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OPEC and the Shale Revolution:

Insights from Equilibrium Modelling and Oil Politics

Dawud Ansari

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Outline

- 2014 – 2016: **Oil price crash**, following US shale growth and an **OPEC decision not to cut production**
- Previous literature: No consensus on **OPEC's intention**
  - *OPEC defeat, OPEC attack, or OPEC experiment*?
- **Bathtub model** to examine if static competition can explain price developments
- **Qualitative discussion** about oil politics of OPEC and Saudi Arabia in particular
- Conclusions:
  - OPEC decision most likely an **attempt to drive out shale** and to **test for shale elasticity**
  - Shale oil might have altered competition permanently, but **OPEC is still an important player**

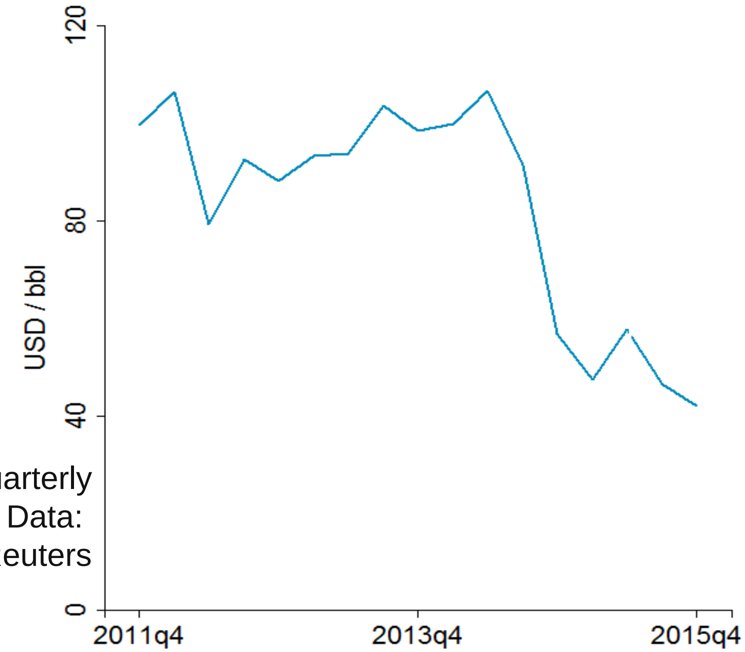
Content

1

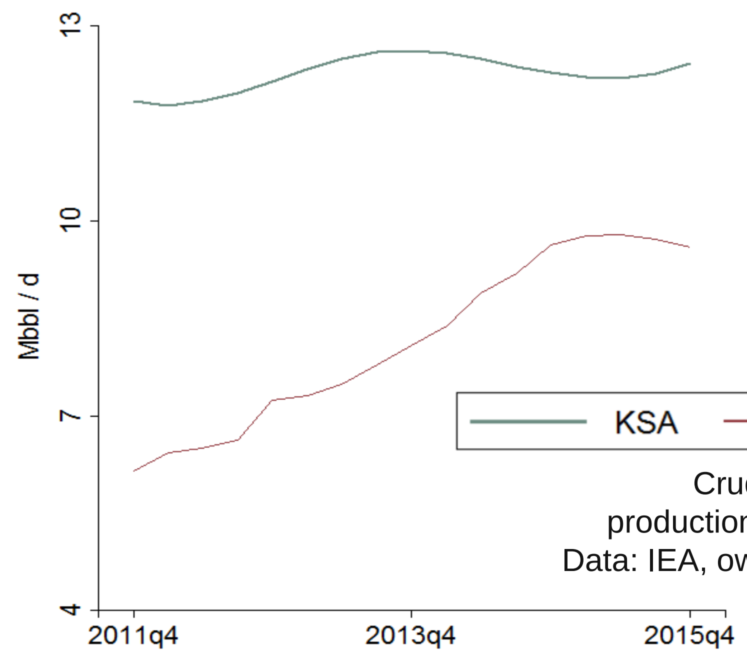
Background:

