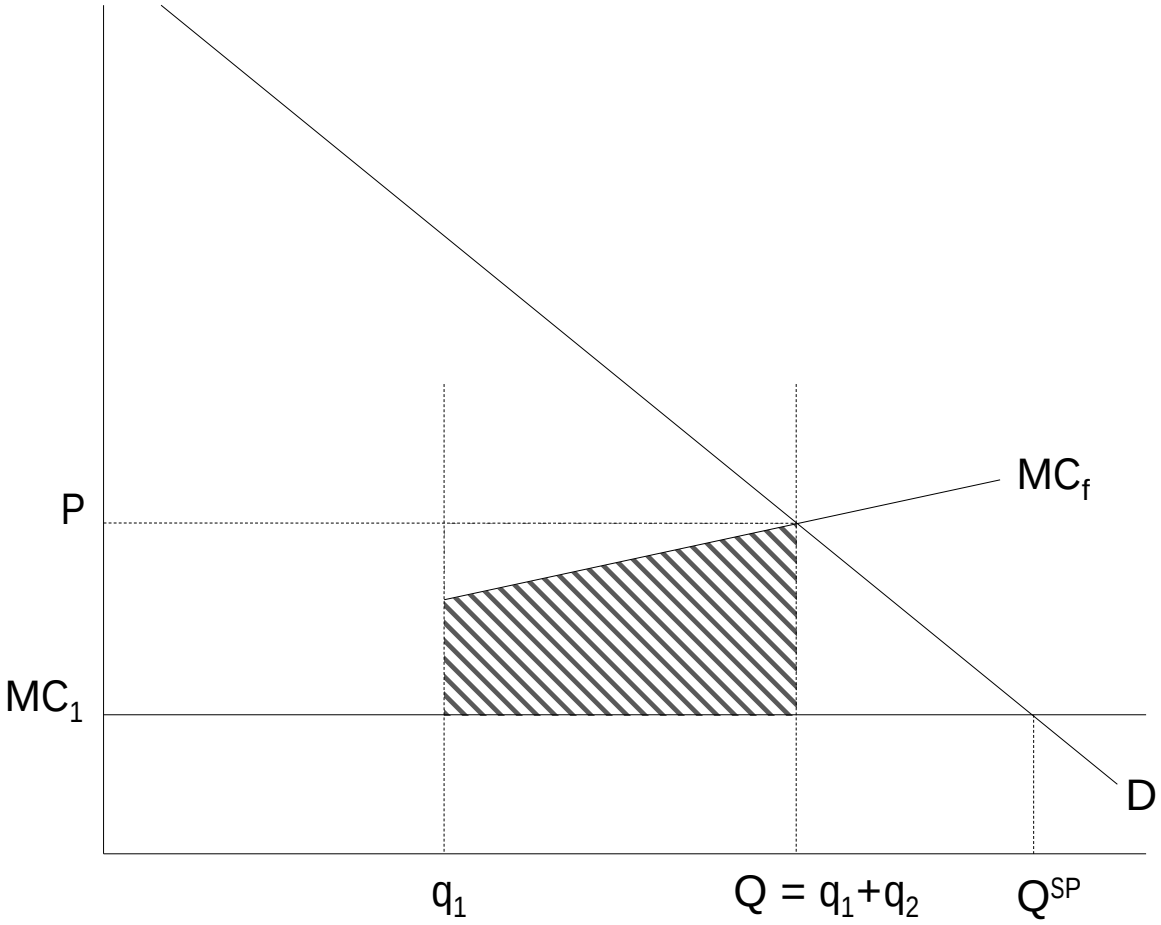
# Motivation

- Research Question: *Impact market power on the misallocation of production?*
- Approach: Data driven examination of upstream oil industry (Extraction and pre-refinery production)
- Why is this interesting?
  - E ect of market power is central to IO.
  - Both cartel activity and unilateral market power.
  - Case of aggregate implications of market power in conte3 0.412 0.643 rg0.333 0.4

