The Energy Revolution

HOW IT IS REDRAWING THE MAP OF THE GLOBAL ECONOMY

PREPARED FOR
Iseo Summer School

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PRESENTED
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KEYBRIDGE
Public Policy Economics

Agenda

I. Goals for Class

II. A Fact-Based Overview of Oil

III. The Natural Resource Curse

IV. What (or Who?) Determines the Price of Oil?

V. How Do Oil Prices Affect a Macroeconomy?

VI. Policy Options to Protect an Economy from Oil Price Swings

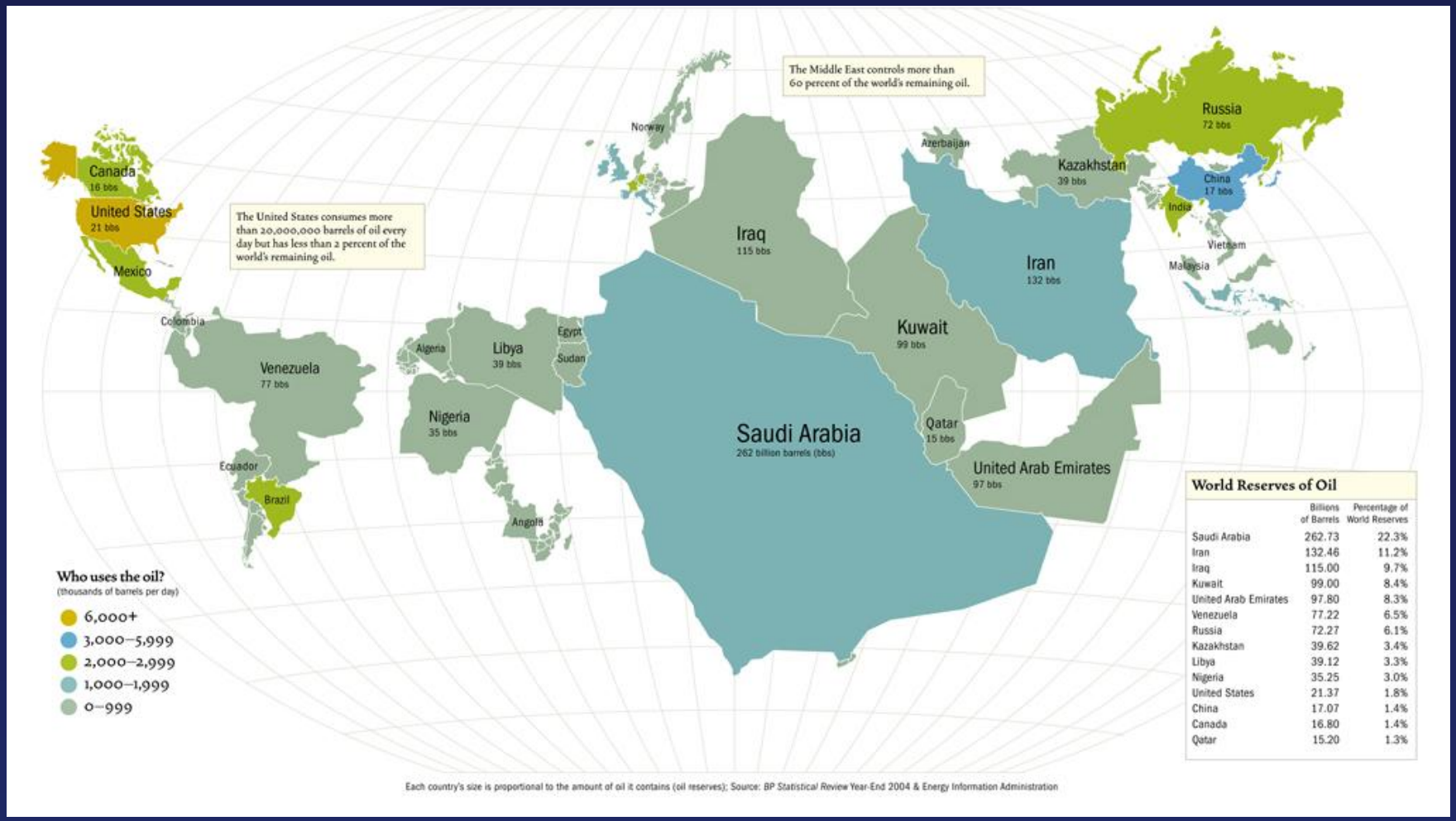
VII. Class Discussion

I. Goals for Class

- Look at new trends in global oil markets
- Review the "natural resource curse" debate
- Develop an understanding of the microeconomic drivers of oil prices, including optimal behavior for a "partial monopolist"
- Develop an understanding of the main channels through which oil price movements affect a modern macro economy
- Discuss policy options to protect an economy from oil price swings

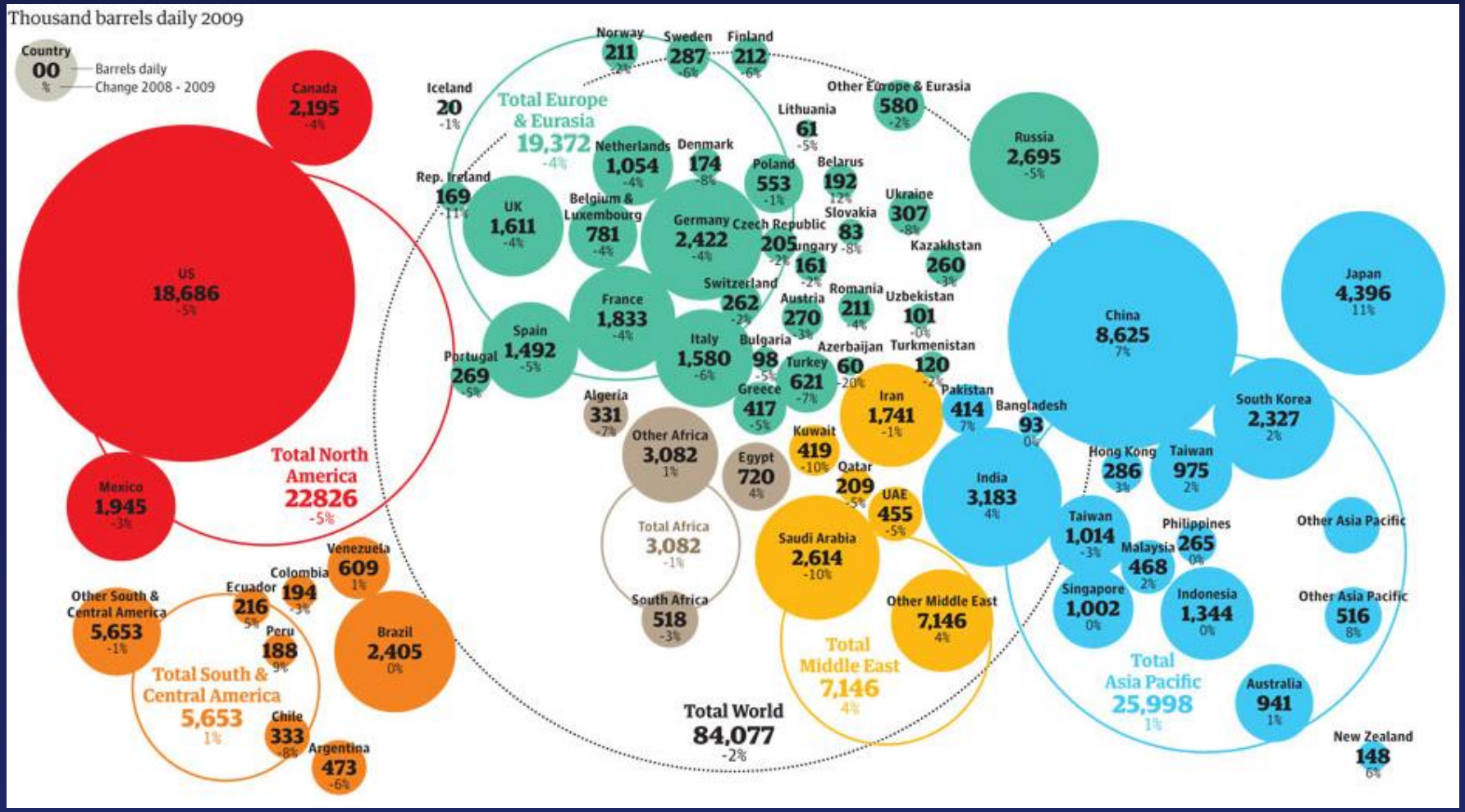
II. Fact-Based Overview of Oil

Where is oil found? The world's largest conventional oil reserves are heavily concentrated in the Middle East.



Source: gCaptain

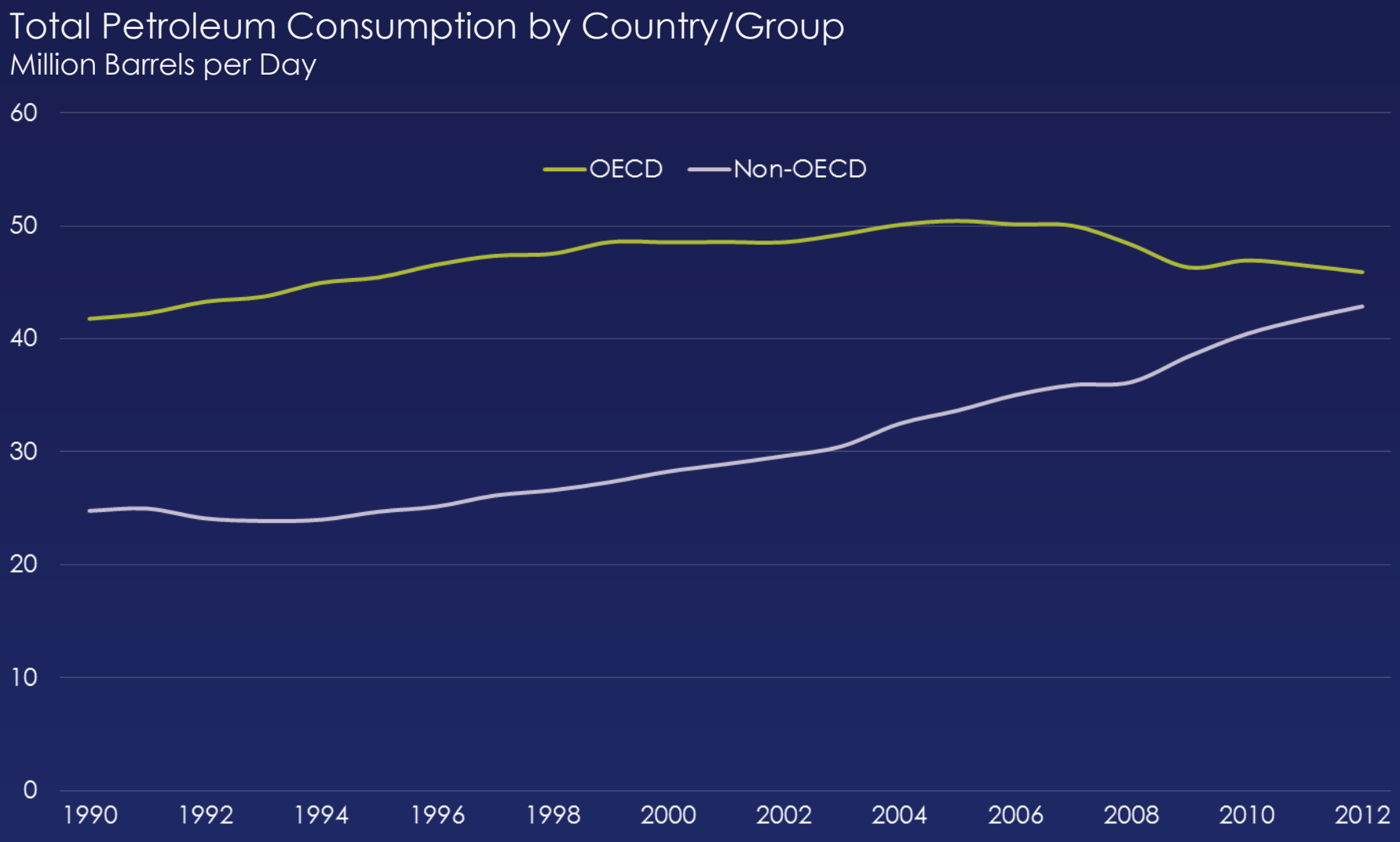
Where is oil consumed? The U.S. consumes more oil than any other country, China is number two, and Japan is number three.



Source: BP Energy Statistics

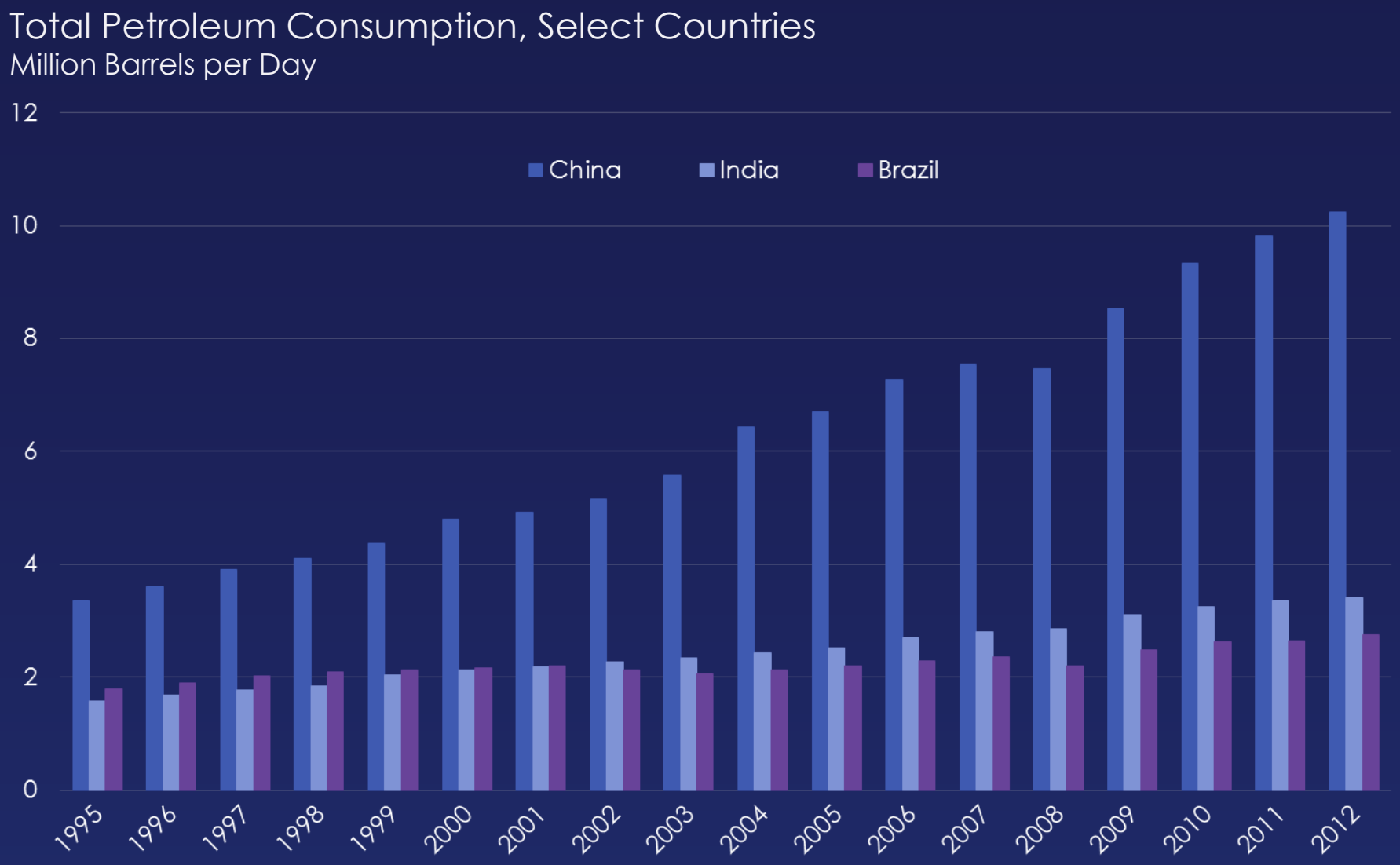
Where is demand for oil growing the fastest?

Where is demand for oil growing the fastest? Non-OECD countries are increasing their consumption, while OECD countries are reducing consumption.



Source: EIA International Energy Statistics.

In particular, oil consumption has doubled in China in the past decade and risen notably in countries like India and Brazil.

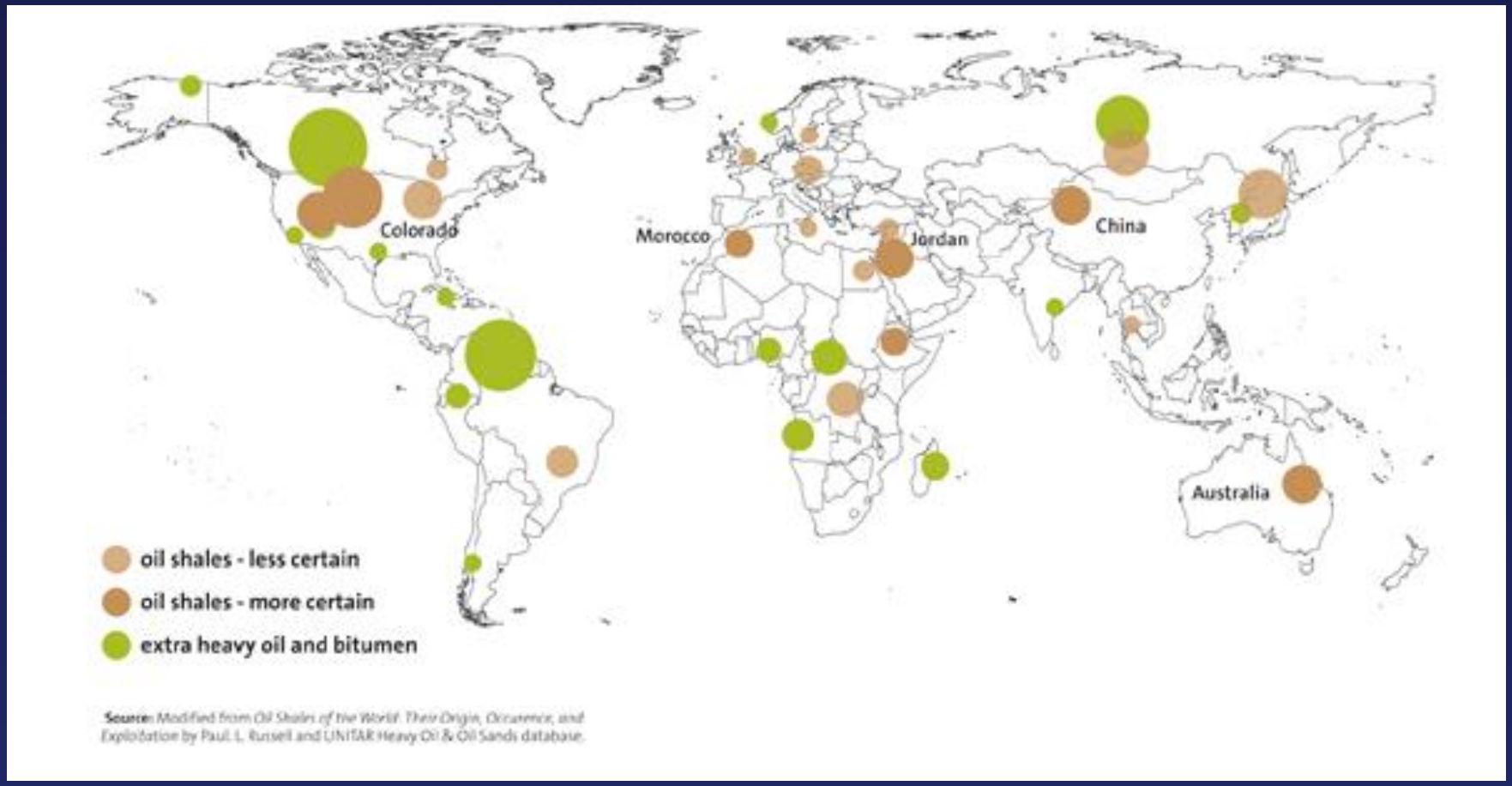


Source: EIA International Energy Statistics.

Rapidly advancing technology has led to rapid increases in production of oil from unconventional sources.