Developments and scientific discourse

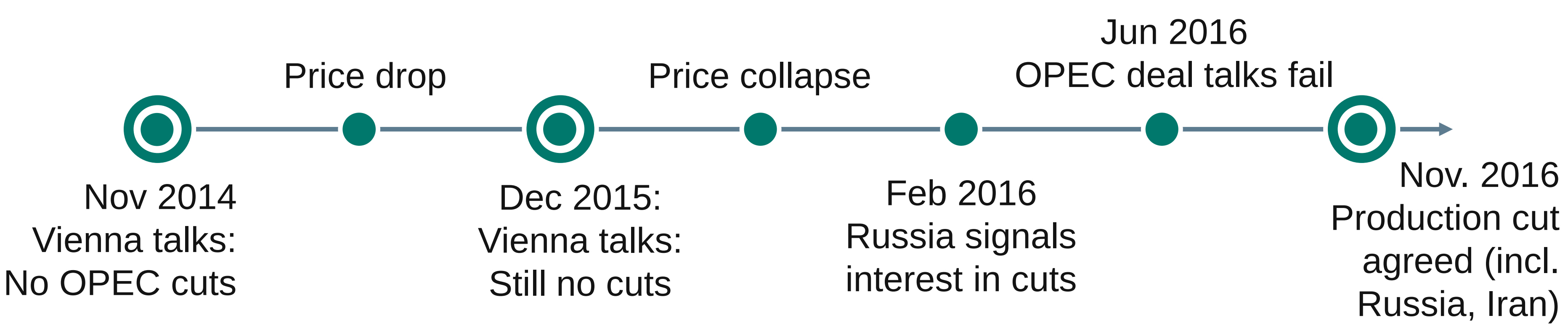
1 Background



WTI quarterly price. Data: Thomson Reuters



Crude oil production capacities
Data: IEA, own calculations



1 No literature consensus

Shale oil revolution
(e.g. Aguilera and Radetzki, 2015)

Financial speculation
(e.g. Fantazzini, 2016, Tokic, 2015)

Dampened demand
(e.g. Baumeister and Kilian, 2016)

New economics of oil
Dale (2016)

OPEC Behaviour

Geopolitical stabilisation
(e.g. Baffes et al., 2015)

OPEC floods the market to **drive out shale**

OPEC **lost its position** as the swing supplier to shale

Uncertainty

Behar and Ritz (2017)
Coy (2015)
Gause (2015)
Mănescu and Nuño (2015)

Fattouh et al. (2016)
Huppmann and Livingston (2015)

Baffes et al. (2015)
Baumeister and Kilian (2016)
Dale (2016)
Kaletsky (2015)
The Economist (2015)

1 OPEC's own interpretation

*"[Ali al-Naimi's] biggest move was the latest one of defending Saudi market share, and **abandoning the OPEC swing role**."*

Mohammad al-Sabban, June 2015

*[…] It is not in the interest of OPEC producers to cut their production. […] **Whether [the price] goes down to $20/B, $40/B, $50/B, $60/B, it is irrelevant**. […] But if it goes down, others will be harmed greatly before we feel any pain.*

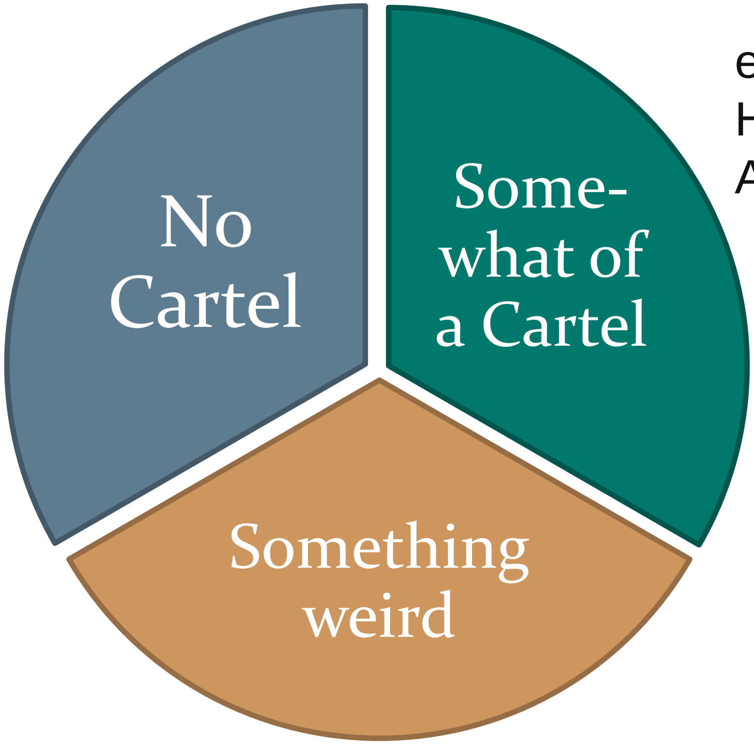
Ali al-Naimi, November 2014

OPEC states:
We will flood the market and defend our market share!

Does history back this decision?

Is OPEC a cartel?

e.g.
Kisswani (2016)
Plaut (1981)



e.g.
Huppmann & Holz (2012)
Almoguera et al. (2011)

e.g. Kisswani (2014), Hochman and Zilberman (2015)

And even worse: How to model that?

Fattouh and Mahadeva (2013): Changing OPEC objectives and behaviour over time make it **impossible to have a single model** explaining all OPEC history.