# Production Distortion: main approach



# Extending the static (graphical) analysis

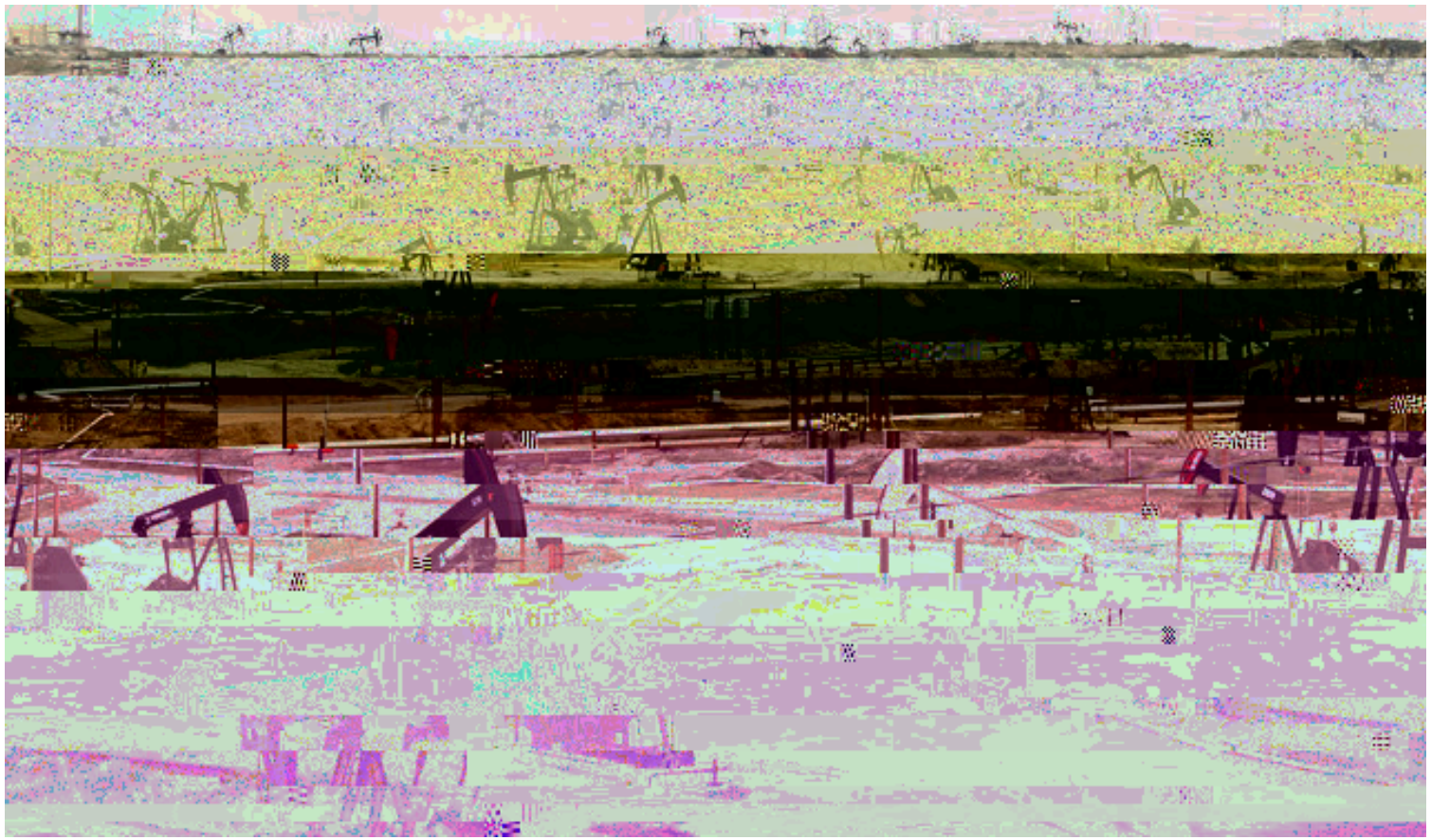
- Oil is an exhaustible resource: we need to take the dynamics of production seriously.
  - Depletion of Reserves.
  - Constraints on extraction rates.