- Conventional oil
  - Petroleum found in liquid form that can be pumped without further processing or dilution
  - Onshore and offshore
- Unconventional oil
  - More difficult to extract and requires unconventional technologies. Cannot be extracted without being heated or diluted
  - Onshore and offshore
  - Types:
    - Oil sands (tar sands) – Sediments composed of sand, clay minerals, water, and bitumen (ex: Canada)
    - Oil shale – Fine-grained sedimentary rocks that contain large amounts of a solid organic matter (kerogen) (ex: Russia)
    - Shale oil (tight oil) – Oil produced from shale reservoirs (ex: North Dakota)

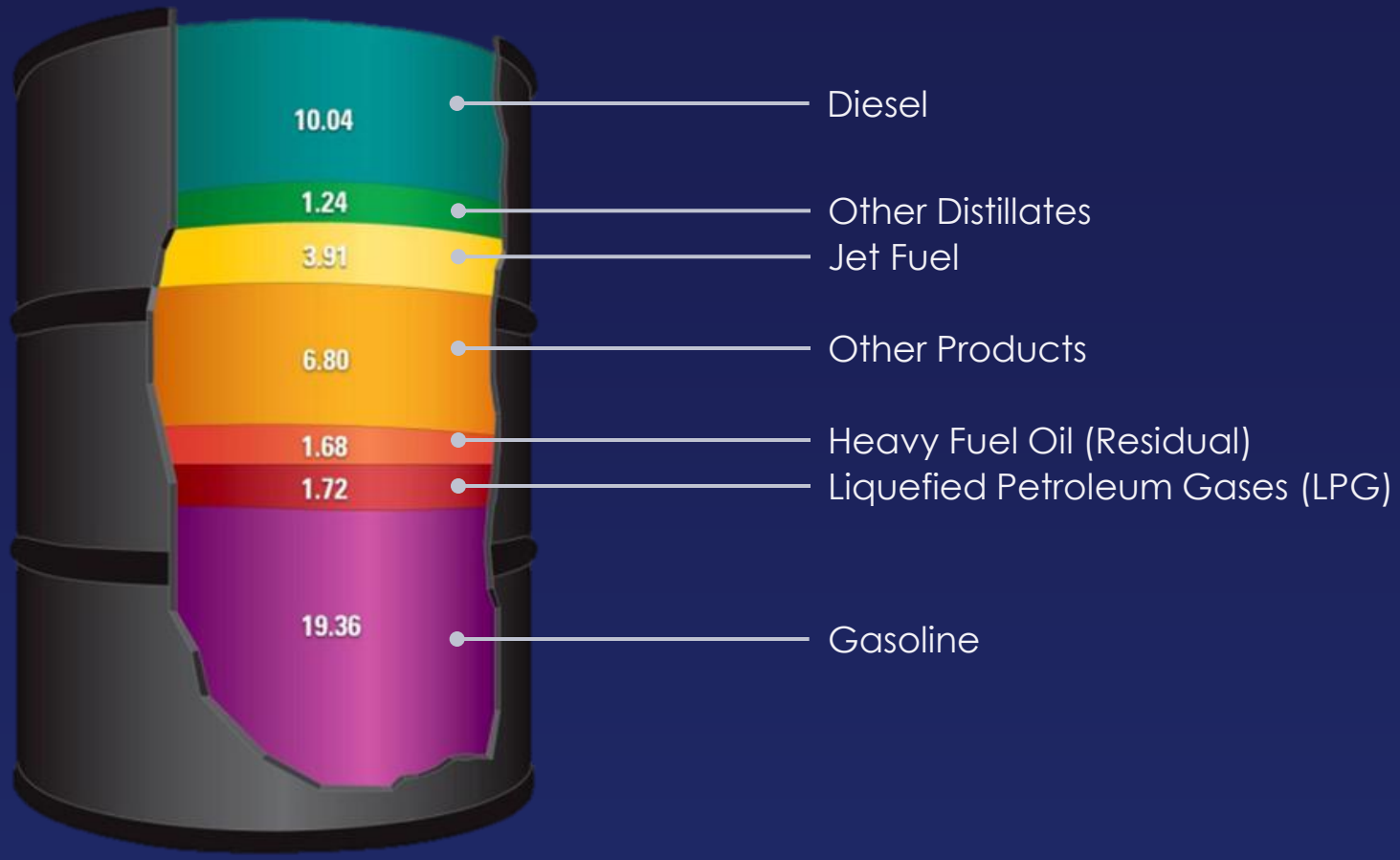
Where are the unconventional reserves? The Americas have significant unconventional oil reserves. Water needed for fracking.



Source: The Tyee

What comes out of a barrel of oil? Cracking a barrel of oil produces…

Products Made from a Barrel of Crude Oil
Gallons, 2009



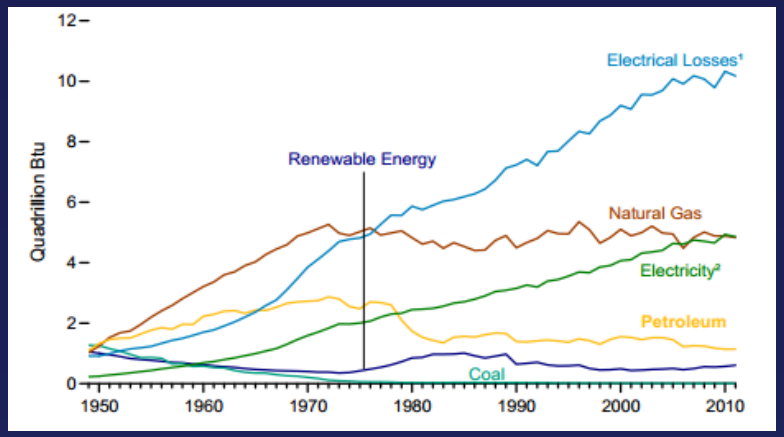
Source: U.S. Department of Energy

What sectors use petroleum?

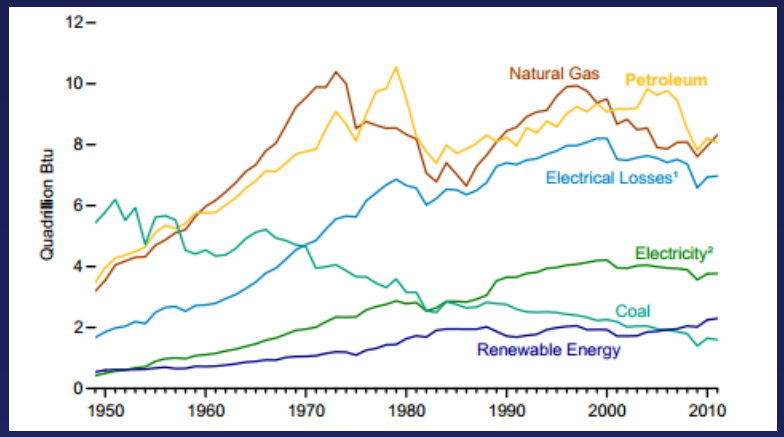
What sectors use petroleum? Increasingly oil use is directed toward transportation.

Energy Consumption Estimates by End-Use Sector, 1949-2011

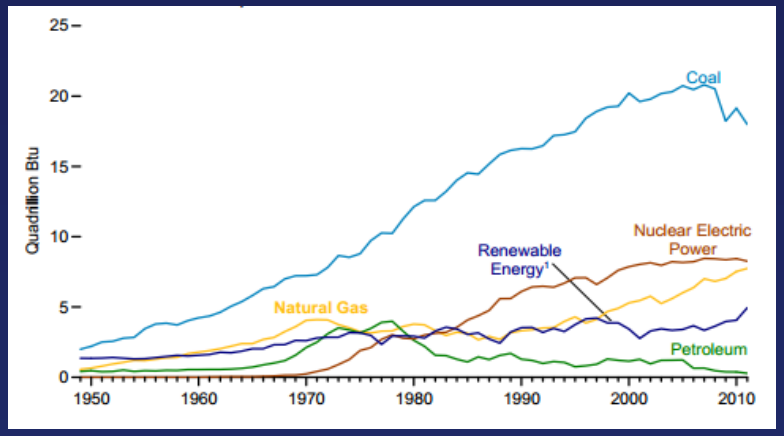
Residential



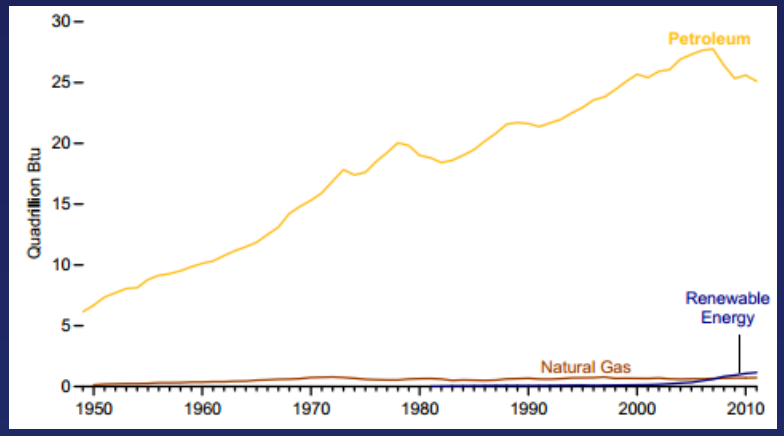
Industrial



Electric Power



Transportation



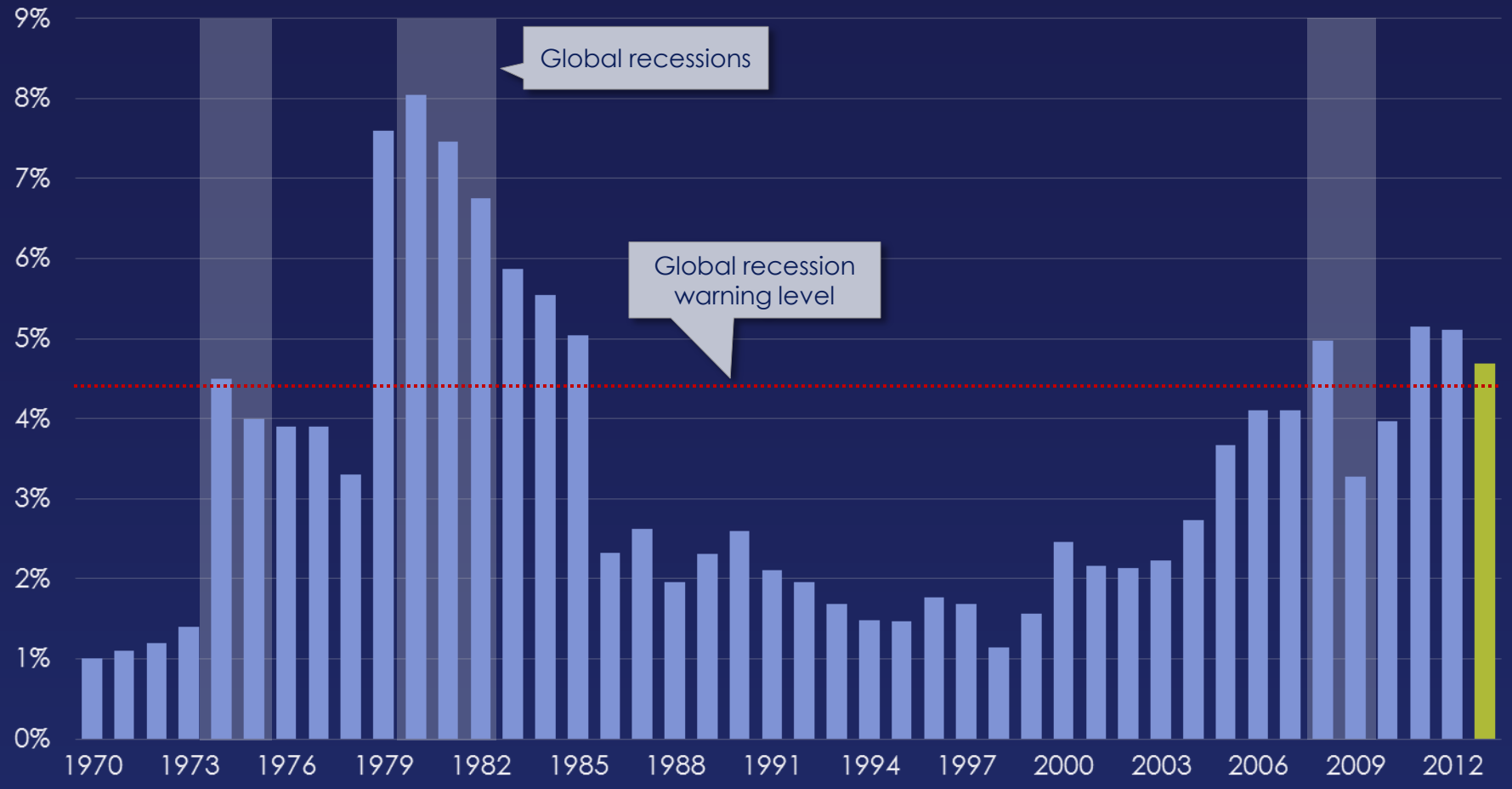
Source: U.S. Energy Information Administration, "Annual Energy Review 2011"

What is the world's oil bill?

What is the world's oil bill?

The World's Oil Bill

World Oil Consumption, Brent Crude Prices / World GDP (Nominal)

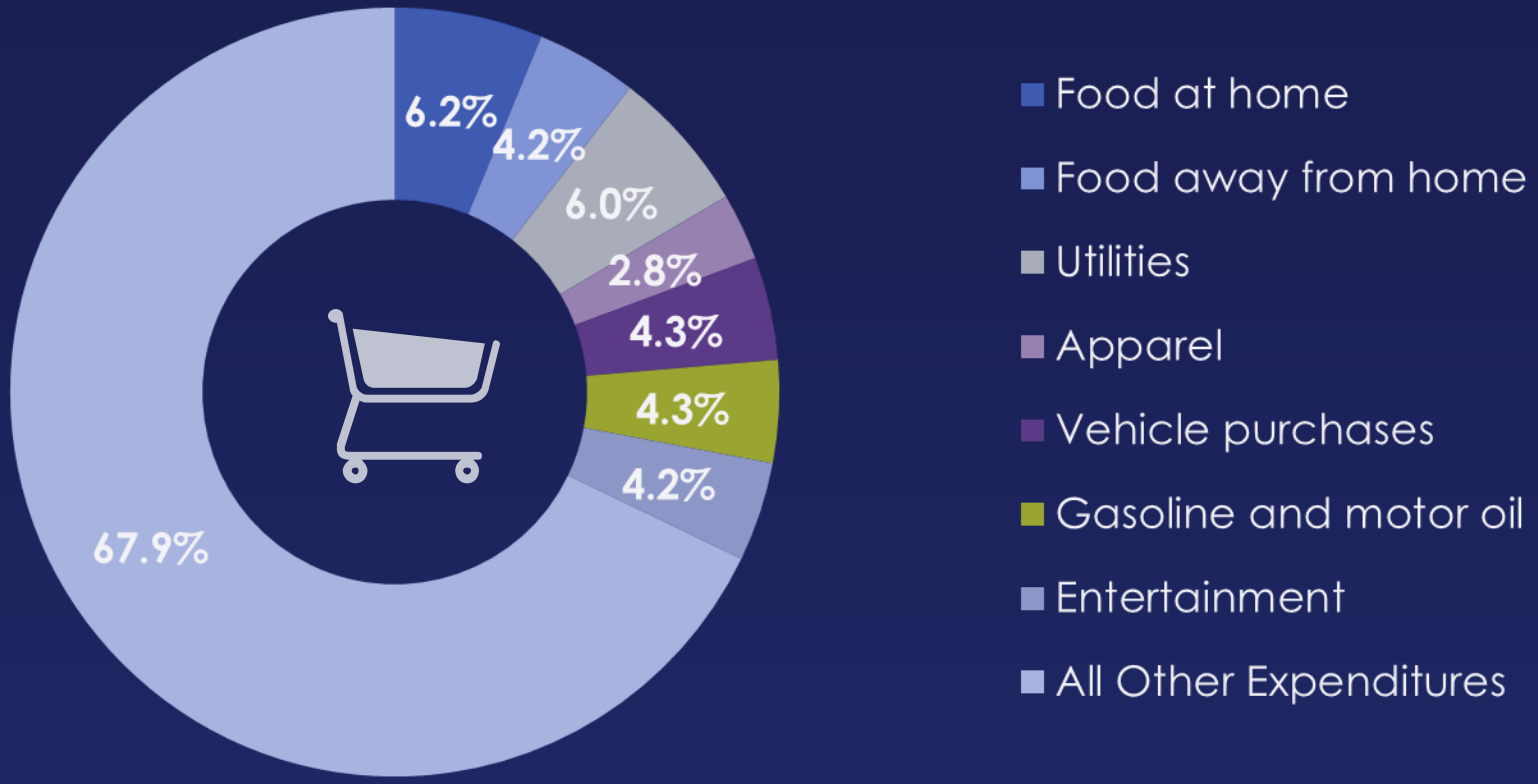


*2012 assumes 3.2% Y/Y real global growth; 2013 assumes 3.3% global growth and $105 oil

Source: IMF , WEO (April 2013), IEA. Oil Market Report (May 2013); EIA; Haver Analytics

How much does oil represent in typical U.S. household budget? About 4.3% of an average budget, or about $2,800 per year.

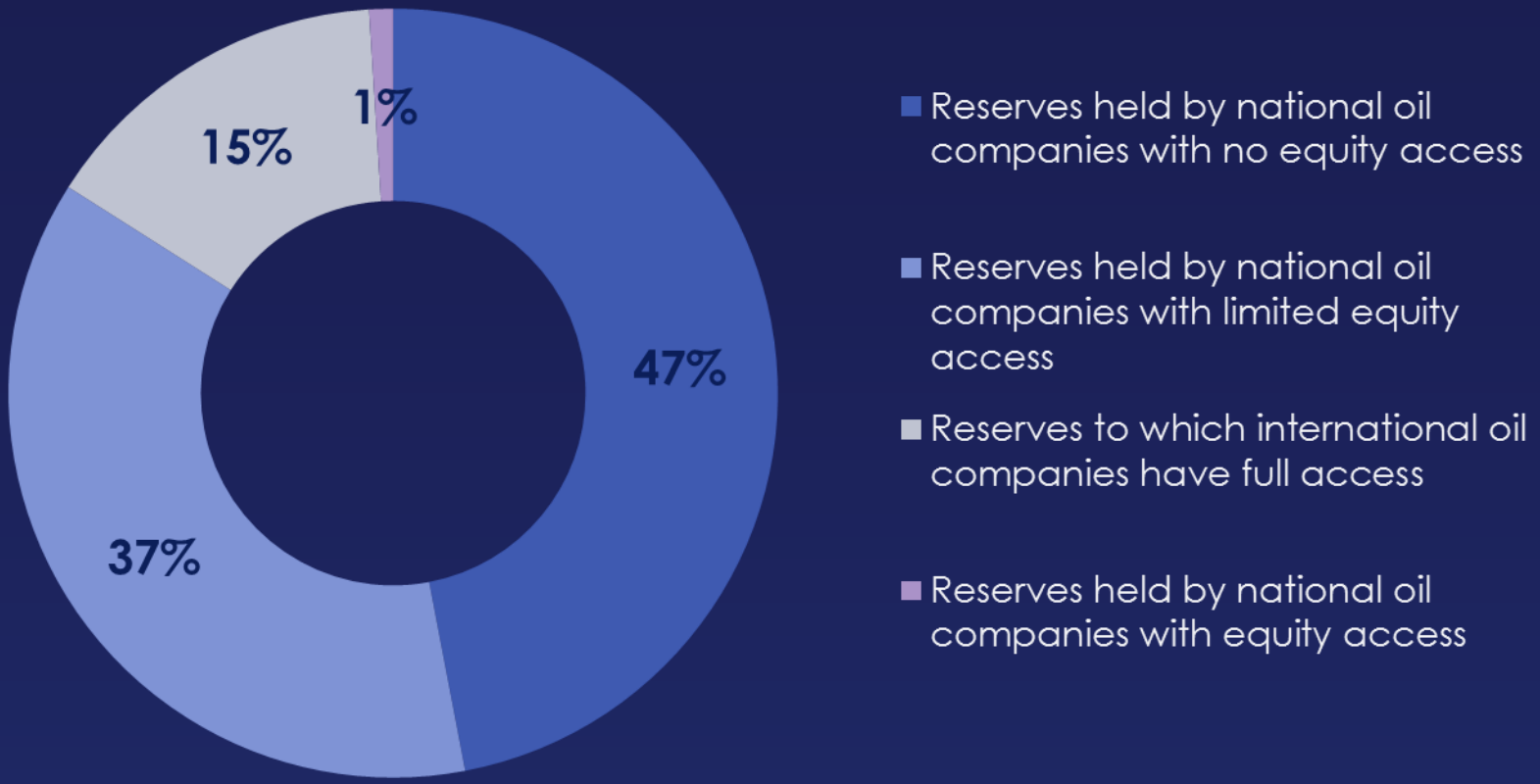
Average Annual Expenditure per American by Item, 2011
Average Income After Taxes



Source: Consumer Expenditure Survey

Who owns the world's oil? Oil is largely controlled by national governments and their state oil companies.