2

A (*not-so*) simple model of the crude oil market

Model description

Perfect Competiton

Lower-end benchmark

Cournot

Equal market power

Stackelberg:

KSA / United OPEC vs Cournot / Fringe

Asymmetric market power

Bathtub market

- Homogeneous crude
- **Pool model:** Unified, **global demand** function
- **Relaxation**: quality adjustment

Present profit maximisation

- **No dynamic** strategic behaviour
- Full information and certainty

Golombek production costs

Linear demand

- From actual demand and fixed elasticity

$$\max_{q_{it}} \{p_t(\cdot)q_{it} - C_{it}(q_{it}) \mid q^s_{-it}\} \ \forall i,t$$

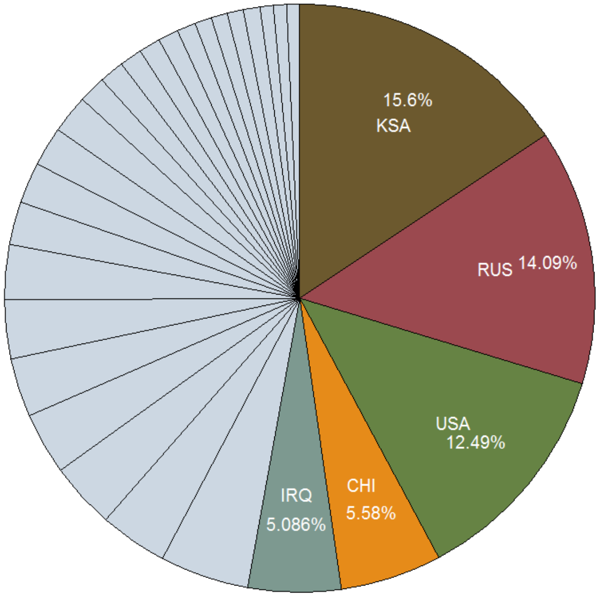
An extension of Huppmann (2013)

t: 2011 Q4 – 2015 Q4, quarterly

2 Data & Implementation

Type	Source
Supply	IEA (29 suppliers with 94.4% of global supply)
Capacities	**OPEC: IEA , Non-OPEC: 97%-of-output** rule and IEA (e.g. Behar & Ritz, 2017)
Production costs	DIW data set (e.g. Langer et al, 2016)
Oil quality adjustment	**Calculations** based on US Dept. of Energy, EIA, Oil & Gas Journal
Demand elasticity	Survey-based: Javan & Zahran (2015), Caldara et al. (2016)

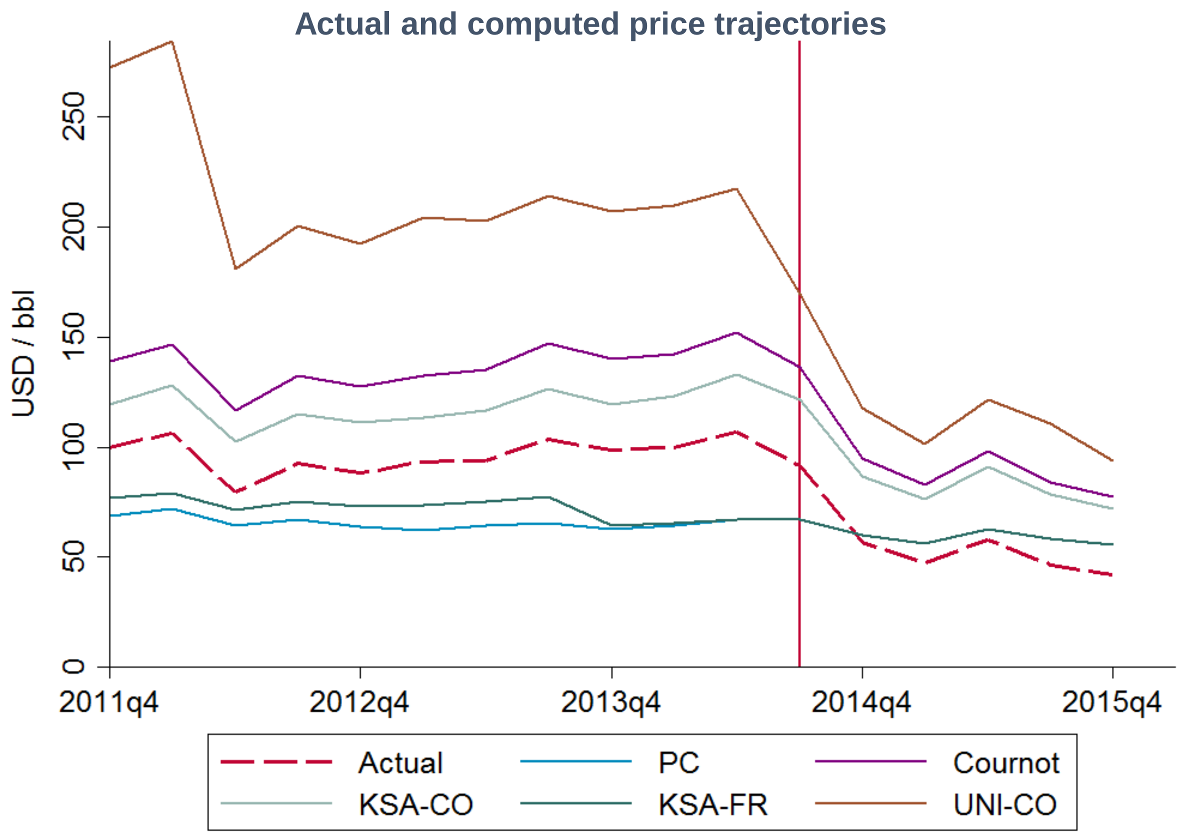
Setup	Formulation	Solver
Cournot, Perfect Comp.	MCP	PATH
Stackelberg	MPEC → MINLP	Bonmin, Couenne



