change

Emerging and developing
FX reserves (\$tn)



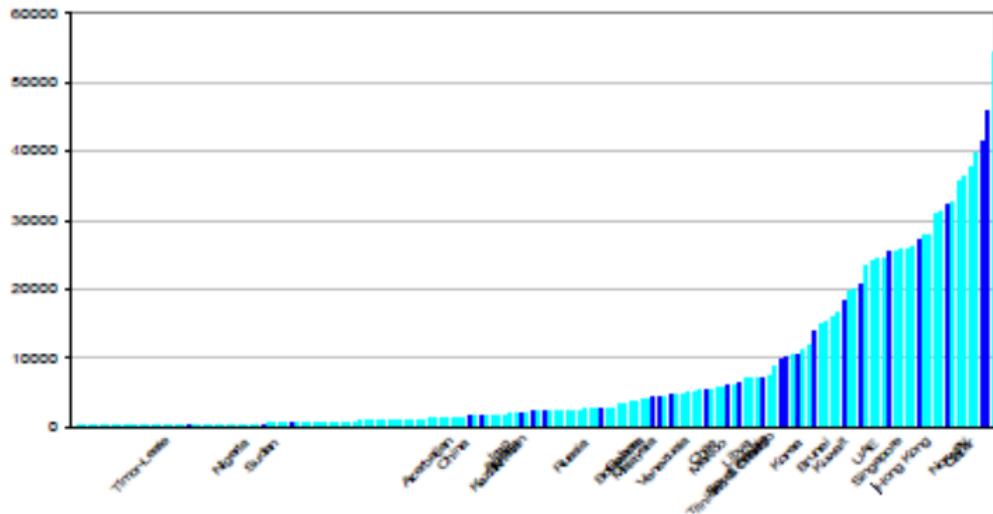
*Pre-1999 = annual data only

Sources: Thomson Reuters Datastream; IMF

FT

Stock and flow of emerging/developing countries' foreign reserves
Source: Thompson Reuters Datastream; IMF; Financial Times

SWF less obviously correlated with income levels



GDP per capita, 2006 (countries with SWF in dark blue) Source: Aizenmann and Glick (2008)

SWF characteristics

- Reflecting diversification/yield enhancement, funds appear to be concentrated among commodity producers and where reserves have reached high levels
- Can possibly (though not necessarily) help with earlier ‘commodity curse’
 - Can be used to stabilize funds available for consumption/investment when commodity prices vary
 - Can be a tool to enhance transparency and accountability by governments managing resource wealth
 - Coordination can aid in ensuring interests of future generations are protected
 - Rules on disbursement can protect against opportunistic/procyclical spending and ‘Dutch disease’ problem
- These are possible benefits but the nature of the fund and the quality of its management/governance influence whether these advantages are realized

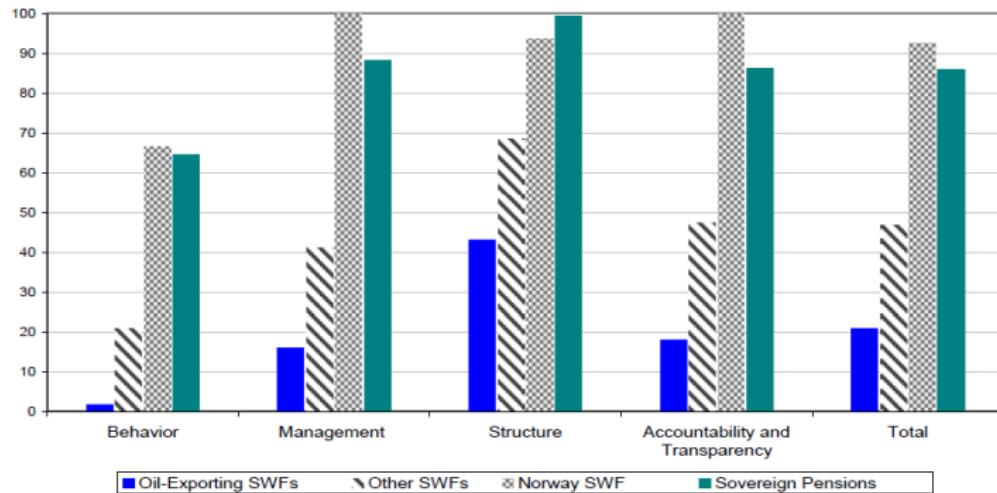
SWF governance - Truman score

- Truman (2008) constructs an indicator of governance quality for SWF, based on four subcomponents
 - **Accountability/transparency:** Clarity of strategy, reporting and audits
 - **Fund structure:** Fiscal treatment, independence from country's international reserves
 - **Fund behavior:** Portfolio management, leverage, use of derivatives
 - **Fund management:** Investment guidelines, role of independent managers, government influence

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SWF governance - Truman score



Truman scores for different SWF groupings (normalized to be percent of possible score for each sub-category) Source: Aizenmann and Glick (2008)