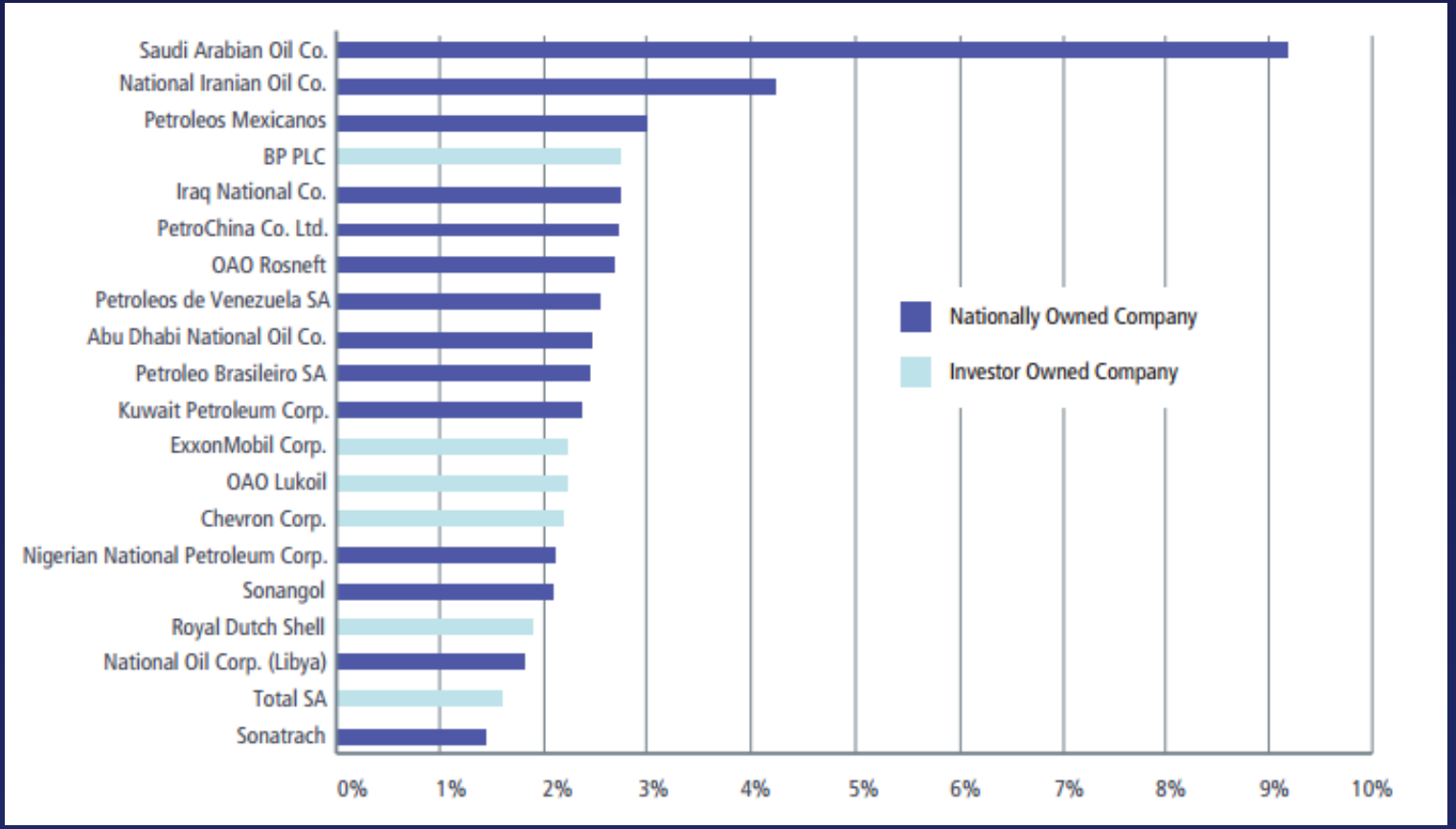
World Oil Reserves Access by Company Type, 2010
Percent of World Total



Source: Morriss and Meiners (2013). "Competition in Global Oil Markets: A Meta-Analysis and Review."

These national owned oil companies account for the vast majority of world crude production.

World Crude Production by Company, 2010
Percent of World Oil Production

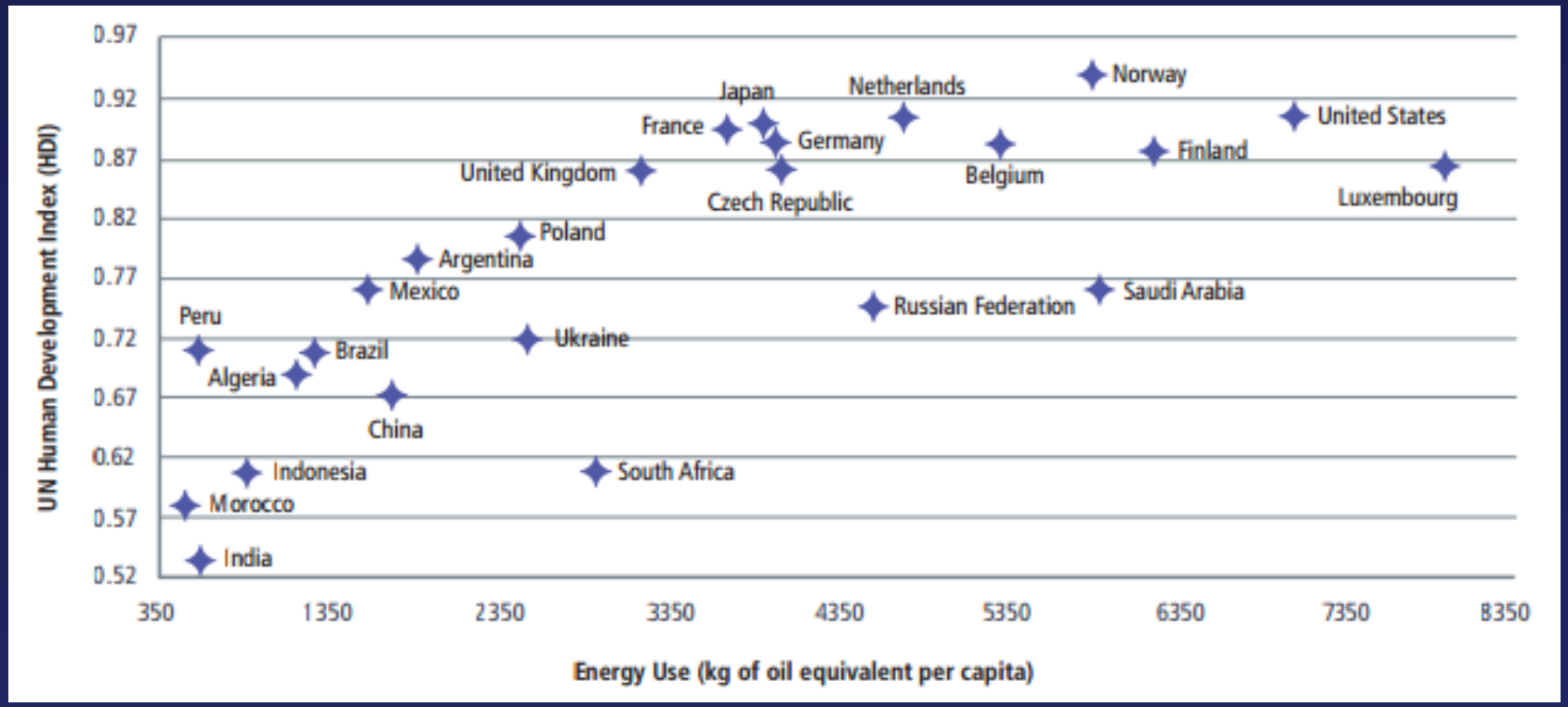


Source: Morriss and Meiners (2013). "Competition in Global Oil Markets: A Meta-Analysis and Review."

How is energy related to economic development?

How is energy related to economic development? There is a clear positive link between economic development and energy use.

U.N. Human Development Index vs. Energy Use, 2009



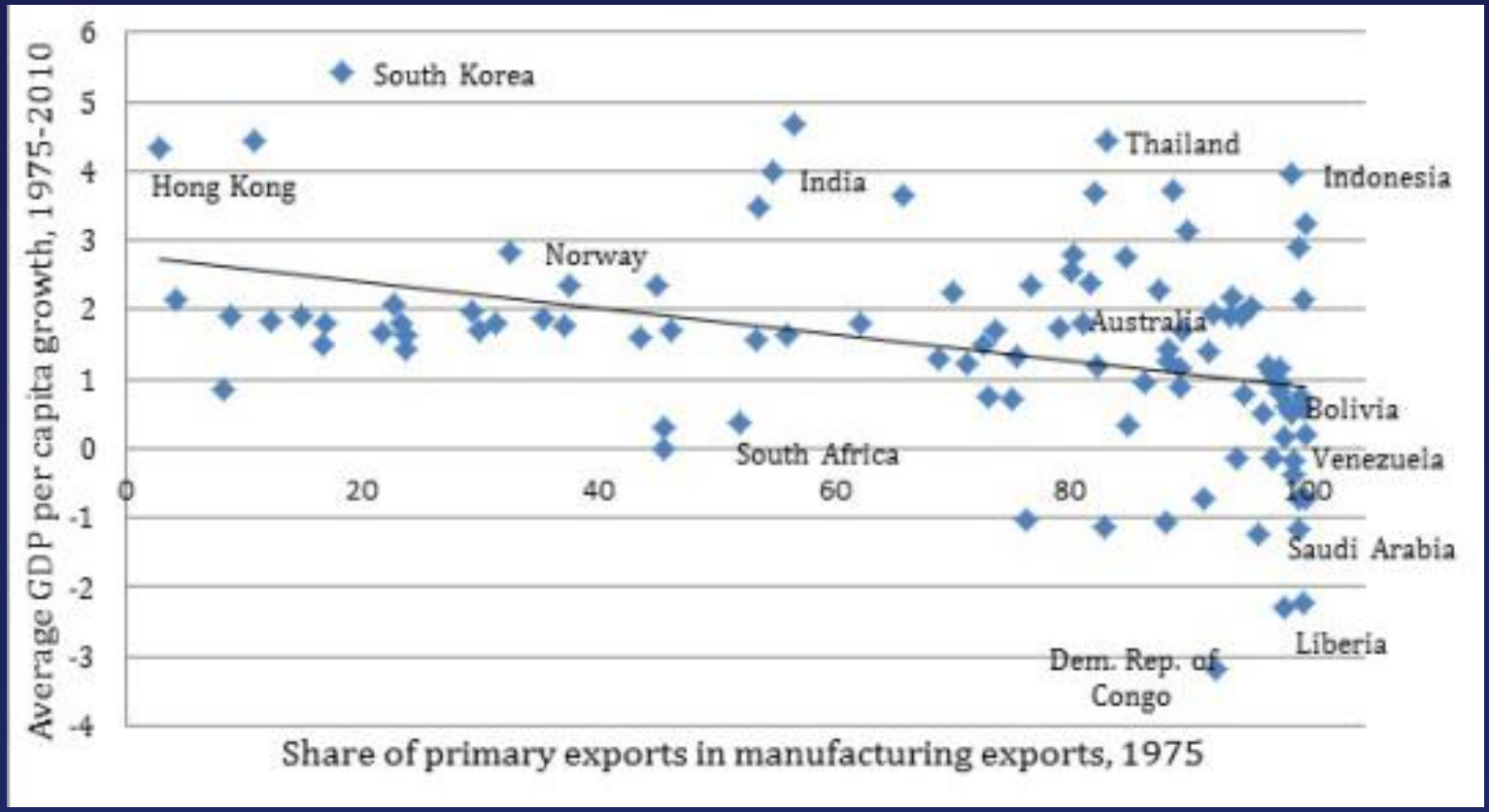
Source: Securing America's Future Energy (SAFE), "Competition in Global Markets: A Meta-Analysis Review," Figure 3 (April 2013)

III. The Natural Resource Curse Debate

Is it good to have large deposits of natural resources?

Is it good to have large deposits of natural resources? Not always. Many countries find that it could actually be a "curse".

Correlation between GDP Growth and Resource Dependence



Source: World Bank database; Forum for Research on Eastern Europe and Emerging Economies (FREE)

What exactly is the natural resource curse?

- Phenomenon discovered in 1990s by Robert Barro (1991) and Richard Auty (1993). Two drivers: econometric studies of economic growth and institutionalists.
- Based upon the observation that countries like Angola, Nigeria, Sudan, and Congo are all rich in oil, diamonds, and minerals, yet experience low per capita income.
- The counterpoint is that countries like Japan, Korea, Taiwan, and Singapore have virtually no exportable natural resources, but have achieved high per capita income.
- Widely written about for the past 20 years by many, including Jeffrey Sachs, Joseph Stiglitz, Carmen Reinhart, Dani Rodrik, and others

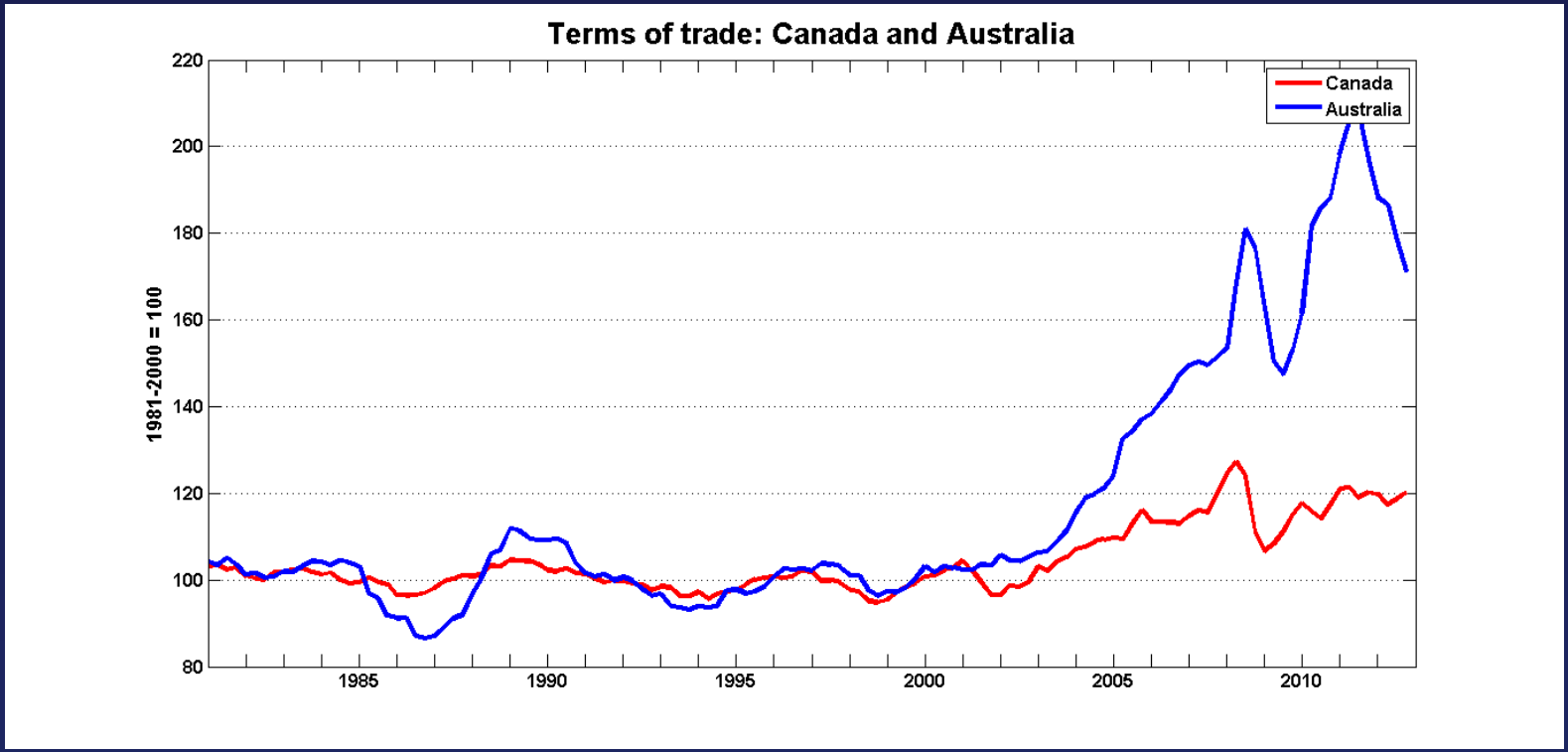
“Natural resource curse” seems like a paradox. Why might countries with abundant natural resources often have lower economic growth?

"Natural resource curse" seems like a paradox. Why might countries with abundant natural resources often have lower economic growth?

Reasons Why Abundance of Natural Resource Could Slow Growth

- Dependence on single source of revenue
- Income inequality
- Volatility of natural resource prices
- Government mismanagement
- Corruption or mismanagement of resources
- Appreciation of the real exchange rate leads to decline in the international competitiveness of other sectors of the economy
- Easy flow of money from a natural resource may lead to unsustainable public expectations for social benefits/welfare programs

"Dutch disease" is an aspect of the resource curse. This occurs when strong resource exports appreciate a country's currency and make its manufactured exports less competitive internationally.



*Terms of trade is the ratio of the price of exported goods to the price of imported goods

Source: Maclean's, "The Dutch Disease Down Under"

What does new economic research suggest about the natural resource curse?

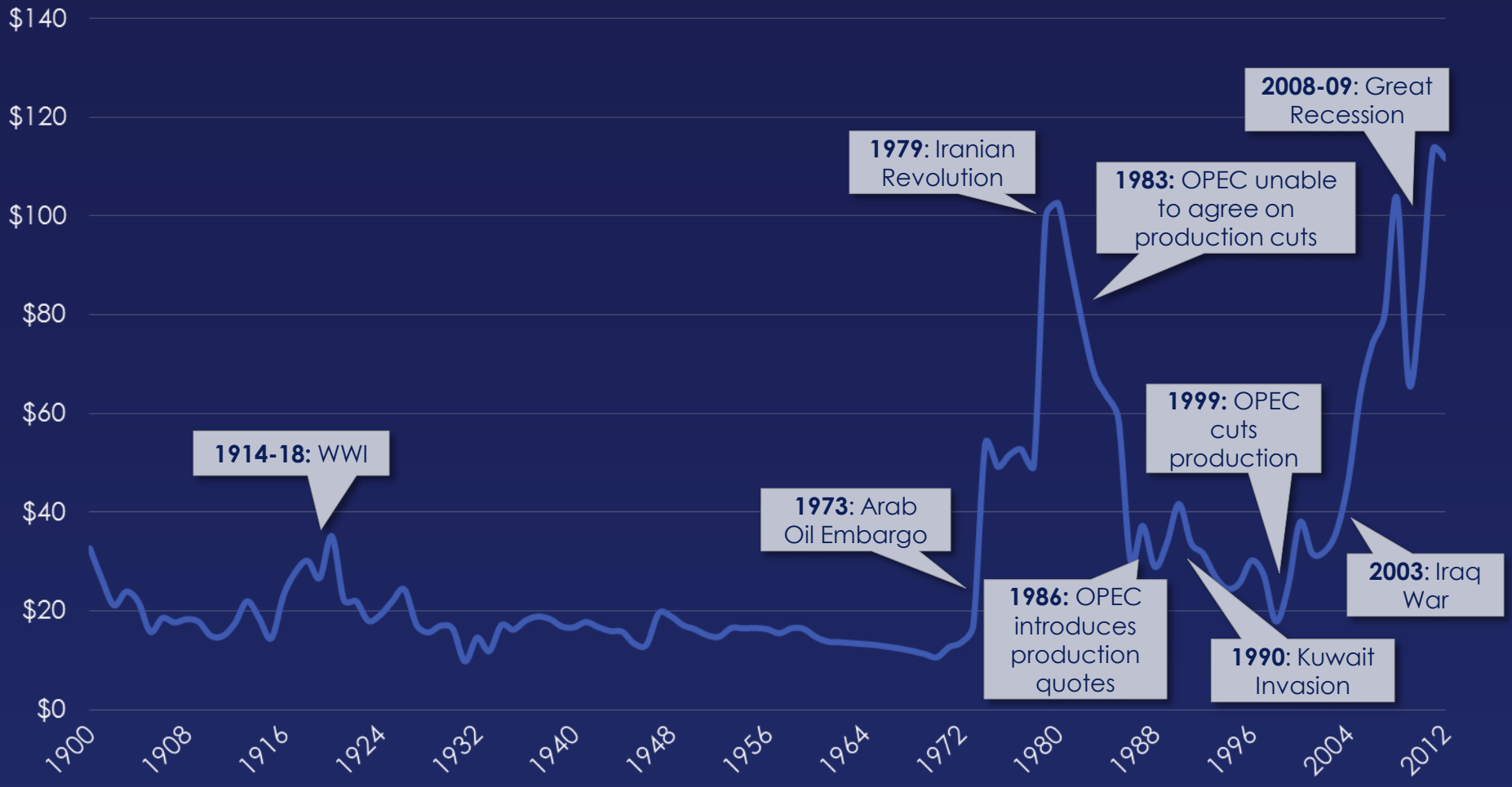
- Frankel (2010) provides a good recent overview. He concludes that it is not necessarily good or bad to have lots of natural resources.
- Cotet and Tsui (2013) find oil abundance uncorrelated with violence, coup attempts, and political violence. But they do find that oil does boost military spending.
- Caselli and Michaels (2013) look at oil windfalls in municipal governments in Brazil. They find that oil does boost spending on public goods and services, infrastructure, etc., but by less than expected. Household income is virtually unchanged. They find that much oil revenue "disappears"—that is, goes to corruption.
- This is not just an issue for emerging market countries. There are concerns in Canada, Australia, Israel, and other countries with heavy natural resource endowments—although worries in these advanced countries focus more on Dutch Disease issues.

IV. What (or Who) Determines the Price of Oil?

Oil prices have been extremely volatile for the past 40 years.

Average Crude Oil Price

Thousand Barrels per Day, Dollars per Barrel (2011 Dollars)



Source: BP Statistical Review of World Energy (2013)

Is oil a competitively priced commodity?

Is oil a competitively priced commodity?

Factors that Make the Oil Market Uncompetitive

- Inelastic demand
  - Lack of substitutes
  - Long-lived assets
  - Infrastructure advantage
- Exhaustible Supply
  - Restricts New Entrants
  - Production Costs Grow
- Public ownership of resources
  - National patrimony
  - Barriers to entry
  - Rent seeking behavior
  - Existence of cartel

Nationally owned oil companies provide governments and officials with the power and means to exert control over the oil market.

Methods of Government Manipulation in the Oil Market

- Taxation
  - Impose severance taxes
  - Impose social tax on oil

- Quotas/Limits
  - May not accept bids for production
  - Limit production (maybe due to environmental concerns or patrimony considerations)
  - Block access to outside/foreign developers

- Rent-Seeking
  - Might require bribes to obtain access to drill
  - Subsidize oil prices for preferential trade partners
  - Support ineffective or corrupt management

Perhaps the most prominent difference between the oil market and more competitive markets is the existence of a cartel.

What is a Cartel?