Share in global crude production capacities

Gini coefficient: 0.505
Data: IEA and own calculations

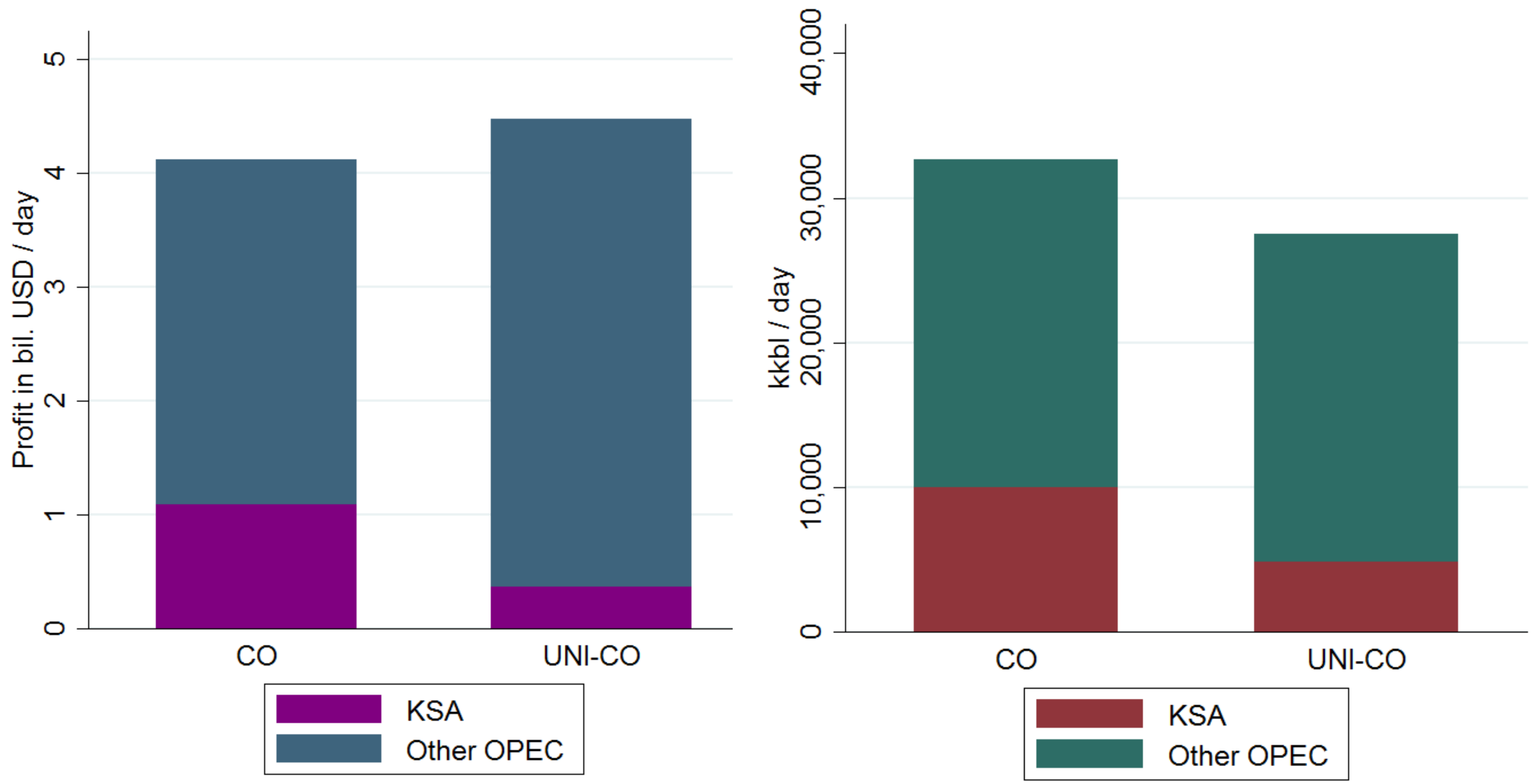
Results: Price trajectories



Goodness of fit

ARME in %	KSA-FR	PC	KSA-CO	Cournot	UNI-CO
Overall	23	27	35	52	120
First period	25	31	24	43	121
Second period	18	18	63	75	119