SWF governance - Truman score

**Table 5.2 Summary analysis of sovereign wealth fund scoreboard
(tests of significant differences)**

Comparison	Number	Mean score	Standard deviation	t-test statistic
Pension SWFs	13	84	8.5	4.8**
Nonpension SWFs	40	50	24.9	
Nonpension SWFs ^a				
IFSWF ^b	23	63	24.4	3.0**
Non-IFSWF	21	42	22.4	
OECD ^c	13	78	15.3	5.0**
Non-OECD	31	43	22.0	
Non-OECD SWFs				
Middle East	11	31	18.6	2.8*
Non-Middle East ^c	24	51	20.4	
Non-Middle East SWFs ^c				
Asian	10	57	19.0	1.2
Non-Asian	14	47	21.0	

* = significant at 5 percent level; ** = significant at 1 percent level.

a. Including Australian Future Fund, Chilean Pension Reserve Fund, Irish National Pensions Reserve Fund, and New Zealand Superannuation Fund.

b. SWF members of the International Forum of Sovereign Wealth Funds (IFSWF); see chapter 6.

c. Including SWFs of Chile, Korea, and Mexico.

Truman scores by type of SWF, Source: Bernstein, Lerner and Schoar (2013)

SWF governance - Truman score

Country	Fund ^a	Score			Change in percentage points
		2009	2008-09	2007-09	
Funds scored three times					
Norway	Government Pension Fund-Global	97	5	5	
United States	California Public Employees' Retirement System (P)	95	8	14	
New Zealand	Superannuation Fund (PR)	94	3	4	
United States	Alaska Permanent Fund	92	0	22	
Timor-Leste	Petroleum Fund	85	5	-2	
Trinidad and Tobago	Heritage and Stabilization Fund	83	30	34	
Australia	Future Fund (PR)	80	5	18	
Azerbaijan	State Oil Fund	76	-2	10	
Canada	Alberta Heritage Savings Trust Fund	74	1	2	
Singapore	Temasek Holdings	73	27	19	
Chile	Economic and Social Stabilization Fund	71	0	9	
Kazakhstan	National Fund	65	2	7	
Singapore	Government of Singapore Investment Corporation	65	24	56	
Kuwait	Kuwait Investment Authority	63	15	15	
Korea	Korea Investment Corporation	60	9	24	
United Arab Emirates	Mubadala Development Company	59	45	47	
China	China Investment Corporation	57	19	33	
Botswana	Pula Fund	56	1	0	
Russia	Stabilization Fund of the Russian Federation	50	-1	12	
São Tomé and Príncipe	National Oil Account	48	0	-1	
Malaysia	Khazanah Nasional	44	6	6	
Mexico	Oil Income Stabilization Fund	44	-3	16	
Kiribati	Revenue Equalization Reserve Fund	35	6	5	
Algeria	Revenue Regulation Fund	29	2	11	
Iran	Oil Stabilization Fund	29	6	7	
Venezuela	Macroeconomic Stabilization Fund	27	5	5	
Oman	State General Reserve Fund	23	0	6	
Brunei Darussalam	Brunei Investment Agency	21	0	15	
Sudan	Oil Revenue Stabilization Account	18	0	4	
Qatar	Qatar Investment Authority	15	0	4	
United Arab Emirates	Istithmar World	15	0	3	
	Abu Dhabi Investment Authority	11	2	5	

Truman score rankings of particular SWF, Source: Bernstein, Lerner and Schoar (2013)

SWF governance - Truman score

- Wide variation across SWF
 - Rankings especially low for commodity (esp. oil-exporting) funds
 - Possibly a reflection of broader political/democratic framework (note the Norway exception for commodity-based funds)
 - Explicit stakeholders (e.g. pensioners) seem to be associated with better performance
 - May also reflect broader fund management norms at inception (older funds often the oil-exporting SWF)
- Influence of politicians also varies across funds - often by region
 - External management seems to produce better results from perspective of 'profit maximization' (see Bernstein *et al*, 2013)
 - But may have non-economic motives or misaligned private incentives
 - Related to regulatory/political controversies and suspicion in recipient countries
- Setting up a SWF does not guarantee an escape from some of the traditional problems of commodity-rich countries

SWF management types

Panel A: Groups

	Funds	Transactions	External managers (%)	Politicians (%)	Average fund size in 2008 (billions of dollars)
Asia group	7	2045	42.85	57.14	132.7
Middle East group	15	533	13.33	13.33	124.76
Western group	7	84	42.85	14.28	40.874

Types of fund managers, Source: Bernstein, Lerner and Schoar (2013)

SWF governance influences performance (different goals?)

Overall, our results lend support to the hypothesis that funds exposed to political influences show major deviations from long-run return maximization. Sovereign wealth funds with politician involvement are more likely to invest domestically, while those sovereign wealth funds where external managers play an important role are more likely to invest internationally. Politically influenced sovereign wealth funds also concentrate their funds in sectors that both have high price-to-earnings levels and then experience a drop in these levels, especially in their domestic investments, patterns that do not hold in funds that rely on external managers...

The performance gap between domestic and international investments when more political appointees are on the board also supports the interpretation that politically connected managers are not purely making poor decisions when investing but that there is a strategic component.

- Bernstein et al, July, 2013