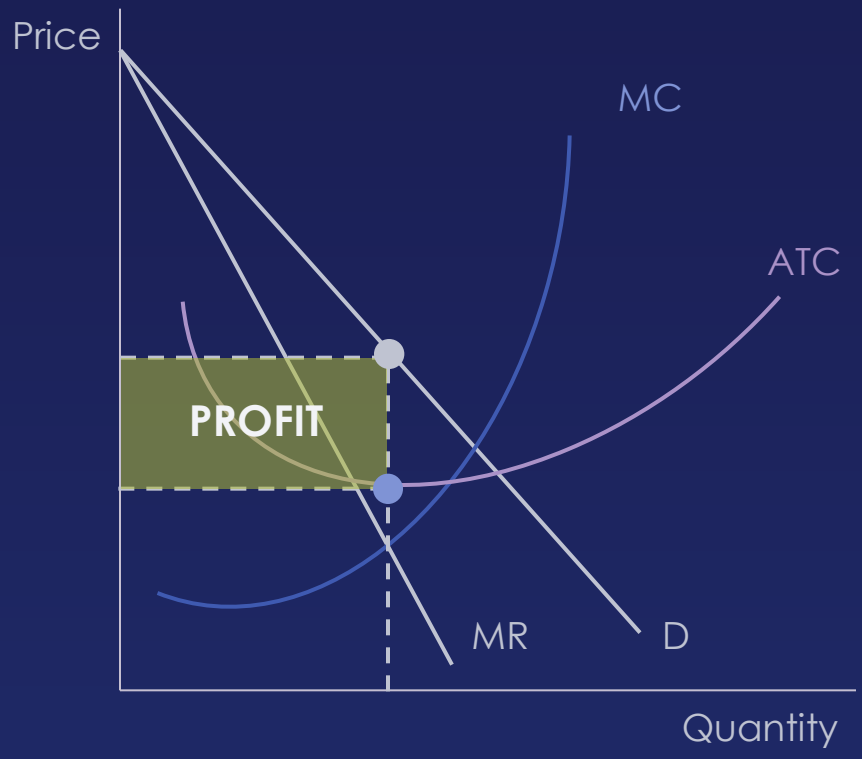
A cartel is a formal agreement between firms to fix prices and production. Members may agree to fix prices, restrict output, or allocate market shares. The goal of a cartel is to increase members' profits by reducing competition.

Conditions for Cartel

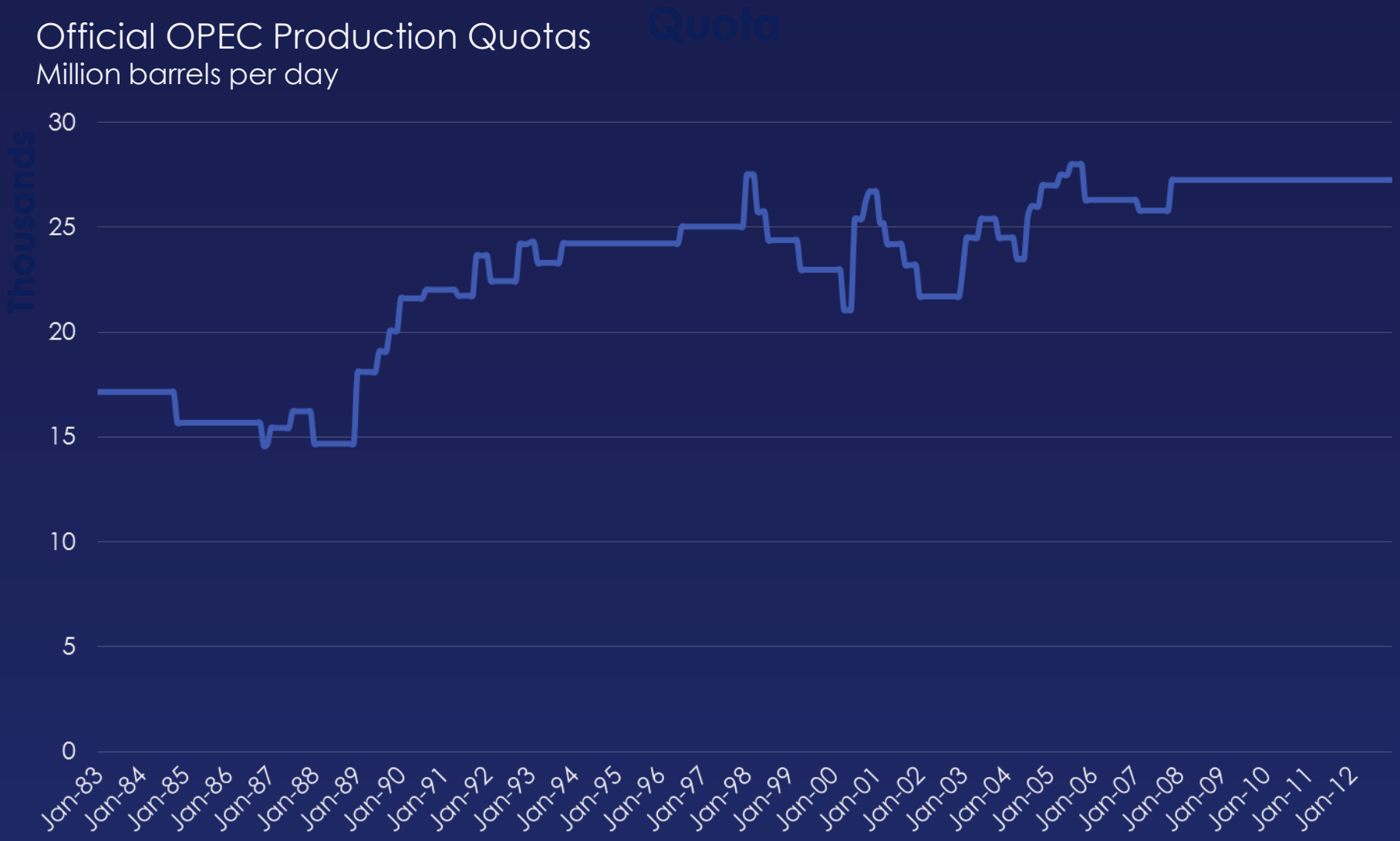
- Homogenous products
- Inelastic demand
- High barriers to entry in an industry:
  - Control of scarce resources
  - Increasing returns to scale
  - Technological superiority
  - Government-created barriers

Outcome of Cartel Price Fixing

Prices are fixed above the point where marginal revenue = marginal cost



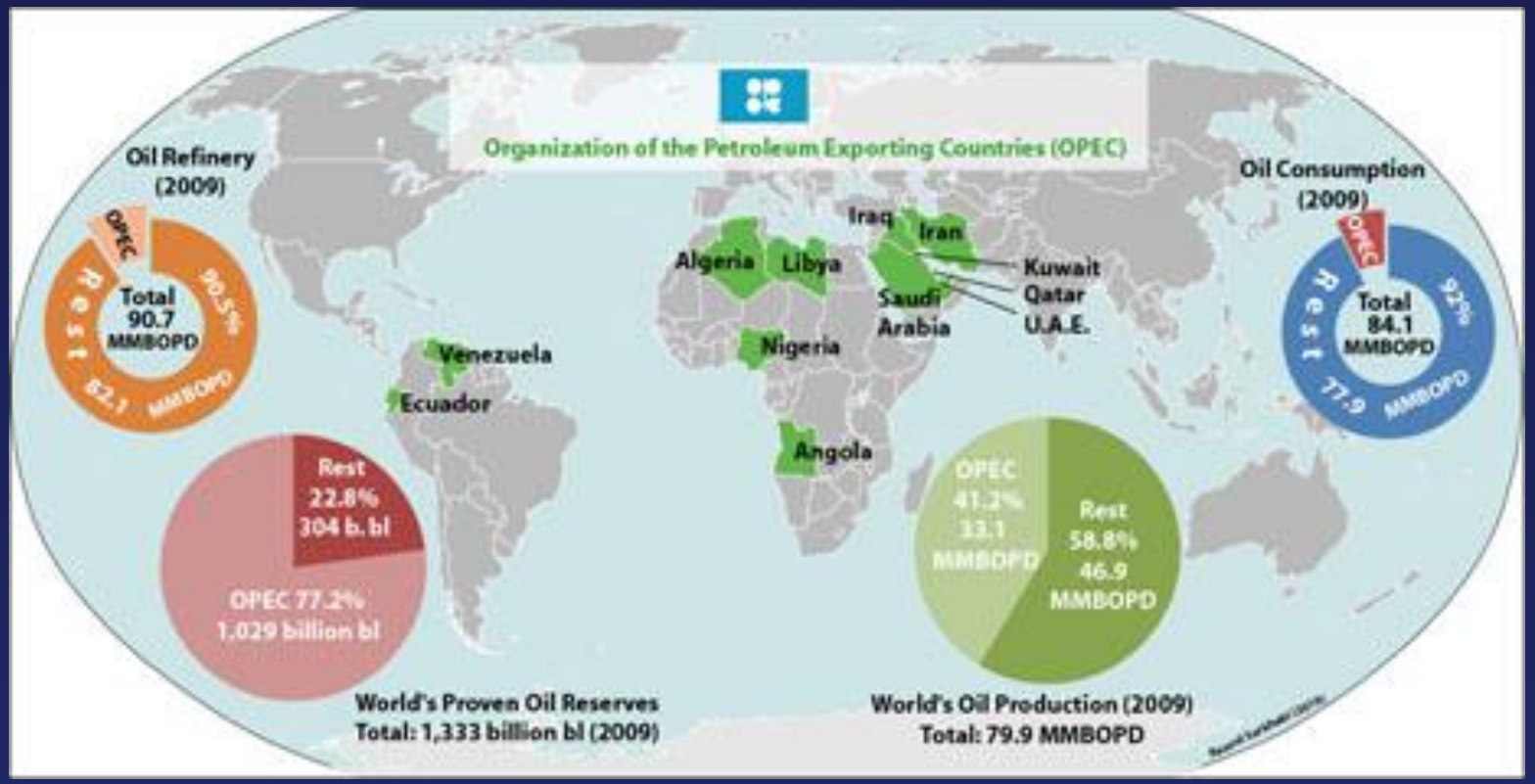
Since the 1980s, OPEC has set target prices and constrained production.



Source: OPEC

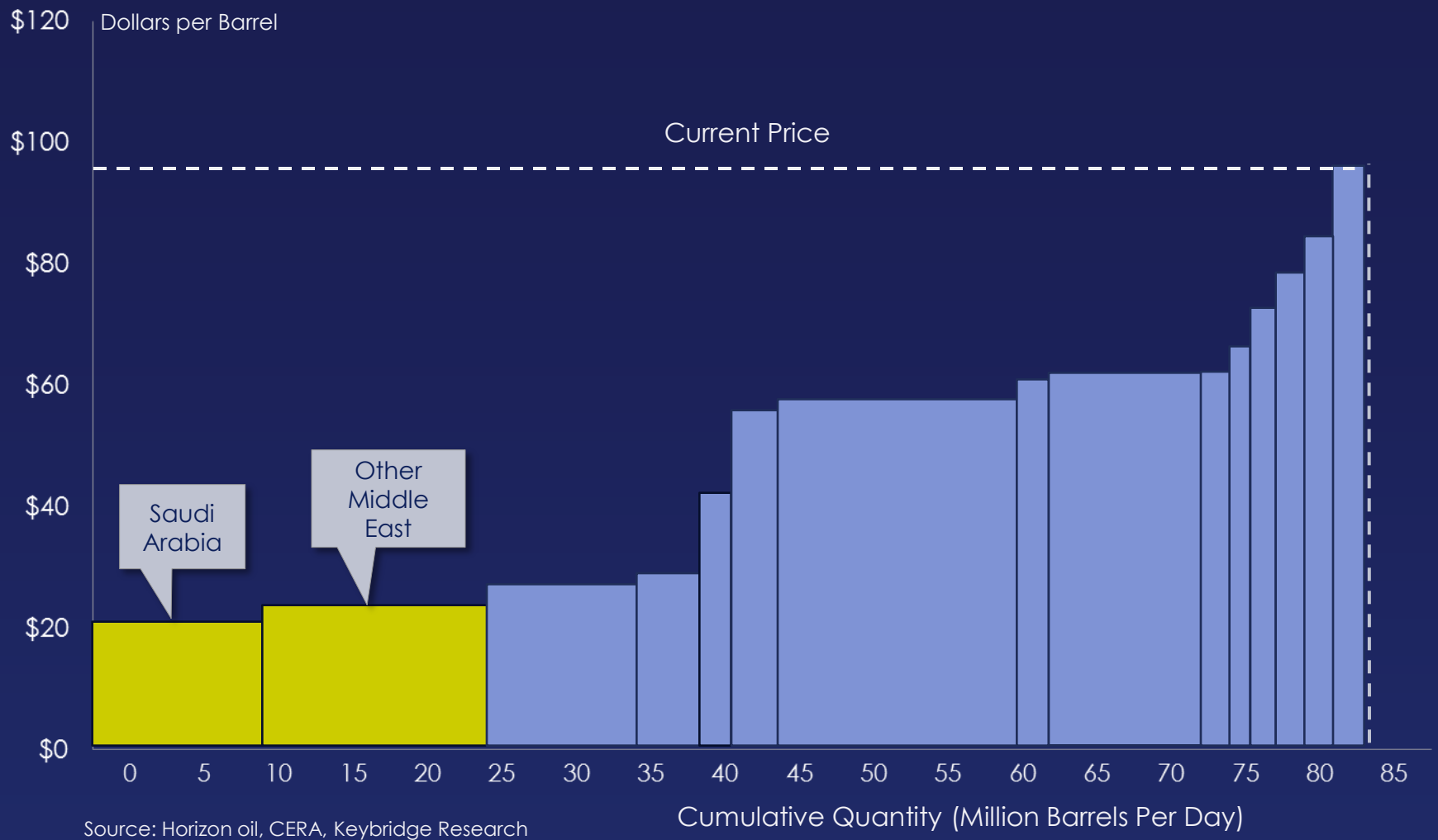
The source of OPEC's power? That fact that 77% of proven oil reserves are in OPEC countries.

Share of Global Recoverable Oil Reserves



OPEC countries control most oil reserves with the lowest marginal costs, providing them enormous pricing power.

Global Marginal Cost of Oil Production (as of 2009)

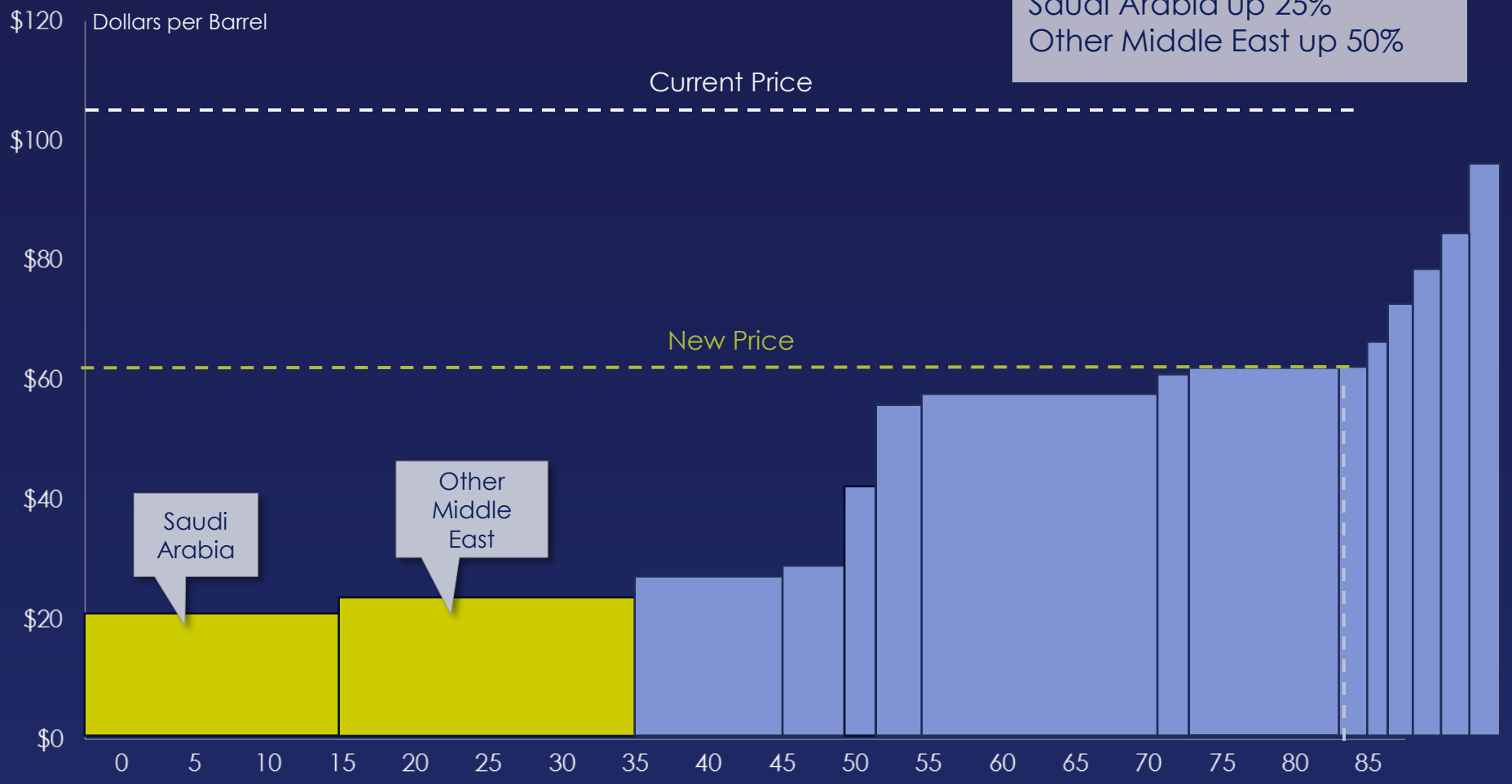


Source: Horizon oil, CERA, Keybridge Research

If several of the major OPEC countries were to increase production of their low cost oil, it could dramatically lower prices.

Global Marginal Cost of Oil Production (as of 2009)

Scenario:
Saudi Arabia up 25%
Other Middle East up 50%

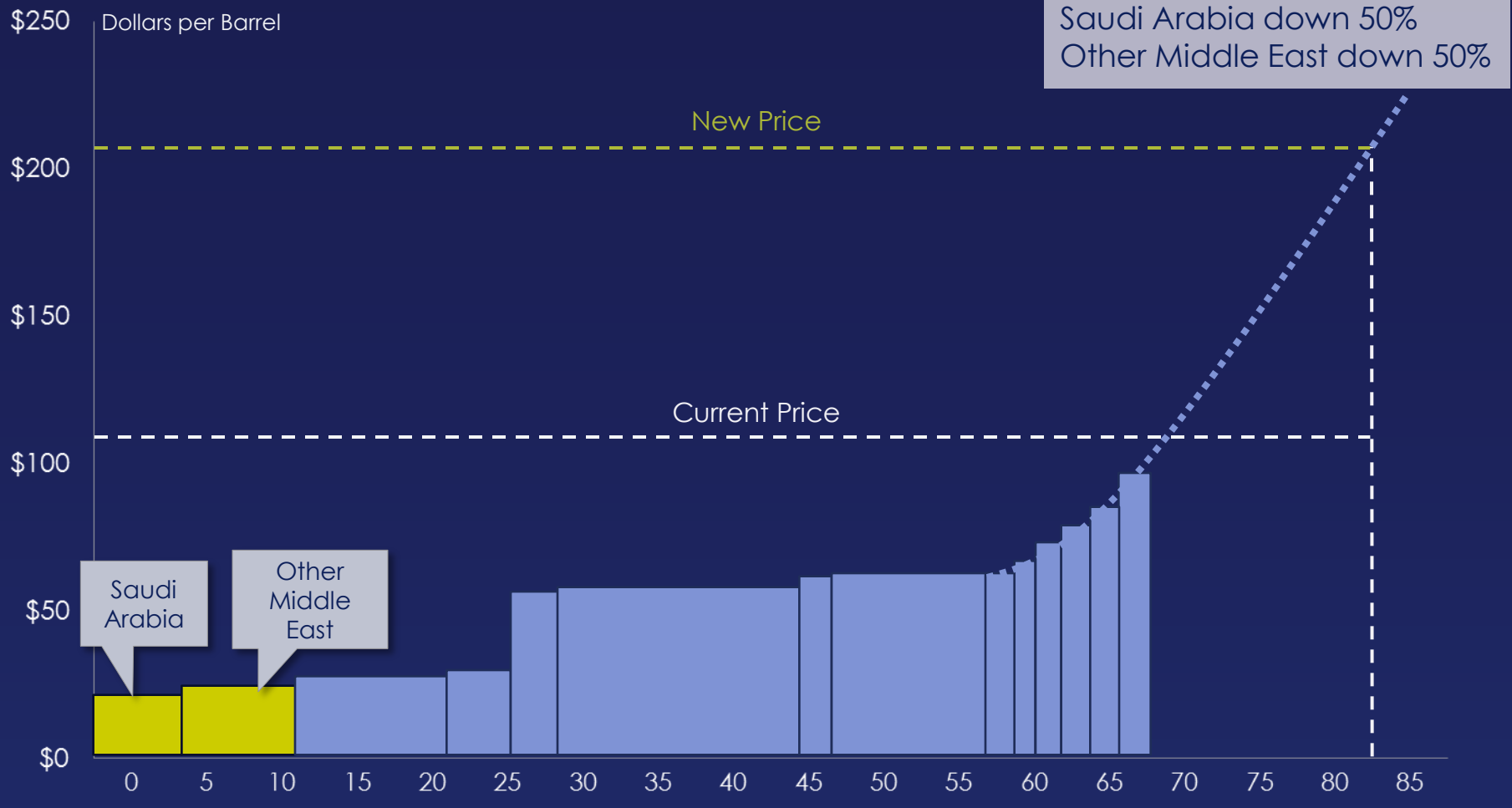


Source: Horizon oil, CERA, Keybridge Research

Similarly, if OPEC producers cut production, other producers would be forced to pump oil with higher marginal production costs.