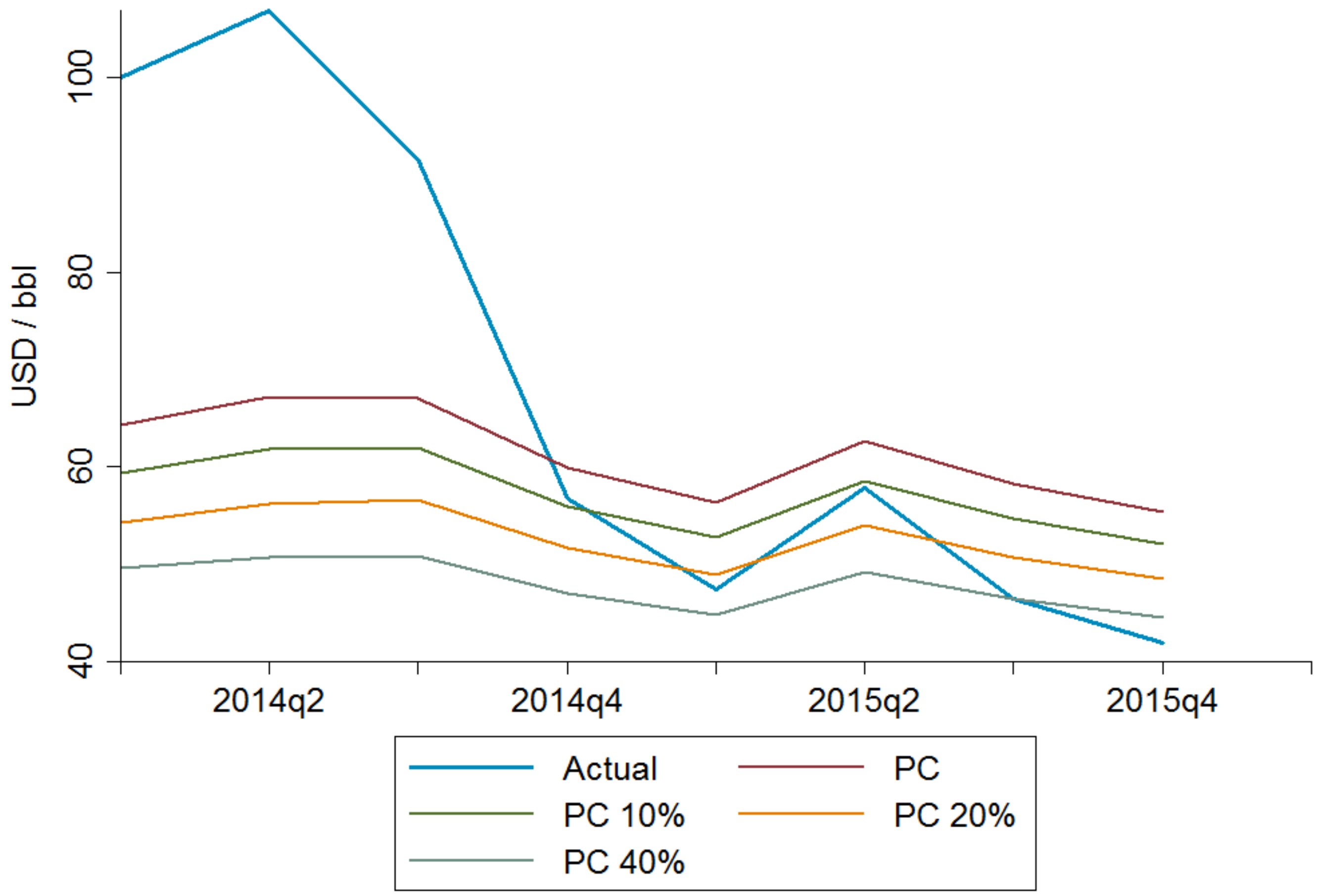
Results: United OPEC



Computed profits (left) and production quantities (right) in the United OPEC setup in Q1 2015 by Saudi Arabia (KSA) and other OPEC members

2

Results: Sensitivity analysis



Robustness of the perfect competition results to cost variations (overall cost reductions in %)