# Literature

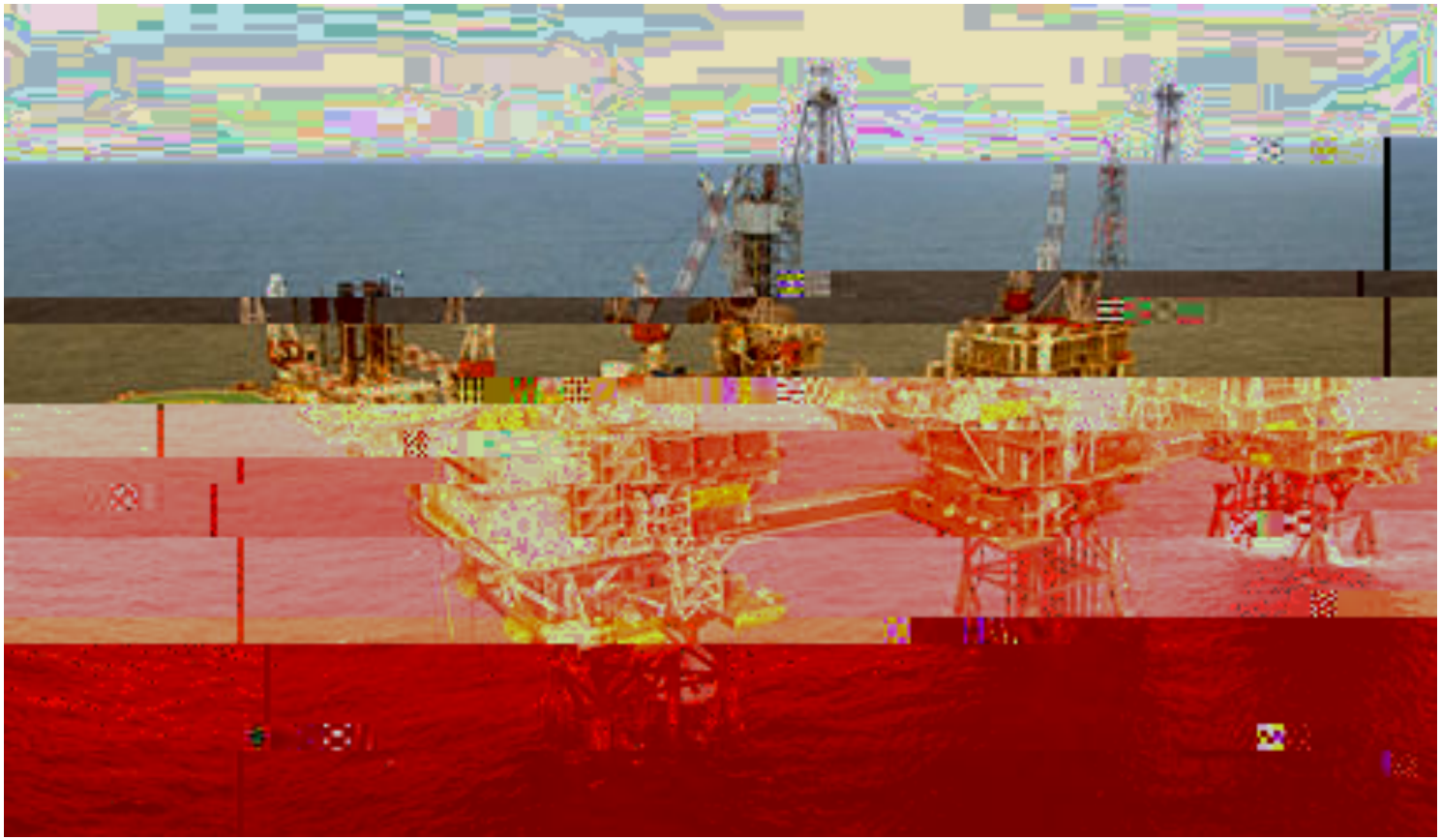
# Background on Oil

- Geology and location have a big impact on costs of extraction
- Exogenous cost variation across production units unrelated to management skill rather:
  - Model (technology): onshore, o shore, shale, etc.
  - Location (geology): bedrock structure, climate, etc.
- Examples:

# West Texas



# Aasgard Norway



# OPEC Cartel

- OPEC is Algeria, Angola, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, UAE, and Venezuela.
- OPEC is an imperfect cartel
  - Production Quota Mechanism: No monetary transfers between members.
  - Frequent instances of cheating on quotas.
  - Saudi Arabia, Kuwait, UAE usually enforce the cartel by raising production.

# Main Oil Producers

Table: Largest crude producers, % of global production 1970-2014

| OPEC | | Non-OPEC | |
|---|---|---|---|
| Saudi Arabia | 11.8% | United States | 14.4% |
| Iran | 5.4% | Russia | 13.0% |
| Venezuala | 3.8% | China | 4.1% |
| UAE | 3.1% | Mexico | 3.7% |
| Nigeria | 2.8% | Canada | 3.3% |
| Iraq | 2.7% | UK | 2.4% |
| Kuwait | 2.6% | Norway | 2.4% |

Notes: Global production from 1970-2014 was 1,156 billion barrels. Collectively these 14 countries account for 85.4% of global production.

# Price and OPEC

# Data

- Rich Data on oil from Rystad Energy, a Norwegian Energy Consultancy. One of the main data suppliers in the industry (IHS, Wood Gundy).
- Field Level Information: Gulfaks South versus Ghawar Uthmamiyah.
- Data from 13,000 fields.
- Information on production, costs, reserves, technology, location.