Global Marginal Cost of Oil Production (as of 2009)

Scenario:
Saudi Arabia down 50%
Other Middle East down 50%

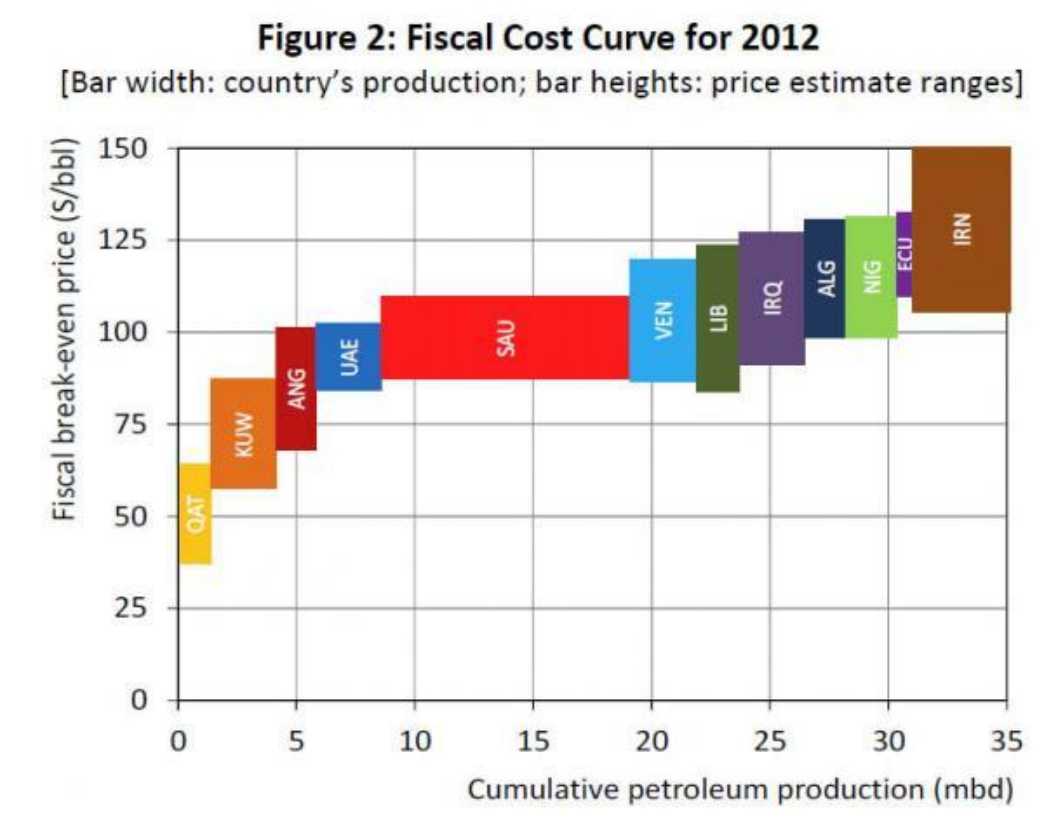


Source: Horizon oil, CERA, Keybridge Research

There are multiple factors that OPEC countries consider when setting target oil prices.

#1: Paying for Government Programs (i.e., the social safety net)

OPEC "Breakeven" Oil Price and Oil Production by Country
Dollars per Barrel, Million Barrels per Day



Source: APICORP Research (August-September 2012). "Fiscal Break-Even Prices Revisited: What More Could they Tell us About OPEC Policy Intent?"

But even OPEC can overplay its hand. There are economic rules that it should not violate when setting target oil prices.

#2: Profit Maximization (from von Stackelberg (1952))

$$P_{max} = \frac{C}{1+\left[\frac{1}{\beta}\sigma(\mu+1)\right]}$$

C = competitive market price

β = price elasticity of demand

σ = market share

μ = price responsiveness of competitors

Source: Greene (2013). "OPEC and the Costs to the U.S. Economy of Oil Dependence: 1970-2010).

Middle of the road oil price demand and supply elasticity parameters allow one to sketch out theoretical supply conditions.

World Oil Demand		
	High Value	**Low Value**
Long-run price elasticity	-0.6	-0.45
Short-run price elasticity	-0.09	-0.068

Non-OPEC Oil Supply		
	High Value	**Low Value**
Long-run price elasticity	0.5	0.4
Short-run price elasticity	0.125	0.08

Source: Greene (2013). "OPEC and the Costs to the U.S. Economy of Oil Dependence."

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	High Value	**Low Value**
Long-run price elasticity	0.5	0.4
Short-run price elasticity	0.125	0.08

Why is the price elasticity of demand for oil so low??????
Hint: the average car is on the road for 16 years!

Source: Greene (2013). "OPEC and the Costs to the U.S. Economy of Oil Dependence."

OPEC's pricing in the 1990s was sustainable long term. Oil pricing today pushes against the limits of short-run pricing levels.

OPEC Cartel Market Share and World Oil Prices

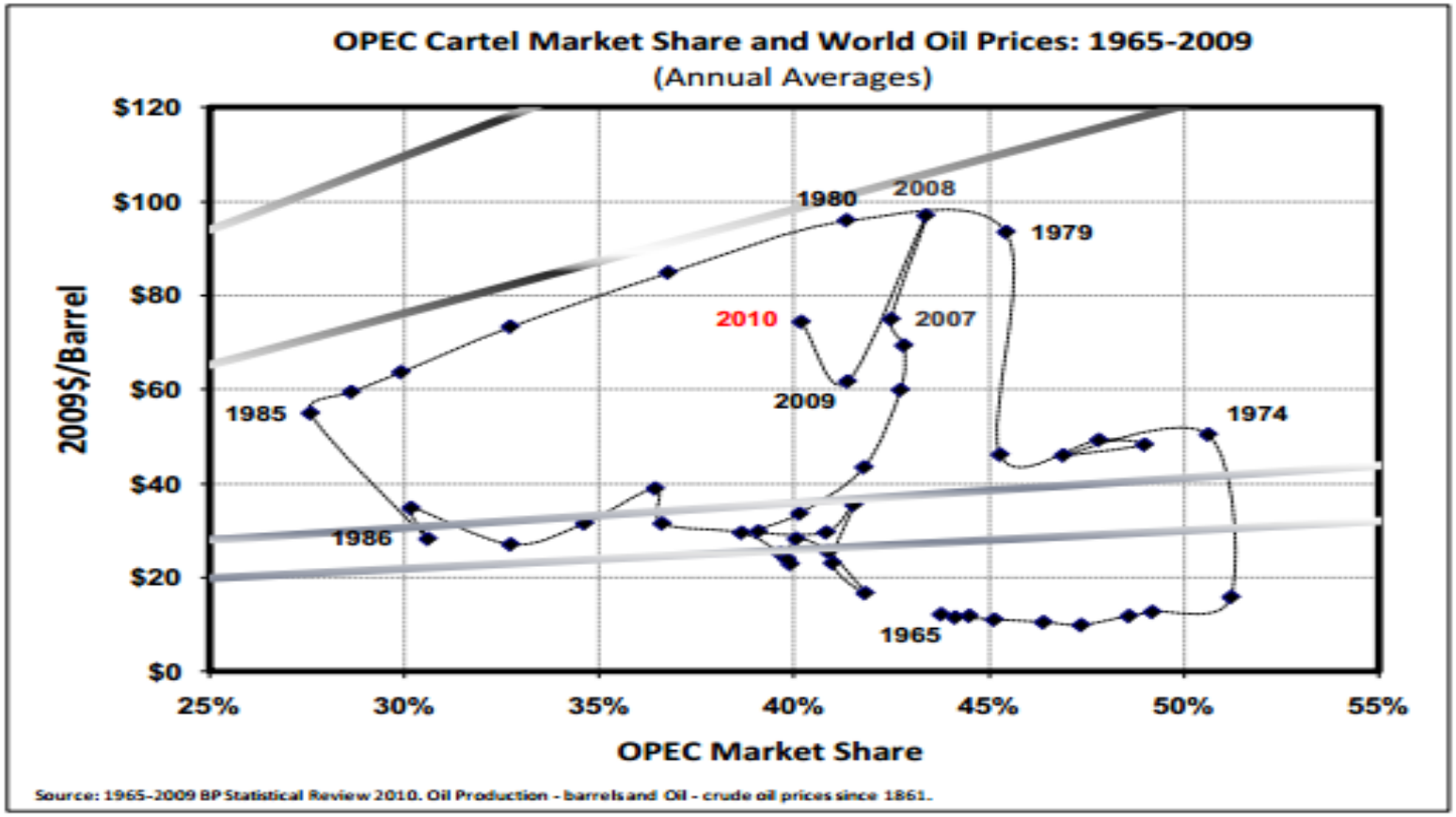

Figure 2. OPEC Cartel Market Share and World Oil Prices: 1965-2010.

Source: Greene (2013). "OPEC and the Costs to the U.S. Economy of Oil Dependence: 1970-2010).

Key lessons from von Stackelberg for OPEC and oil producers in general:

If you overcharge consistently for your oil, what will happen?

Key lessons from von Stackelberg for OPEC and oil producers in general:

If you overcharge consistently for your oil:

- You may cause a global recession and hurt demand for your oil
- You may lose market share
- You may encourage technical innovation to replace your oil
- You may encourage consumer governments to shift policies, impose an import fee on your oil, etc.

Key lessons from von Stackelberg for OPEC and oil producers in general:

If you want to maximize your revenue over a number of years, it could be a good idea to:

Key lessons from von Stackelberg for OPEC and oil producers in general:

If you want to maximize your revenue over a number of years, you should:

- Exploit the low short-run price elasticity for oil
- Have variable prices—high most years, but low some other years to de-validate investments by IOCs, alternative energy suppliers, EV makers, technology companies, etc.
- Pay attention when your consumers make investments in more efficient or non-oil capital goods (cars, power plants, etc.)

Will oil prices rise or fall in the next 10 years? The 1980 wager between Paul Ehrlich and Julian Simon.

The Bet:

- $1,000
- Choose 5 minerals (Ehrlich chose copper, tin, nickel, chromium, and tungsten.)
- Choose any 10-year window.

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Malthusians:

- Supplies fixed as population increases
- Resulting scarcity drives up prices

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- Choose any 10-year window. (Ehrlich chose 1980-1990)

Malthusians:

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Cornucopians:

- Scarcity drives up prices,
- Demand falls, supply increases
- Technology advances to solve the problem,
- After a lag, prices fall

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Cornucopians:

- Scarcity drives up prices,
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- Technology advances to solve the problem,
- After a lag, prices fall

The Outcome:

- Simon won easily. The prices of all 5 minerals dropped.

On the supply side, oil – and other natural resources – differs from normal goods in that it is an exhaustible resource.

Hubbert's Peak (1956)

Billions of Barrels per Day

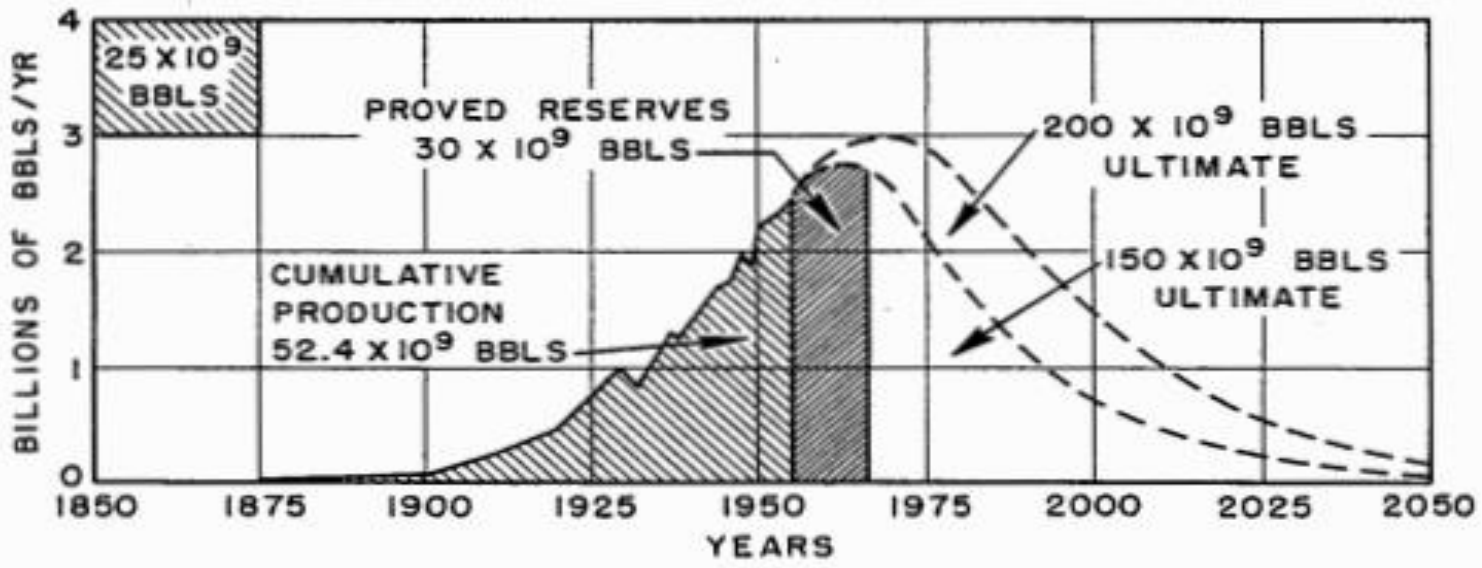


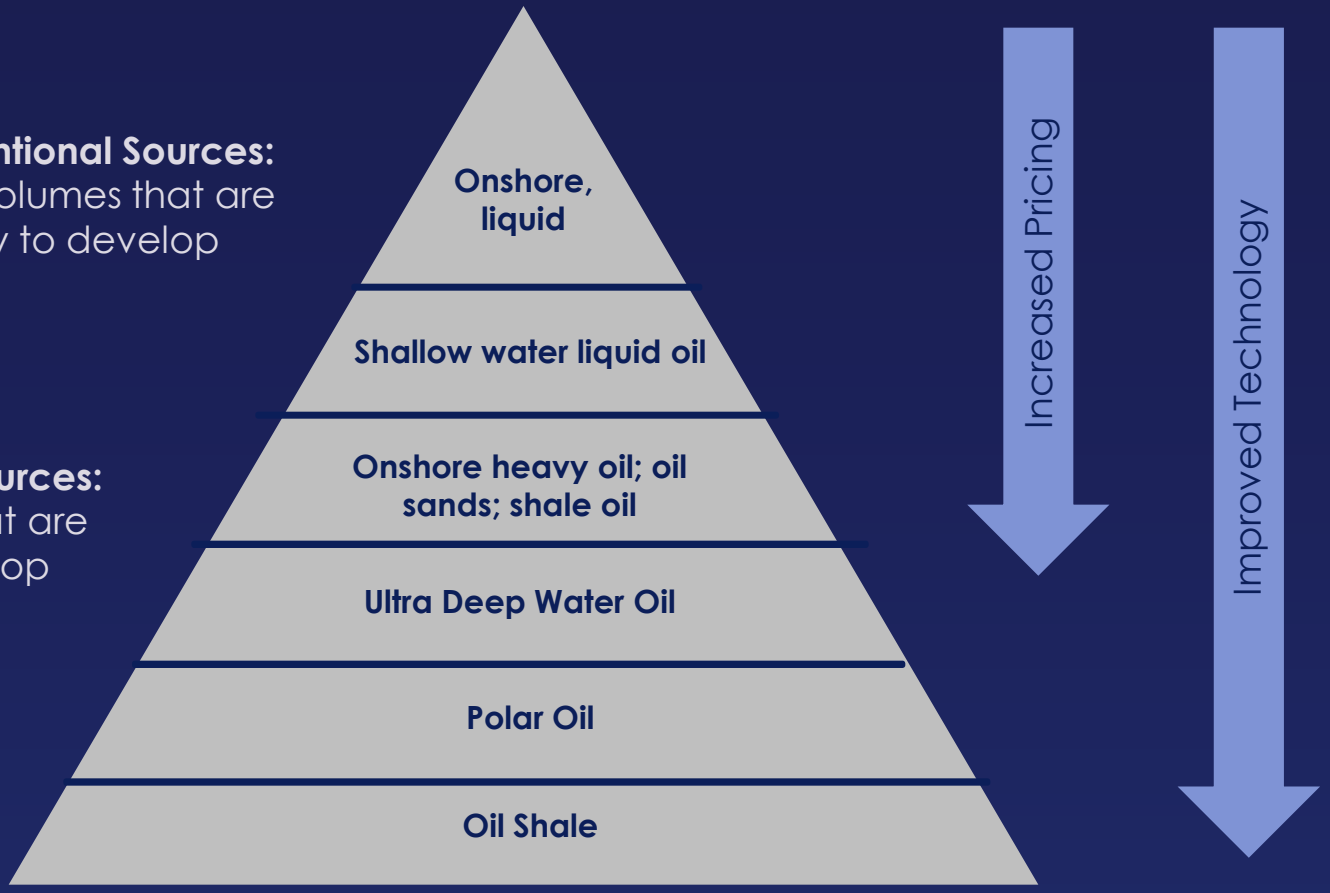
Figure 21 – Ultimate United States crude-oil production based on assumed initial reserves of 150 and 200 billion barrels.

Source: M. King Hubbert (1956). "Nuclear Energy and Fossil Fuels." Figure 21.

As conventional resources get depleted, new technologies are helping producers reach previously inaccessible resources.

Conventional Sources:
Small volumes that are easy to develop

Unconventional Sources:
Large volumes that are difficult to develop

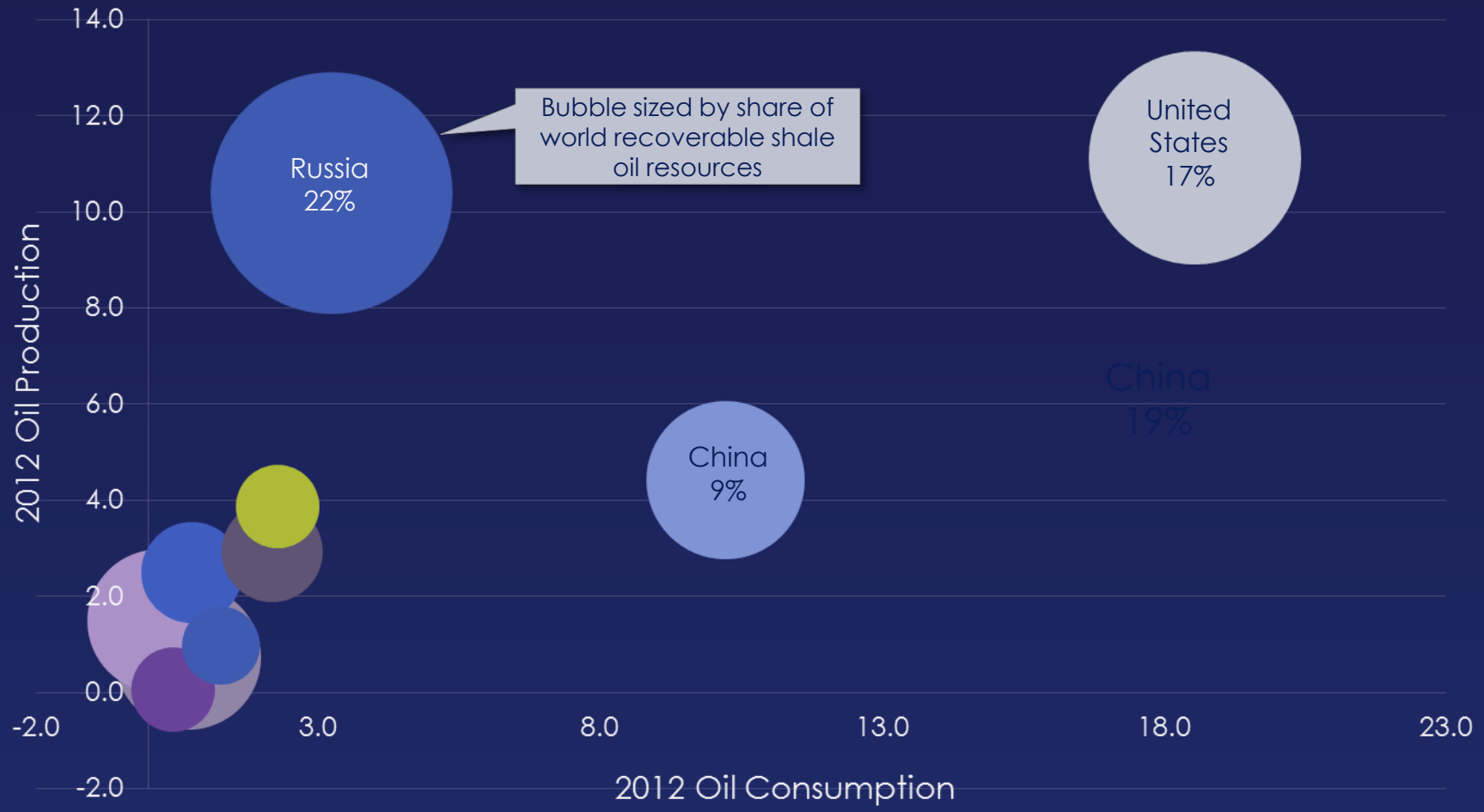


Source: Adapted from Gail Tvberg, Blog, Our Finite World

Shale oil in particular, could become a valuable source of production for some of the largest oil consumers.