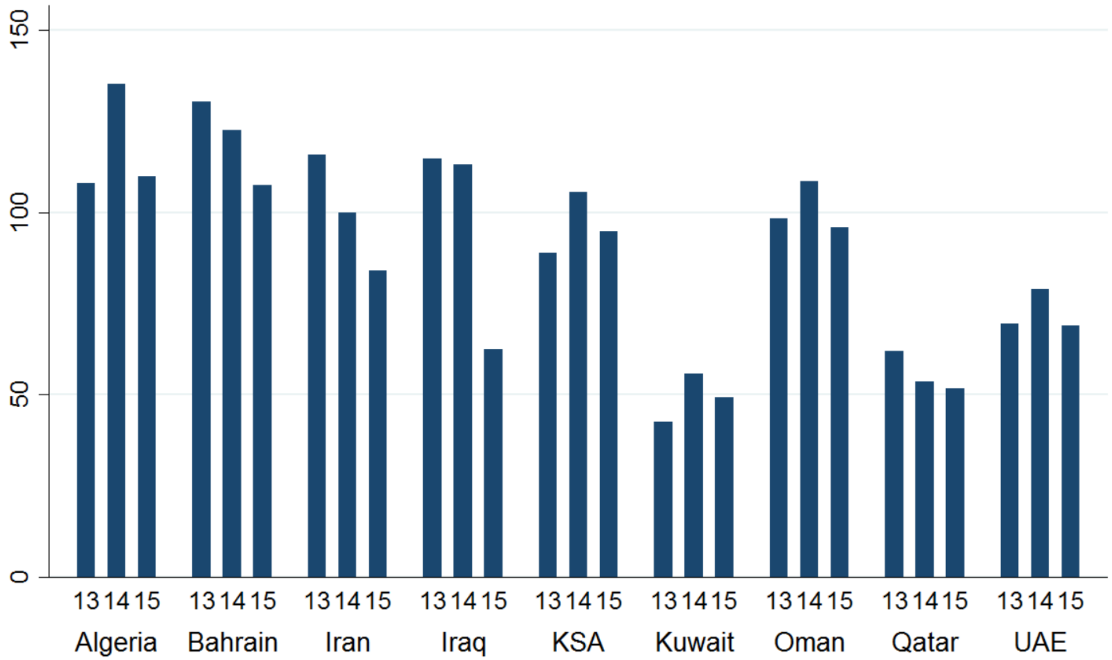
3

Qualitative discussion:

Oil Politics

3 Saudi calculus: Revenues or market-shares?

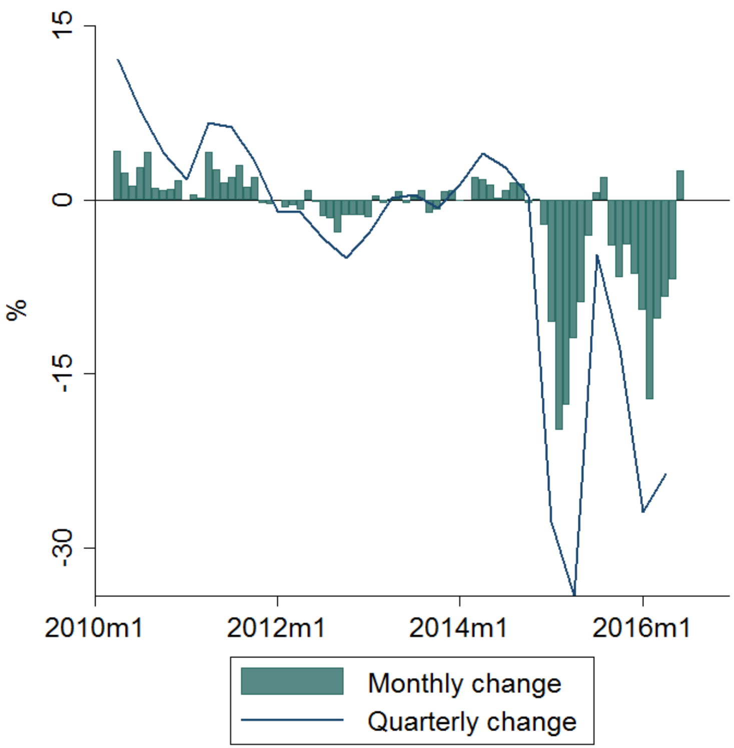
- **Trade-off** between revenue maximisation and market-shares
- Prolonged low oil prices can result in economic and political havoc
- Geopolitical impact ambiguous, Saudi Arabia advances in refining, Vision 2030
- A toughened oil market faces **peak-demand** (climate policies, alternative tech., energy efficiency)
  - Green paradox?
- Similarities to the 1980s?
- Saudi-Arabia's priority in deal negotiations:
  - No moral hazard!
  - No self-harm
- Influence of domestic politics?