# Summary Statistics

| Variable | mean | median | 5% | 95% |
|---|---|---|---|---|

# Reserves, 2014

| | Reserves (mB) | reserves (%) | Reserves/(Annual production) (%) |
|---|---|---|---|
| Non-OPEC | 218,054 | 50 | 10 |
| OPEC | 220,561 | 50 | 19 |
| Saudi Arabia | 74,194 | 17 | 18 |

- Reserves are measured as the unextracted, but recoverable, quantity of oil remaining in the ground in a field.
  1. Descriptive stats: P50 value at an oil price of $70
  2. Counterfactual (1970 onward) sum of: i) the actual production history from 1970 to 2014, and ii) the P50 value at an oil price of $70 a barrel in 2014.

# Cost Changes over time: Saudi Arabia

black: 95%, grey: 99% and circle: max.

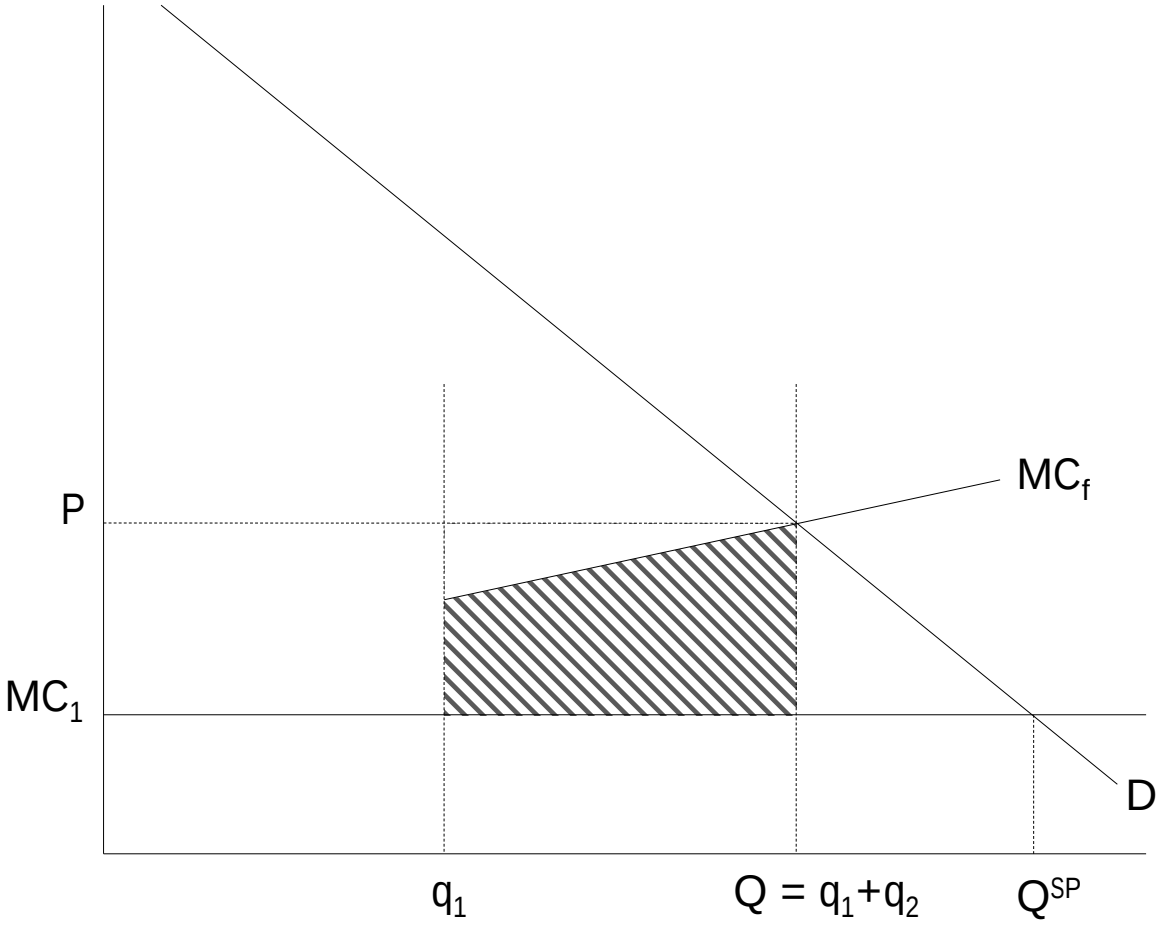
# Cost Changes over time: Nigeria

# Cost

# Cost Changes over time: United States

# Cost Changes over time: Canada

# Production Distortion



# Competitive Equilibrium

- Productive Ine ciency Definition

  *Productive ine ciency is the net present value of the di erence between the realized costs of production, and the cost of production had the realized production path been produced by rms taking prices as exogenous.*

- In an exhaustible resource industry, the welfare losses come from the welfare e ects of *when* to extract oil given discounting.