Crude Oil Production and Consumption, Share of Recoverable Shale Oil

Thousand Barrels Per Day

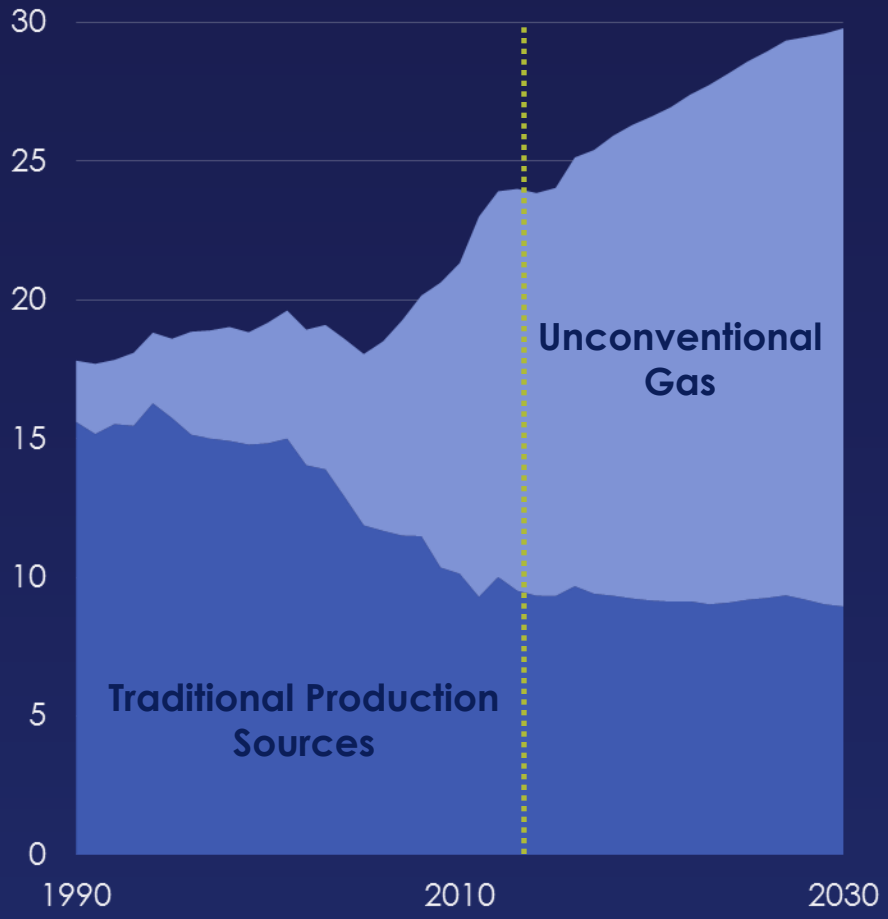


Source: EIA international Energy Statistics; IEA Assessment of Technically Recoverable Shale Oil and Gas Resources .

For example, U.S. shale gas and oil are greatly changing the U.S. production story.

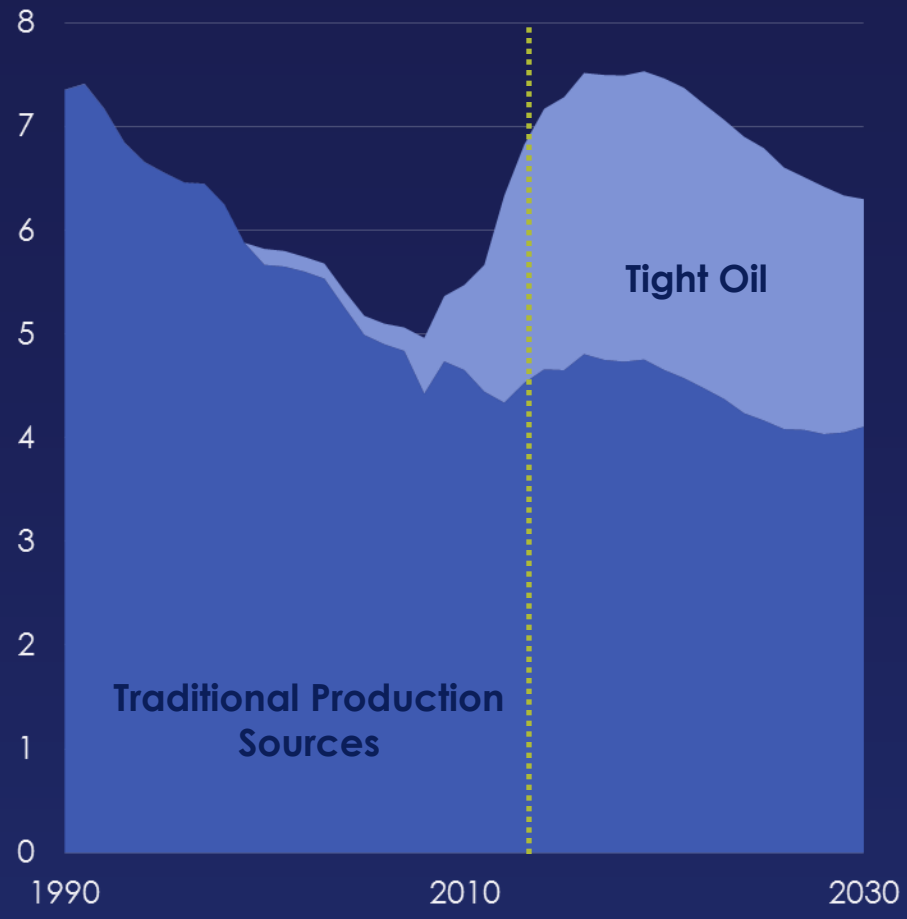
U.S. Dry Natural Gas Production

Trillion Cubic Feet



U.S. Domestic Crude Oil Production

Million Barrels Per Day



Note: Unconventional gas includes both tight and shale gas

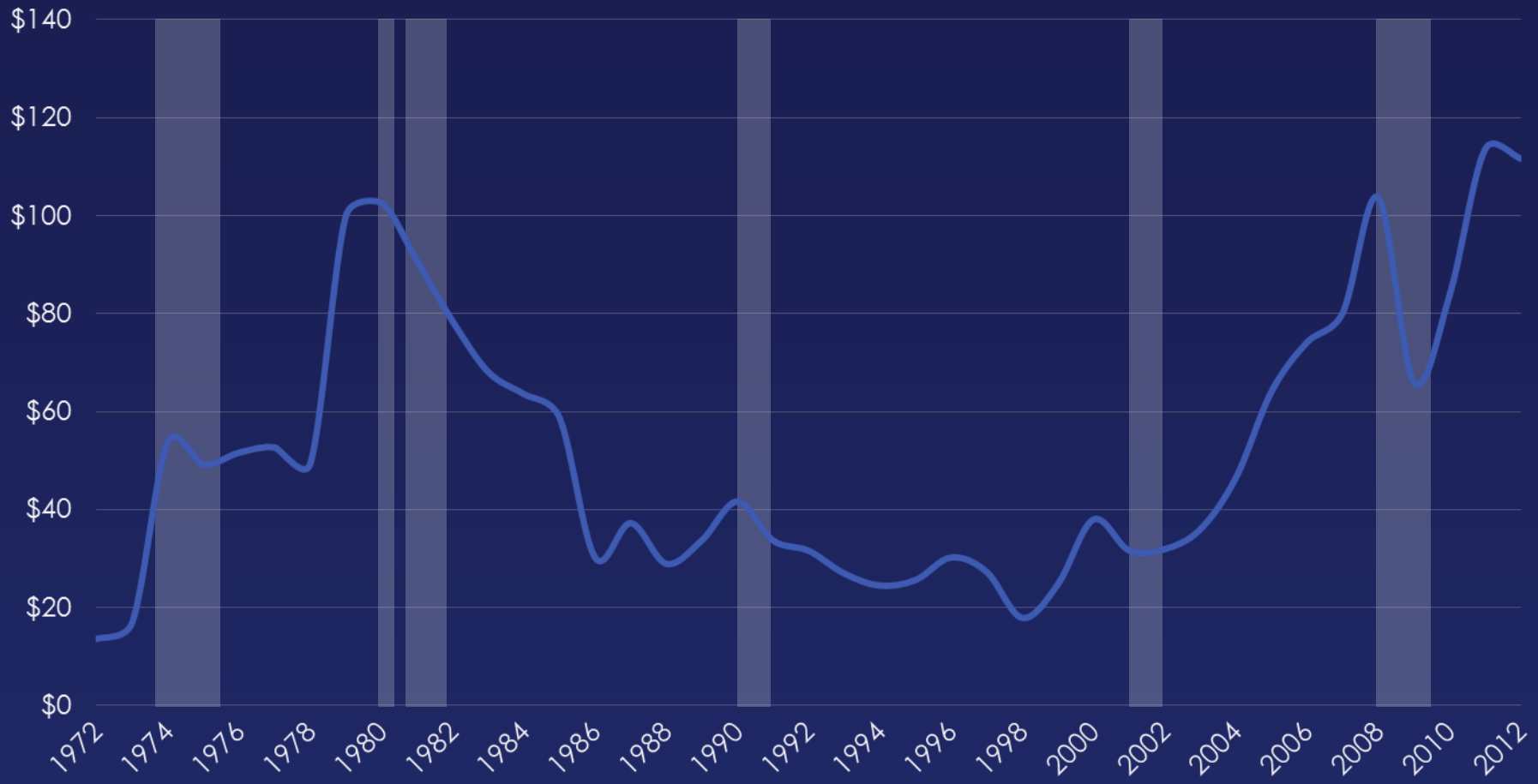
Source: Energy Information Association, "Annual Energy Outlook 2013 Early Release," Figure 3, Figure 1

V. How Do Oil Price Swings Affect a Macroeconomy?

There is a powerful link between spiking oil prices and global recessions, although the relationship is imperfect.

Average Crude Oil Price and NBER Recessions

Dollars per Barrel (2011 Dollars)



Source: BP Statistical Review of World Energy (2013); NBER Cycles

There are four main channels through which high oil prices affect a macroeconomy:

Demand Effects

- *High oil prices reduce real income growth*
- *More spending for fuel means less income for other forms of consumption*

Supply Effects

- *Rising energy costs eat into business profits if they cannot be passed on*
- *Energy-intensive sectors, like airlines, may cancel flights, layoff workers, or cancel orders for new planes*

Policy Effects

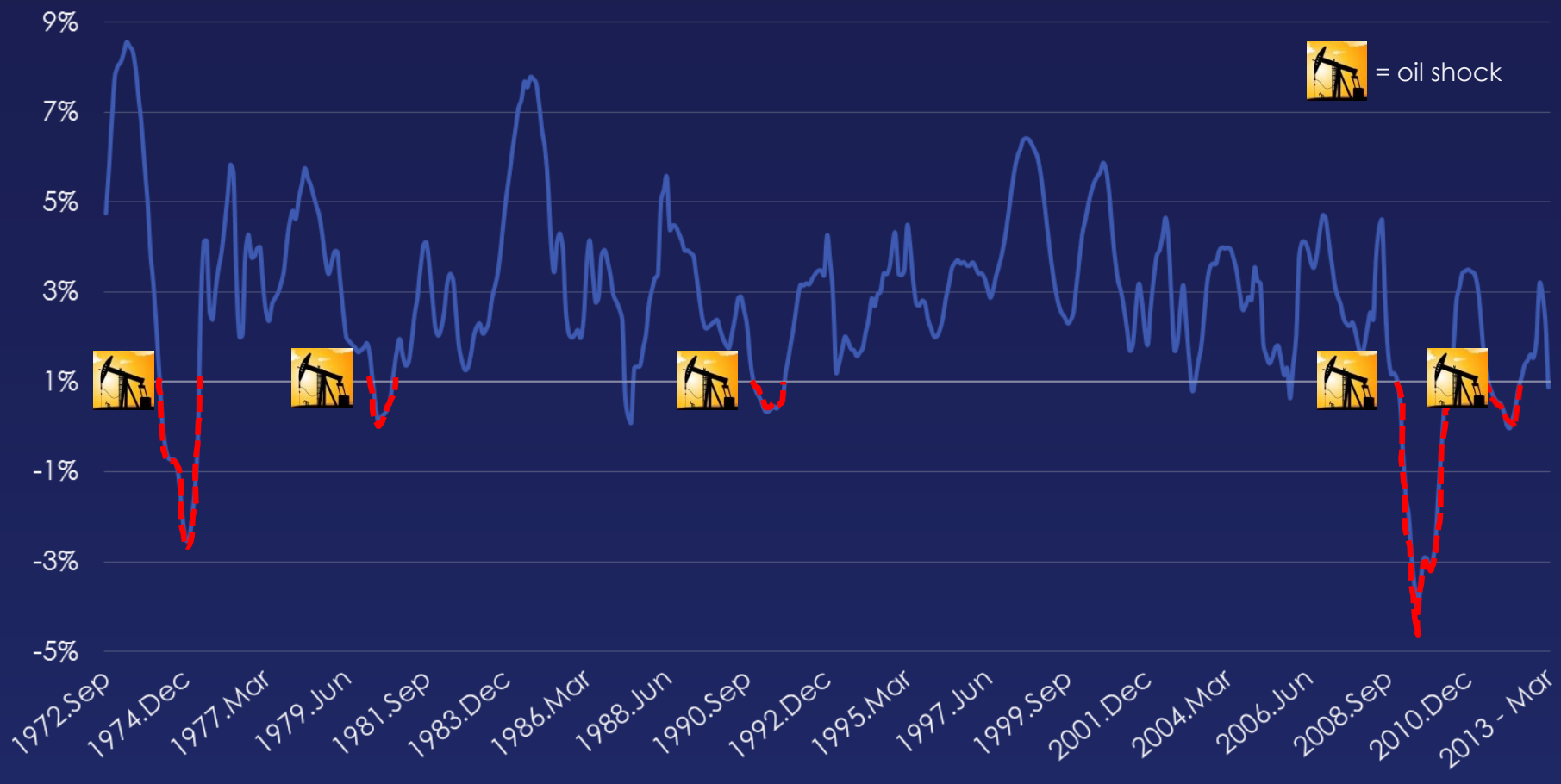
- *Although central bankers may emphasize core inflation more than headline inflation, higher inflation may spark fears of a price-wage spiral and cause monetary tightening*
- *This could weaken housing, investment spending, and car sales*

Effects on Confidence & Markets

- *Higher oil prices hurt both consumer and investor confidence*
- *As equity prices decline, household wealth effects turn negative*

High oil prices depress real income in oil importing countries. U.S. real disposable income has virtually never fallen below 1% growth for 3 consecutive months, except after oil shocks.

Year-on-Year Change in U.S. Real Disposable Income
3 Month Moving Average

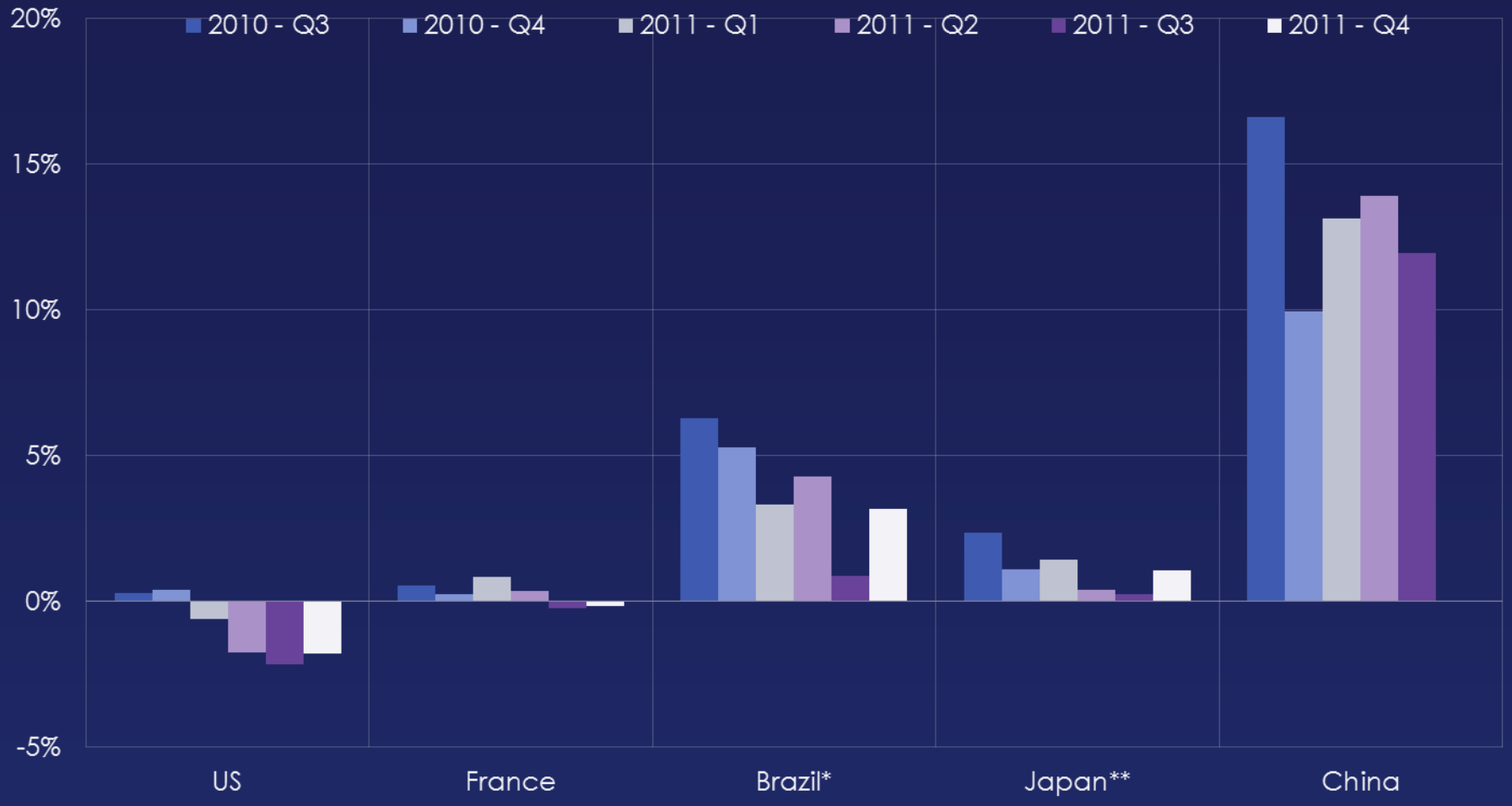


Note: an oil price shock is defined as any period in which oil prices increased: 1) by 70% or more, or 2) by $40 a barrel or more, each within a 10-month window

Source: Bureau of Economic Analysis

This is a global effect: after "Arab Spring," high oil prices depressed wages in oil importing countries around the world.

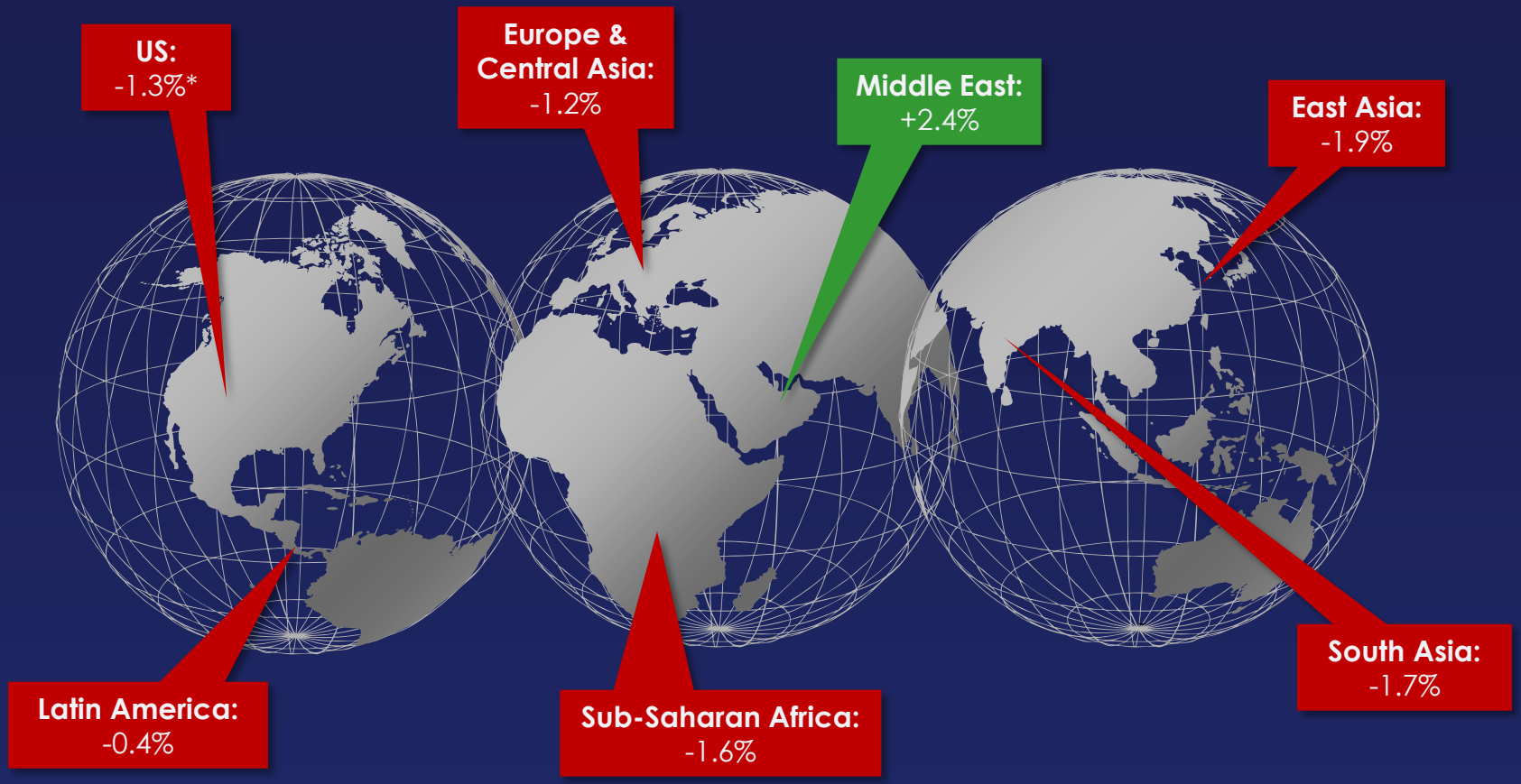
Year-on-Year Change in Real Wages & Salaries



Sources: US Bureau of Labor Statistics; Statistical Office of the European Communities (France); OECD (Brazil & Japan); China National Bureau of Statistics. *Brazil data uses real earnings. **Japan data uses real private sector earnings.