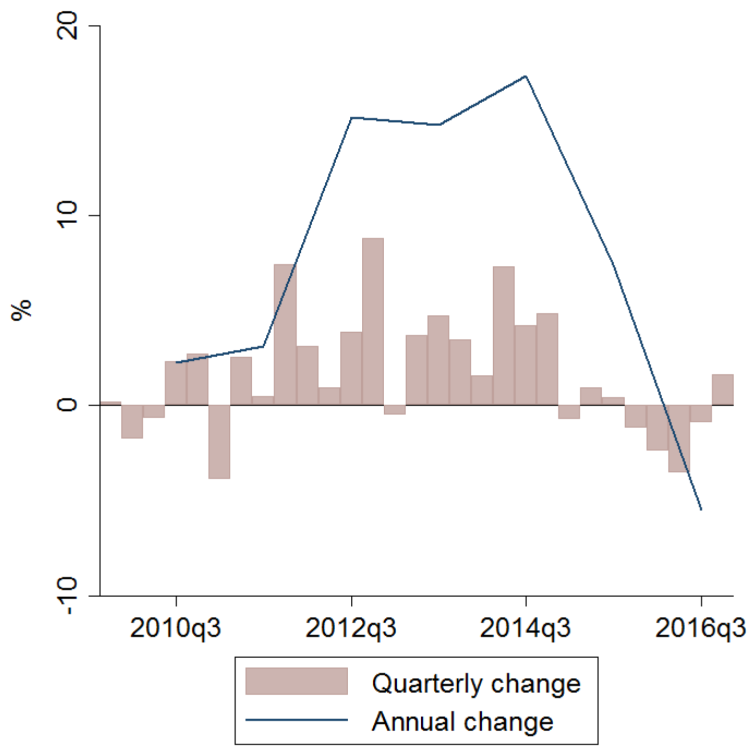


Fiscal breakeven prices in USD / bbl in 2013 – 2015. Data: IMF

3 Shale Performance under Pressure

- Shale economics: Different cooperative, financial, and cost structure
- Severe **overvaluation of shale breakeven** before the drop
- Potential misunderstanding of the breakeven concept itself (Kleinberg et al., 2016)
- Significant decrease in production, although far below OPEC hopes (OPEC, 2016)





Month-to-month and quarter-to-quarter changes in US rigs (left) and quarter-to-quarter and year-to-year changes in US daily crude oil production (right). Data: EIA

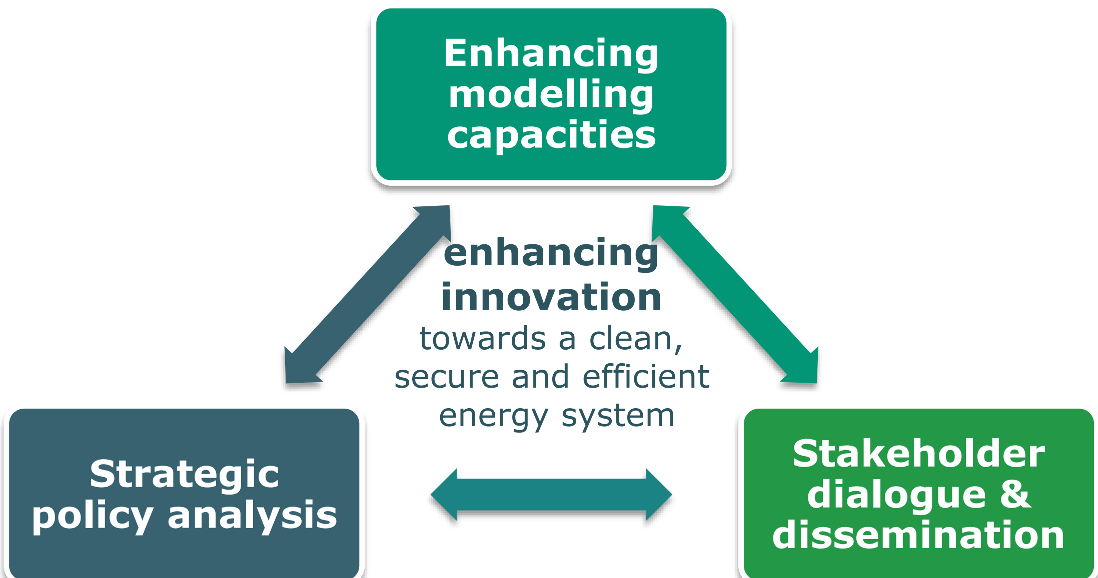
Summary & Conclusion

4 Conclusion

- Prices **before the drop** are consistent with **static short-term profit maximisation**.
- **Prices after the drop** can hardly result from such a behaviour but rather from **dynamic calculus or information-revealing behaviour**.
- Shale oil might have altered competition permanently, but **OPEC stays an important player** in the market.
- A return to high prices is only possible after large, unilateral cuts
- Modelling OPEC is anything but trivial.