# Costs

- We want to take a relatively long run perspective on costs: what if OPEC had not 86E65run

# Structural Model

- Use the sorting algorithm to compute counterfactual paths for the industry | the competitive path.
- Notice that, as in the figure, we are looking at changes in costs holding total quantity fixed.
- We will first present two types of counterfactuals:
  - Static Counterfactual: one period e ects of moving to a competitive equilibrium.
  - Dynamic Counterfactuals: long run e ects | all about when a barrel will be extracted, not if.

# Static Distortion: as of 2014 OPEC

| Cty | Actual Shr | Counterfactual Shr | ! Shr |
|---|---|---|---|
| Persian Gulf OPEC | 0.258 | 0.744 | 0.486 |
| Iran | 0.057 | 0.091 | 0.034 |
| Iraq | 0.029 | 0.069 | 0.040 |
| Kuwait | 0.030 | 0.155 | 0.125 |
| Qatar | 0.009 | 0.015 | 0.006 |
| Saudi Arabia | 0.133 | 0.414 | 0.281 |
| United Arab Emirates | 0.031 | 0.075 | 0.044 |
| Other OPEC | 0.135 | 0.044 | -0.091 |
| Algeria | 0.021 | 0.015 | -0.006 |
| Indonesia | 0.020 | 0.002 | -0.018 |
| Libya | 0.025 | 0.012 | -0.013 |
| Nigeria | 0.028 | 0.006 | -0.022 |
| Venezuela | 0.041 | 0.009 | -0.032 |

# Static Distortion: as of 2014 Not-OPEC

| Country | Actual output share | Counterfactual output share | ! Share |
|---|---|---|---|
| Non-OPEC | 0.607 | 0.212 | -0.395 |
| Brazil | 0.014 | 0.001 | -0.013 |
| Canada | 0.023 | 0.006 | -0.017 |
| China | 0.045 | 0.002 | -0.043 |
| Kazakhstan | 0.010 | 0.000 | -0.01 |
| Mexico | 0.023 | 0.013 | -0.01 |
| Norway | 0.027 | 0.009 | -0.018 |
| Russia | 0.144 | 0.047 | -0.097 |
| United Kingdom | 0.022 | 0.001 | -0.021 |
| United States | 0.132 | 0.013 | -0.119 |
| Rest of the World | 0.136 | 0.044 | -0.092 |

# Welfare accounting: implementation

- Nested Set of Constraints:
  - Hold

# Dynamic Counterfactual

Simulate from 1970 to 2015: NPV starting in 1970.

Almost all the production in the 1970s is accounted for by a couple of fields: Ghawar Uthmaniyah, Greater Burgan, Ghawar Shedgum.

# Full dynamic model: results

Table 6: Dynamic counterfactual results
(NPV of costs in billions of 2014 dollars)

| | Timespan | | | |
|---|---|---|---|---|
| | 1970-2014 | | 1970-2100 | |
| Actual (A) | 2184 | (125) | 2499 | (130) |
| Counterfactual (C) | 1268 | (76) | 1756 | (79) |
| Total distortion (A - C) | 916 | (124) | 744 | (112) |
| Decomposition of total distortion | | | | |
| Within country (non-OPEC) | 329 | (80) | 284 | (41) |
| Within country (OPEC) | 192 | (46) | 157 | (72) |
| Across country (within non-OPEC) | 163 | (18) | 139 | (17) |
| Across country (within OPEC) (X) | 85 | (22) | 58 | (21) |
| Between OPEC and non-OPEC (Y) | 148 | (29) | 105 | (25) |
| Production distortion due to OPEC market power | | | | |
| Upper bound (X+Y) | | | | |

# Conclusions

- Significant misallocation aligned with known OPEC mechanism.
  - Countries with clear market power: Gulf OPEC members.
  - Most of impact comes from timing of Ghawar (SA), Burgan (KW) and Kirkuk (IQ) extractions.
  - Misallocation rises when OPEC is known to be holding down productions and prices spike.
- Very large welfare loss , due to productive ine ciency: 160 billion USD.
- No discussion of the role of distortionary taxes or carbon externalities in this market.