In fact, the effect of higher oil prices is fairly uniform around the world—except of course for oil producers.

Peak GDP Effects of a $50 Increase in the Price of Oil



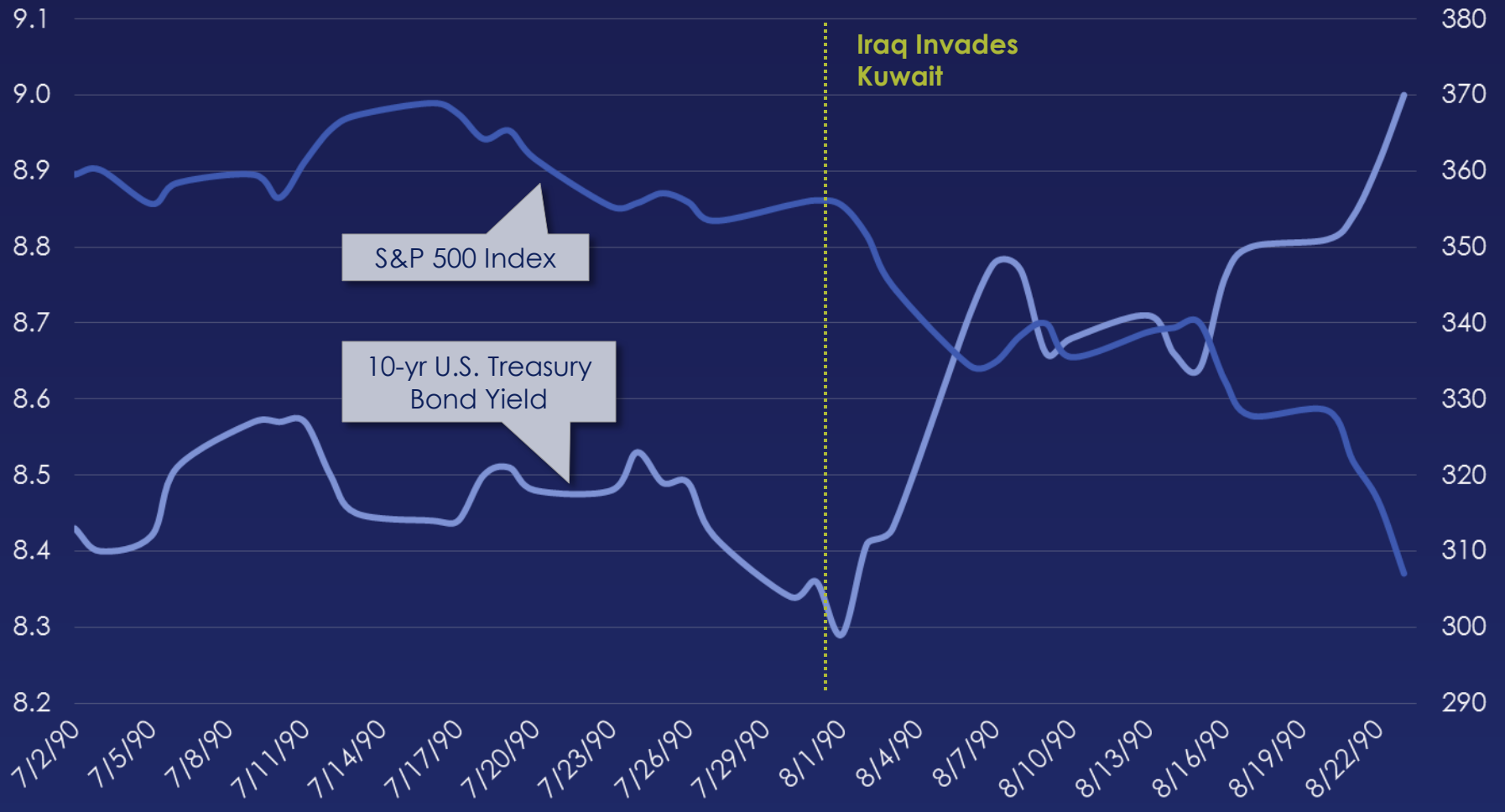
*Author's estimates

Source: World Bank simulations (June 2011). "GDP impact of oil price shock." All regional figures assume oil-importing countries, except the Middle East figure, which represents oil-exporting countries.

There are also negative market psychology effects.

Interest Rate and Stock Market Response to Iraq's 1990 Invasion of Kuwait

U.S. 10-yr Treasury Bond Yield, S&P 500 Index



Source: U.S. Treasury Department; Yahoo Finance

The powerful inter-linkages among world events, oil prices, and market psychology continues even to today.

FT JUNE 15, 2013

Oil prices rise on fears over broader Middle East conflict

rging market also regained r strength fol- falls earlier in th many inves- ng caution that narket assets if the Fed l liquidity. of emerging l banks took the week to urrencies fol- p losses. l 0.8 per cent lian rupee to s58 following y India's cen- the rupee hit . The dollar er cent lower urkish lira at tervention by ral bank to rency. S currency ger against market cur- 0.8 per cent l to R$2.14 il's central to stem the se 1.3 per South Afri- 8.

encies

COMMODITIES

By Emiko Terazono

Oil prices rallied to a two-month high after Washington's announcement that it would provide arms to Syrian rebel groups raised fears of the conflict spreading to the rest of the Middle East.

The Brent August benchmark jumped 1 per cent yesterday to $106.64 a barrel, the highest level since April 10 as concerns about geopolitical risk came to the fore.

The deeper US involvement in the Syrian crisis widened the geopolitical game, said traders and analysts.

Olivier Jakob, of oil consultancy Petromatrix, said the situation was "not only morphing into a US-Russia proxy war but also into a US-Iran proxy war and nobody knows how this will terminate".

In the short term, the concerns centre on the Syrian conflict spilling over to the wider region.

Israel, for example, is becoming increasingly worried about security of its border in the Golan Heights. This has raised the risk of a pre-emptive strike by Israel and then potential retaliations by Hizbollah or Syria.

Iraq is feeling the impact from Syria with sectarian violence at a five-year high during April and May.

While the direct impact on oil infrastructure has so far been limited, the Kirkuk-Ceyhan export pipeline has already been bombed once in June after four attacks in May.

> Barclays is forecasting crude oil prices to retrace the $111 a barrel level

The decision by President Barack Obama has come as the crude oil markets have been relatively stable amid weak demand growth for oil as well as rising inventory levels.

Brent fluctuated in a narrow band of just less than $3 a barrel this week as the outlook for consumption had masked production declines and project delays, including the potential disruption in Middle East production.

Barclays is forecasting crude oil prices to retrace the $111 a barrel level, taking into account existing supply shortfalls, as well as future unplanned outages caused by continuing geopolitical tensions.

The bank estimates supply shortfalls from Opec to be close to 2m barrels a day – equivalent to the oil imports of Germany.

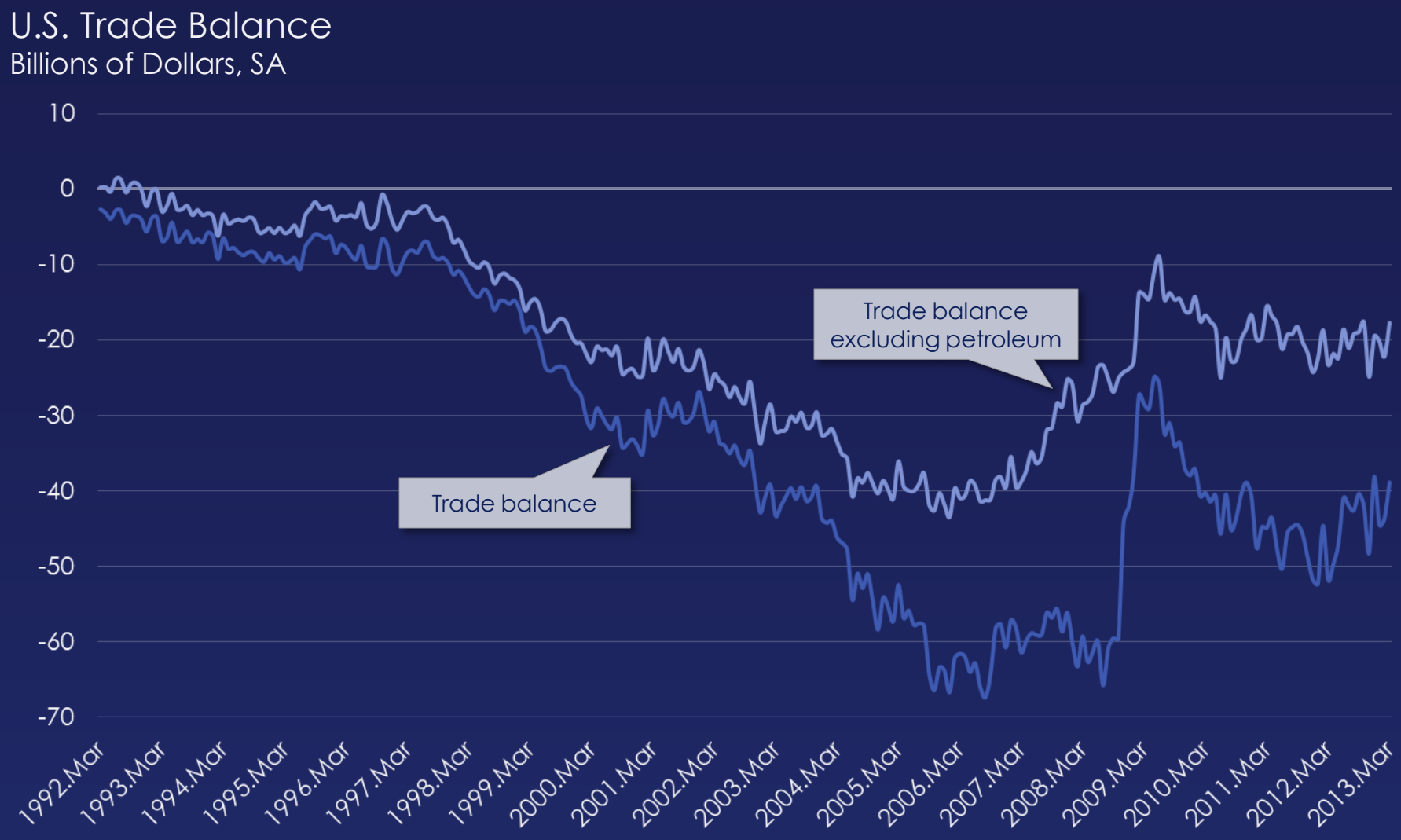
According to the bank's analysis, Libyan oil output has fallen below 1m b/d, due to protests at fields and terminals, while Nigerian oil output remained below 2m b/d, due to oil theft-related damage to pipelines.

Iraqi crude exports continue to be under pressure, due to reduced shipments from the south and north, and Iranian output stands at about 2.7m b/d, 0.9m b/d lower than average levels produced in 2011.

www.ft.com/commodities
Twitter: @ftcommodities

Source: Financial Times

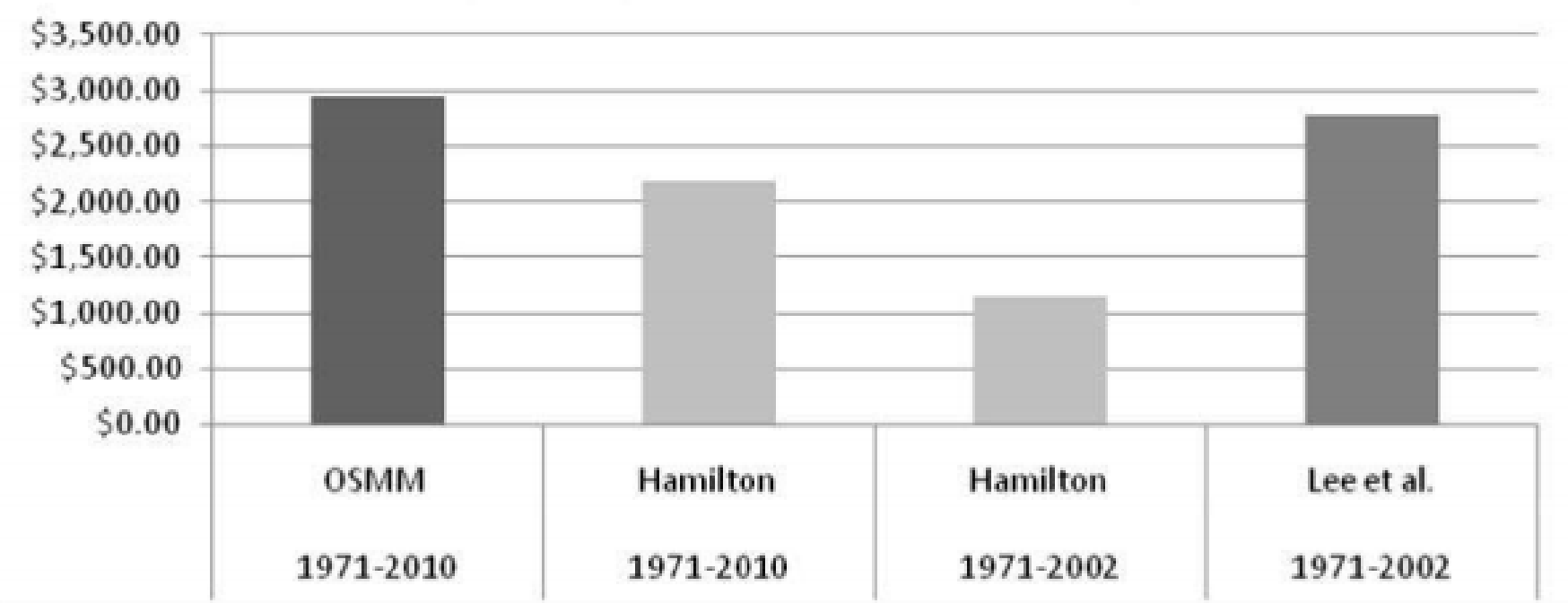
Oil also negatively impacts importing countries' trade balances. More than half of the U.S. trade deficit is due to oil imports.



Source: Census Bureau

Modeling studies estimate that changes in oil prices since OPEC's creation have cost the global economy trillions of dollars.

Comparison of Total Historical Cost Impact of OPEC on the U.S. Economy
Billion Dollars



Source: Greene (2013). "OPEC and the Costs to the U.S. Economy of Oil Dependence: 1970-2010).

However, there can be positive macro effects with new oil and gas discoveries. U.S., manufacturers have recently announced $96 billion in investments to take advantage of the cheap natural gas.

Recent Investment Announcements from the U.S. Manufacturing Sector

Sector	Total Number of Announcements
Chemicals & Fertilizer	67
Steel & Aluminum	18
Tires	4
Plastics	6
Natural Gas to Liquids	3
Glass	1
Transportation	3
Packaging	1

Source: Dow Chemical; Rockwell Automation

Increased domestic energy production and low gas prices are projected to bring many benefits to the U.S. economy.

Higher Growth

By 2020 new production and reduced consumption could lead to a 2.0 to 3.3% increase in real GDP, or $370-$624 billion (in 2005$) respectively.

Increased Employment

A total of 2.7 to 3.6 million net new jobs could be created by 2020, with 600,000 of those in the oil and gas extraction sector and 1.9 million in ancillary sectors.

Improved Trade Balance

The current account deficit—currently 3% of GDP—could be reduced to 1.2 to 2.4% of GDP by 2020.

Higher Industrial Production

Lower natural gas and electric power prices and increased productivity could allow industrial production to be 2.9% higher by 2017; by 2035, 4.7% higher.

Source: Citi, "Energy 2020: North America, the New Middle East?"; IHS Global Insight, "The Economic and Employment Contributions of Shale Gas in the United States"

VI. Policy Options to Protect an Economy from Energy Price Swings

Heavy dependence on foreign oil can negatively affect importing countries. How?

Problems of Heavy Dependence on Foreign Oil

Heavy dependence on foreign oil can negatively affect importing countries. How?

Problems of Heavy Dependence on Foreign Oil

- Cause a recession or higher unemployment
- Dependence on volatile or unfriendly trade partners
- May undermine your foreign policy goals
- Require large expenditures for military/energy security
- Exposure to oil price swings
- Exposure to temporary supply shortages
- Hurts your trade balance
- Greenhouse gas emissions

There are at least four key externalities that stem from heavy dependence on oil.

Greenhouse Gases

In the U.S., transportation activities accounted for 33% of all carbon dioxide emissions from fossil fuel combustion in 2011, with virtually all of this coming from petroleum products.

Defense Budgets

The U.S. Department of Defense spends an estimated $86 - $104 billion per year protecting its shipping lanes for oil in the Persian Gulf.

Foreign Policy Priorities

Dependence on oil can lead to changes in a country's foreign policy priorities, including in China.

Oil Spills

The 2010 Gulf of Mexico oil spill resulted in more than 127 million gallons of crude oil spilling into the Gulf for nearly 90 days, damaging thousands of miles along the coastline.

Source: EIA; Congressional Research Service, "Department of Defense Energy Initiatives: Background and Issues for Congress" (June 2012); The Daily Green

With steadily rising transportation needs, how can the world slow oil demand in future decades? Key pathways include:

With steadily rising transportation needs, how can the world slow oil demand in future decades? Key pathways include:

Alternative Sources of Liquid Fuels

- Corn/Sugar-based biofuels
- Cellulosic-based biofuels
- Biodiesel
- Coal/gas to liquids

Improve Vehicle Efficiency

- Fuel-economy standards
- Hybrids/engine improvements
- Adjust vehicle attributes/preferences.
- Traffic management

Alternative Drivetrains

- Electric vehicles
- Plug-in hybrid vehicles
- Natural gas vehicles
- Hydrogen vehicles

Reduce Vehicle Miles Travelled

- Public transportation
- Carpooling
- Telecommuting
- Bicycles, walking

What policies can governments adopt to encourage adoption of these technologies and strategies?

Taxes

Technology Mandates & Subsidies

R&D Support

Public Infrastructure

What policies can governments adopt to encourage adoption of these technologies and strategies?

Taxes

- Gasoline and Carbon Taxes
- Cap & Trade
- Gas Guzzler Tax
- User Fees (Toll, Congestion Pricing)
- High vehicle registration fees for big cars

Technology Mandates & Subsidies

- CAFE (fuel economy) Standards
- Fuel Mandates
- Tax Credits
- Financing Assistance (Loans and Guarantees)

R&D Support

- Public Research Initiatives (e.g., ARPA-E)
- R&D Tax Credits
- Support for Pilot/Demonstration Projects

Public Infrastructure

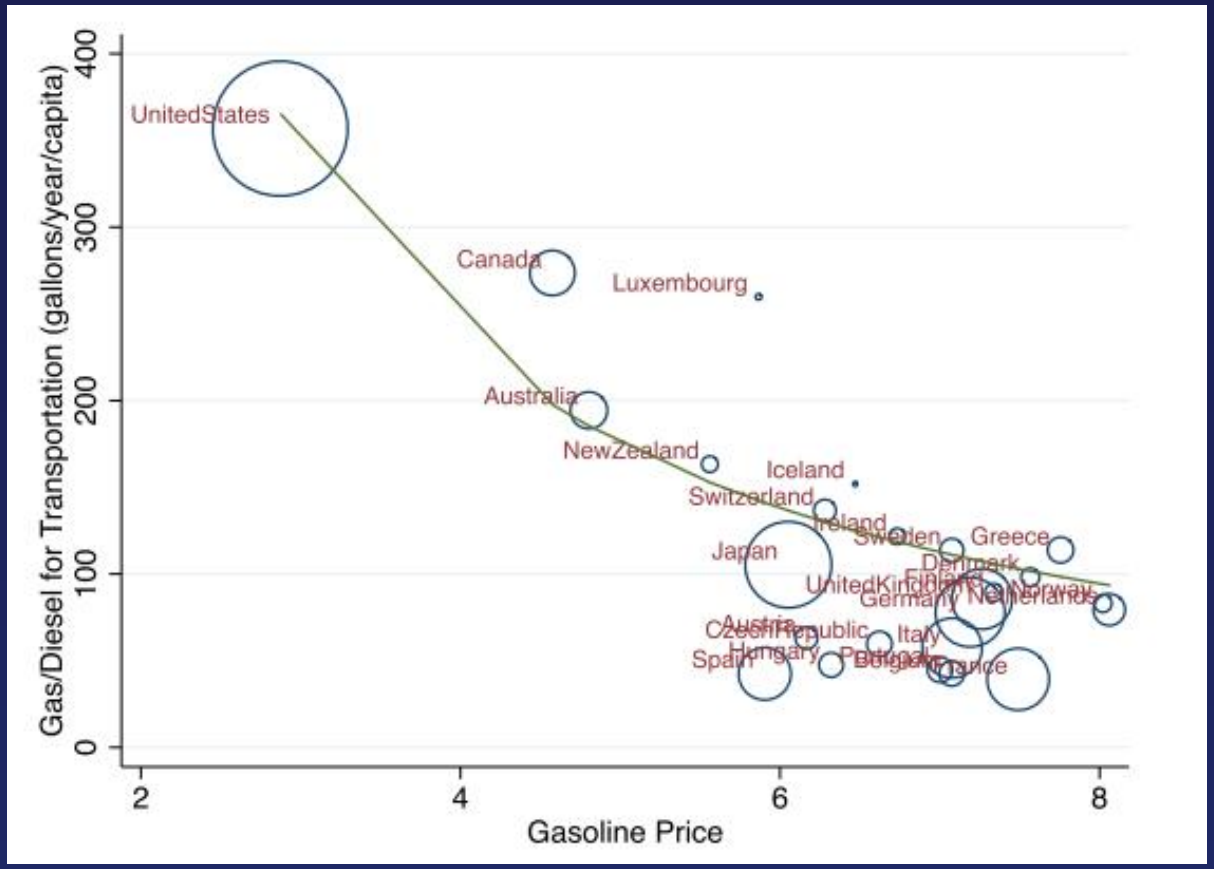
- Public Transit Expansion/Modernization
- Anti-Sprawl Zoning Laws
- Carpool and Bike Lanes
- Smart/Hybrid Infrastructure
- Alternative Fuel Infrastructure

Source: Presidio.gov; Urbanrail.net; Bidrmanev.com

Gasoline consumption per capita does tend to decline as price increases

Transportation Fuel Consumer per Capita Versus Fuel Price

Gallons per Year per Capita, Dollars



Source: Knittel (December 2011). "Reducing Petroleum Consumption from Transportation."

Policy Option: Motor Fuel Tax

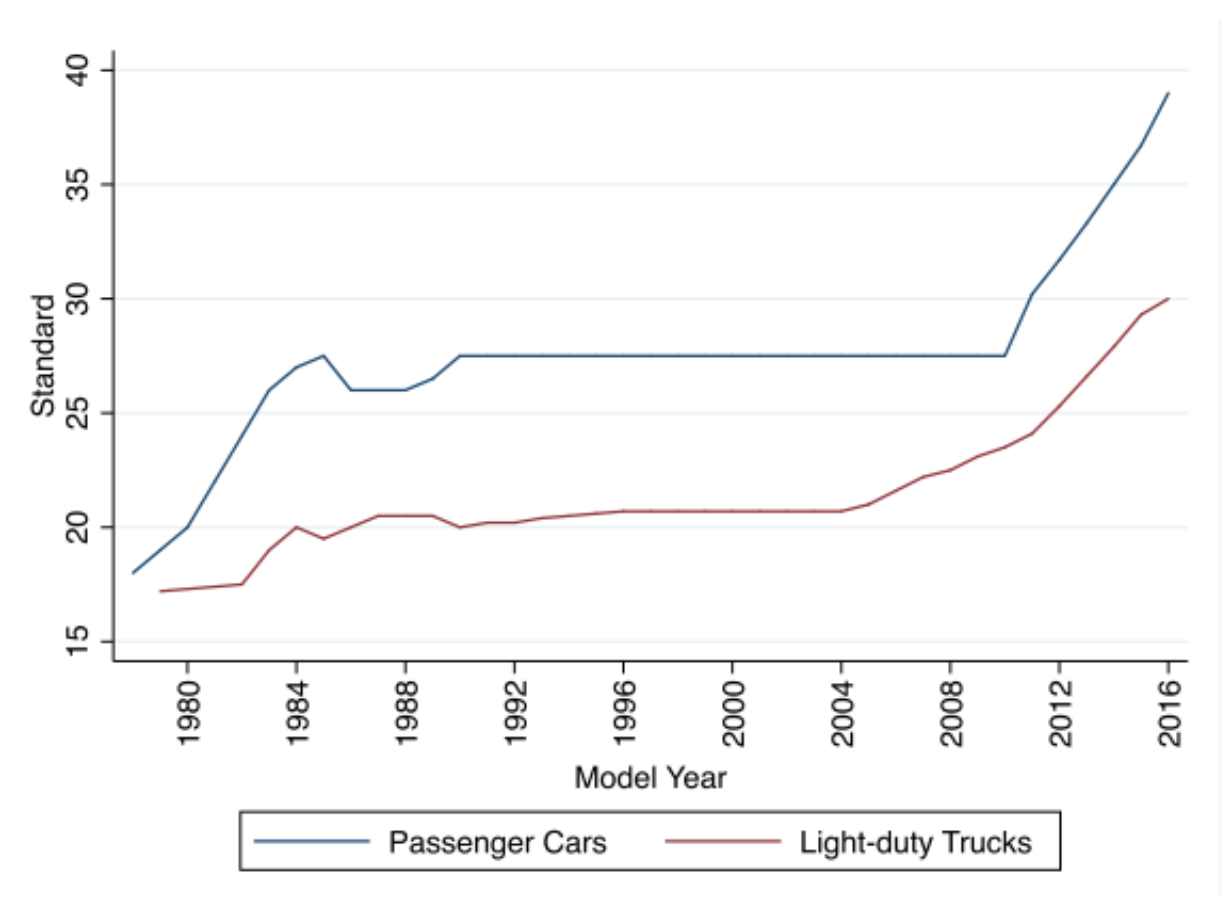
2010 Motor Fuel Taxes for OECD Category 1 Countries
Dollars per Gallon

Country	Gasoline	Diesel
US	$0.49	$0.59
Canada	$0.96	$0.77
New Zealand	$1.20	$0.00
Australia	$1.34	$1.34
Iceland	$2.28	$2.03
Japan	$2.59	$1.55
Korea	$2.64	$1.87
Spain	$2.66	$2.08
Hungary	$2.68	$2.17
Austria	$2.77	$2.18
Luxembrg	$2.90	$1.94
Czech Republic	$3.04	$2.59
Switzerland	$3.09	$3.15
Slovak Republic	$3.23	$2.31
Sweden	$3.24	$2.56
Ireland	$3.41	$2.82
Italy	$3.54	$2.65
Belgium	$3.58	$2.10
Denmark	$3.58	$2.68
Portugal	$3.65	$2.28
France	$3.80	$2.69
Greece	$3.82	$2.39
Norway	$3.87	$2.97
Finland	$3.93	$2.28
UK	$3.95	$3.95
Germany	$4.10	$2.95
Netherlands	$4.19	$2.29

Source: Knittel (December 2011). "Reducing Petroleum Consumption from Transportation."

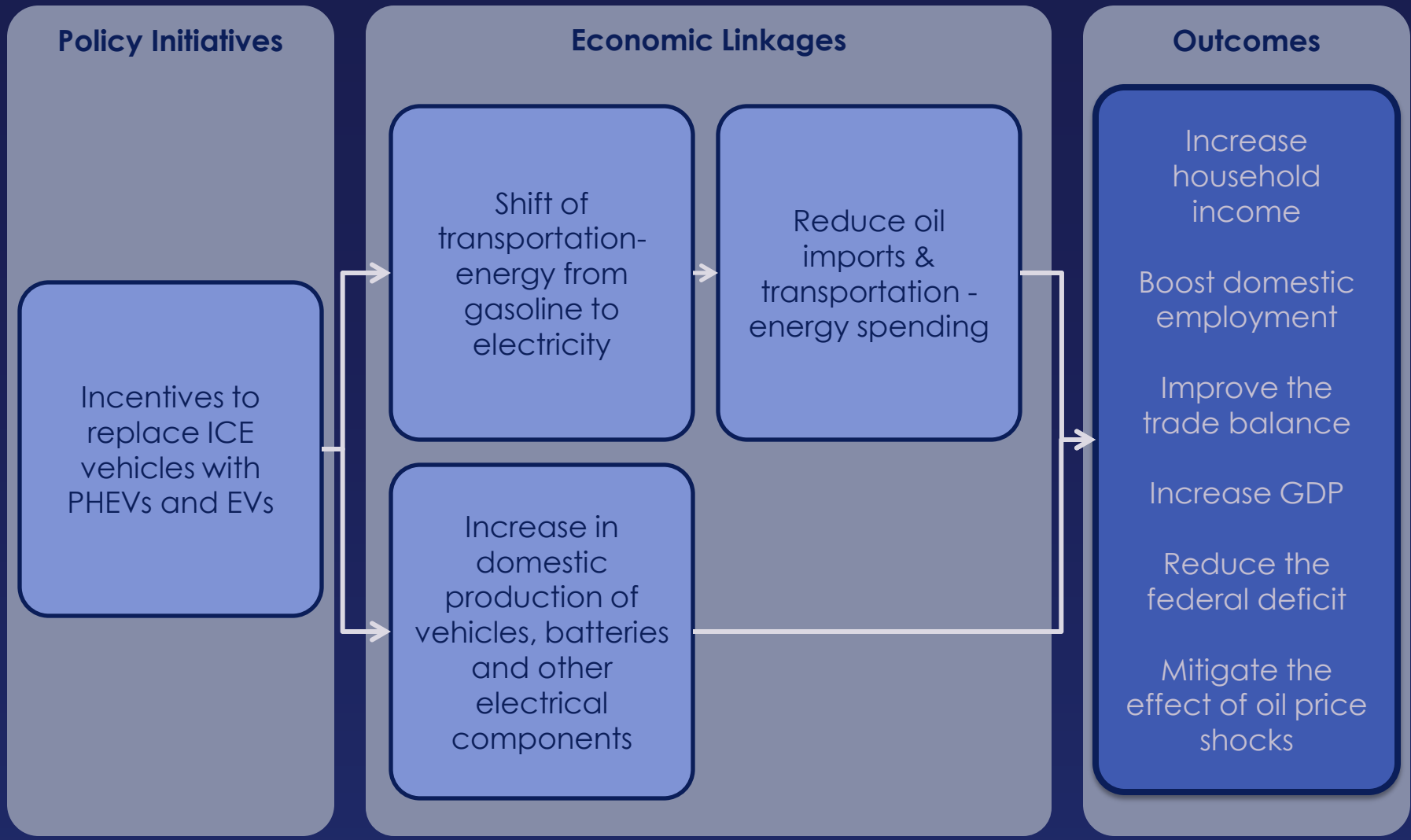
Policy Option: Fuel Economy Standards

CAFE Standards from 1978 to 2016
Miles per Gallon



Source: Knittel (December 2011). "Reducing Petroleum Consumption from Transportation."

In a 2010 study, Werling and Wescott studied how vehicle-electrification policies could affect the U.S. economy.



Source: Keybridge (2010). "Quantifying the Impacts of Electrification of the Transportation Sector." Prepared for SAFE.

The policy proposal included incentives to transform the U.S. transportation sector through the purchase of GEVs.

Grid-Enabled Electric Vehicle Sales and Stock
Percent of Sales or Stock

Scenario	Base Case		EC Policy Scenario	
Year	GEV Sales (share)	GEV Stock (share)	GEV Sales (share)	GEV Stock (share)
2010	0.0%	0.0%	0.0%	0.0%
2015	1.5%	0.1%	4.5%	0.7%
2020	1.6%	0.1%	25.7%	5.3%
2025	2.1%	0.1%	69.9%	20.6%
2030	2.6%	0.2%	91.2%	42.4%

*Grid Enabled Vehicles ("GEV") include plug-in hybrids and electric vehicles.

Source: Keybridge (2010). Quantifying the Impacts of Electrification of the Transportation Sector. Prepared for SAFE.

A key driver of economic change was that lower gasoline consumption would reduce U.S. reliance on oil imports.

Oil Imports
Million Barrels per Day

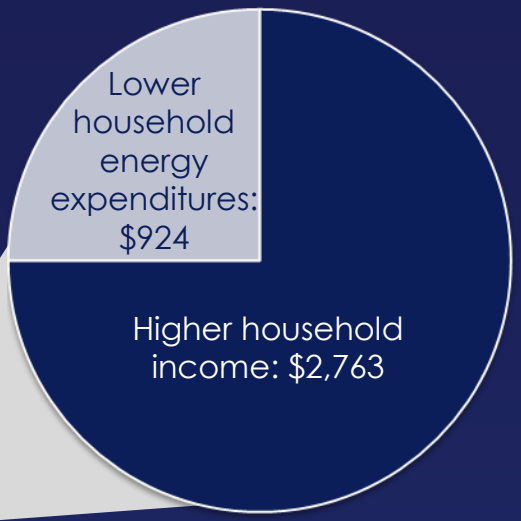
Year	Base Case	EC Policy	Difference
2010	11.9	11.7	-0.2
2015	12.5	11.7	-0.9
2020	12.4	11.0	-1.5
2025	11.8	9.5	-2.2
2030	12.1	8.9	-3.2
Cumulative BBL Oil Reduction, 2010-2030	---	---	**-11,908**

Source: Keybridge (2010). Quantifying the Impacts of Electrification of the Transportation Sector. Prepared for SAFE.

The study found that the average U.S. household would be better off due to rising income and lower energy consumption.

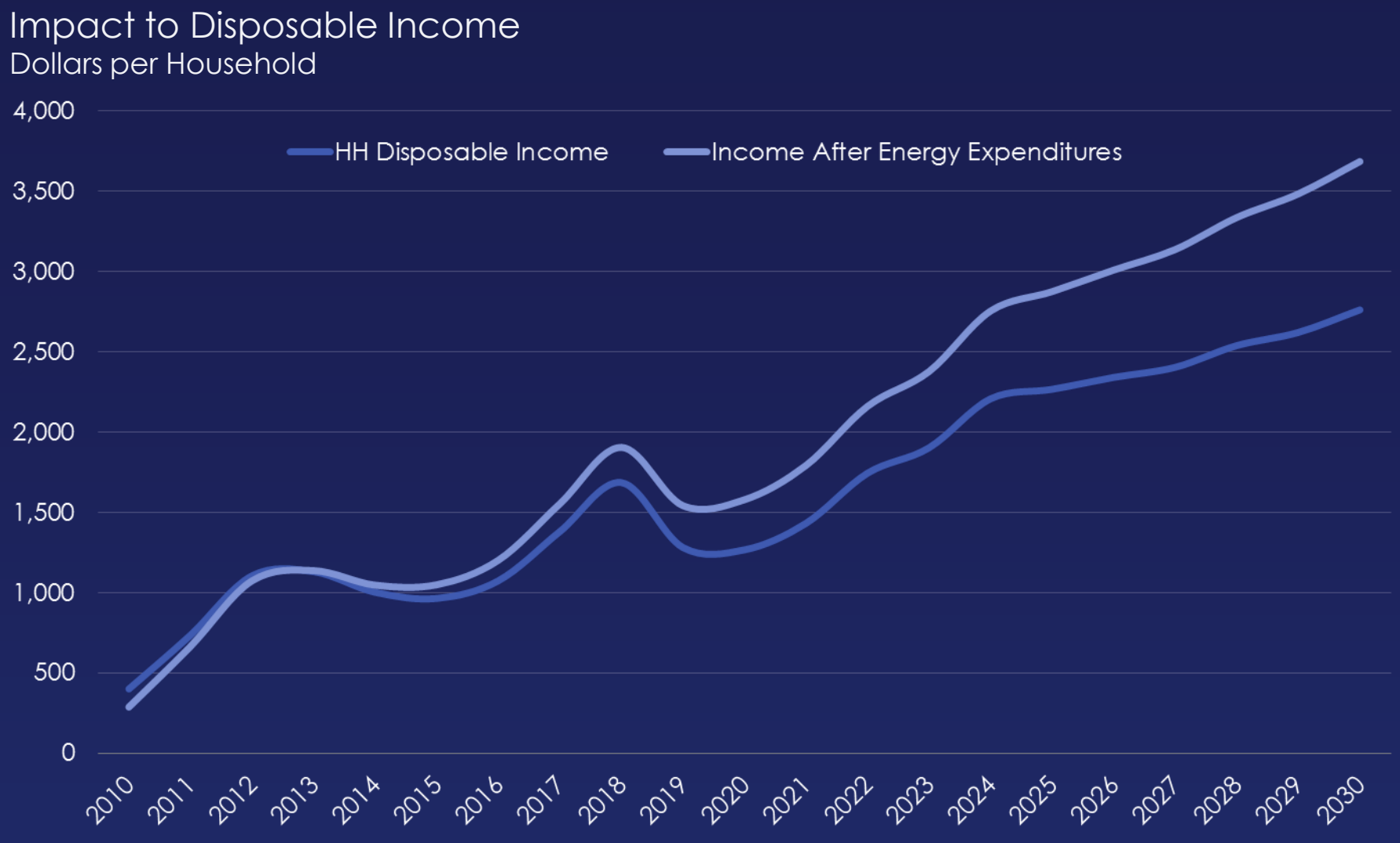
Difference in Disposable Income
Billions

Scenario / YeaECr	Income After Energy Expenditures			
	Base ($ bn)	EC ($ bn)	Total Change ($ bn)	Per Household ($)
2010	$10,253	$10,287	$35	$289
2015	$12,012	$12,144	$131	$1,051
2020	$13,865	$14,071	$206	$1,580
2025	$15,622	$16,014	$393	$2,876
2030	$17,856	$18,383	$527	$3,687



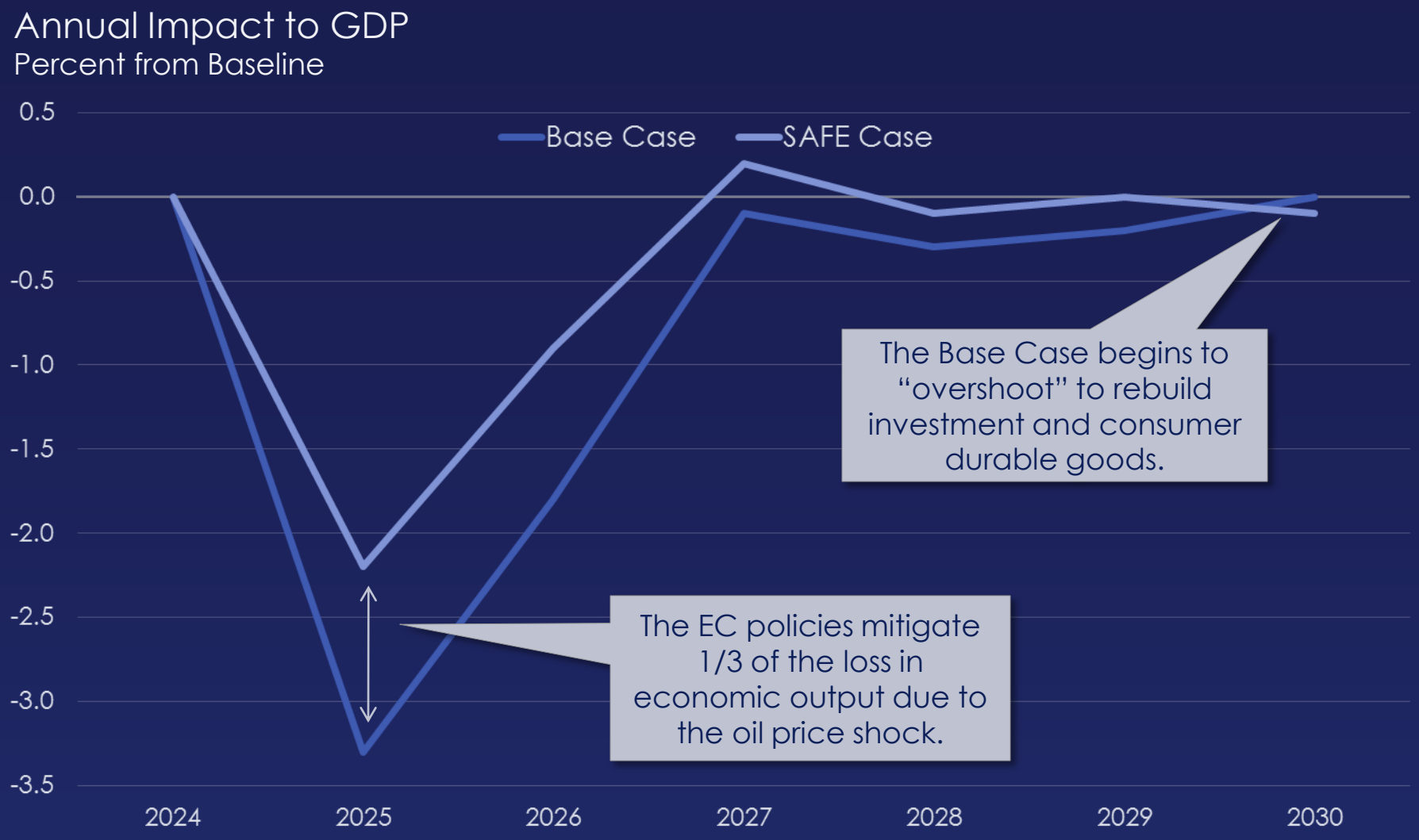
Source: Keybridge (2010). Quantifying the Impacts of Electrification of the Transportation Sector. Prepared for SAFE.

The study found that average household in the U.S. would be better off due to rising income and lower energy consumption.



Source: Keybridge (2010). Quantifying the Impacts of Electrification of the Transportation Sector. Prepared for SAFE.

Furthermore, the study found that EC policies could mitigate roughly one-third of the damage of an oil price shock.



Source: Keybridge (2010). Quantifying the Impacts of Electrification of the Transportation Sector. Prepared for SAFE.

Do we really need to use petroleum to fuel our cars?

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How will it all turn out? Wescott's views on energy shifts between now and 2030:

Oil

- Sharp price decline in next few years to undermine alternatives, unconventionals. Then sharp rebound in prices.
- Gradually rising unconventional production.
- Demand rises until 2020-25, then declines due to electrification of transportation

Gas

- Becomes key bridge fuel to renewables
- Growing use in transportation sector – both gas-to-liquids and CNG
- Low capital costs of gas-fueled electric power assists conversion to renewables

Renewables

- Achieve true "grid parity" by 2016-20
- Suffer temporary setbacks when prices of fossil fuels tumble.

Transportation

- Steady increases in hybridization, with more electric; but gradual, not a single breakthrough; Tesla is a $12 billion company today.
- Widespread electrification by 2020-30

VII. Class Discussion

Questions to ponder…

- What should be the priorities for building energy policy for a modern macroeconomy?
- How much freedom should governments give their citizens in terms of energy use?
- What is the best basis for modifying energy use: carrots or sticks?
- How might behavioral economics be applied to reduce energy usage?
- Do you believe energy will always be a scare commodity in your lifetime?
- Are there other potential paradigm shifts that are likely to occur in the next 30 years that are as profound as the energy paradigm shift?
- If you were the boss of OPEC, how would you price oil for the next 10 years?
- It is now 2025. Oil is at $50 a barrel. What happened? What didn't happen?
- It is now 2025. Oil is at $250 a barrel. What happened? What didn't happen?