4 Research Outlook

- Current DIW oil research as part of H2020 project **SET-Nav** (http://www.set-nav.eu)
  - How could the fossil fuel markets develop, and how does this effect climate change mitigation?
  - **Scenarios for the global fossil fuel markets to 2050**
- Recommendation: SET-Nav Workshop in September 2017 @ Vienna



Thank you for your attention.

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DIW Berlin — Deutsches Institut für Wirtschaftsforschung e.V.
Mohrenstraße 58, 10117 Berlin
www.diw.de

Editor
Dawud Ansari
dansari@diw.de

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Backup

Model notation

Set Indices	
$i \in I$	Crude oil producing countries
$j \in J \subseteq I$	Stackelberg leaders
$k \in K \subseteq I$	Stackelberg followers
$t \in T$	Time periods in quarterly steps from 4th quarter 2011 onwards
Parameters	
β_{1t}, β_{2t}	Demand parameters
ε	Price elasticity
φ_t	Observed actual price
χ_t	Observed actual quantity
$\gamma_{1i}, \gamma_{2i}, \gamma_{3i}$	Cost parameters
κ_{it}	Production capacity
η_i	Quality of oil index
Variables	
$p_t \in \mathbb{R}_0^+$	Market price in period t
$q_{it} \in \mathbb{R}_0^+$	Quantity supplied by producer i in period t

General relationships

$$C_{it}(q_{it}) = \gamma_{1i} q_{it} + \gamma_{2i} q_{it}^2 - \gamma_{3i}(q_{it} - \kappa_{it})\left(\ln\left(1 - \frac{q_{it}}{\kappa_{it}}\right) - 1\right)$$

$$\Rightarrow MC_{it} \equiv \frac{\partial C_{it}}{\partial q_{it}} = \gamma_{1i} + 2\gamma_{2i} q_{it} - \gamma_{3i}\ \ln\left(1 - \frac{q_{it}}{\kappa_{it}}\right)$$

$$p_t = \ \beta_{1t} + \beta_{2t} \sum\nolimits_{i \in I} q_{it}$$

$$\beta_{1t} = \varphi_t(1 - \varepsilon^{-1})$$

$$\beta_{2t} = \varphi_t(\chi_t \varepsilon)^{-1}$$

$$q_{it} \leq \ \kappa_{it}$$

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Perfect competition KKTs

$$0 \leq p_t - \eta_{it} MC_{it} \perp \kappa_{it} - q_{it} \geq 0 \qquad \forall i \in I \quad \forall t \in T$$

$$MC_{it} = \gamma_{1i} + 2\gamma_{2i} q_{it} - \gamma_{3i} \ln\left(1 - \frac{q_{it}}{\kappa_{it}}\right) \qquad \forall i \in I \quad \forall t \in T$$

$$p_t = \beta_{1t} + \beta_{2t} \sum\nolimits_{i \in I} q_{it} \qquad \forall t \in T$$

Cournot KKTs

$$0 \leq p_t - \eta_{it} MC_{it} - \tau_i \perp \kappa_{it} - q_{it} \geq 0 \qquad \forall i \in I \quad \forall t \in T$$

$$MC_{it} = \gamma_{1i} + 2\gamma_{2i} q_{it} - \gamma_{3i} \ln\left(1 - \frac{q_{it}}{\kappa_{it}}\right) \qquad \forall i \in I \quad \forall t \in T$$

$$p_t = \beta_{1t} + \beta_{2t} \sum_{i \in I} q_{it} \qquad \forall t \in T$$

Stackelberg MINLP

$$\max_{\substack{q_{jt} \\ \forall j \in J}} \left\{ p_t * \sum_{j \in J} q_{jt} - \sum_{j \in J} \left[\eta_{jt} C_{jt} + +\tau_j q_{jt} \right] \right\} \qquad \forall t \in T$$

$$C_{jt} = \gamma_{1i} q_{it} + \gamma_{2i} q_{it}^2 - \gamma_{3i} (q_{it} - \kappa_{it}) \left(\ln\left(1 - \frac{q_{it}}{\kappa_{it}}\right) - 1 \right) \qquad \forall j \in J \quad \forall t \in T$$

$$0 \leq p_t + (1 - f)\beta_{2t} q_{kt} - \eta_{kt} MC_{kt} \qquad \forall k \in K \quad \forall t \in T$$

$$MC_{kt} = \gamma_{1k} + 2\gamma_{2k} q_{kt} - \gamma_{3k} \ln\left(1 - \frac{q_{kt}}{\kappa_{kt}}\right) \qquad \forall k \in K \quad \forall t \in T$$

$$0 \leq \kappa_{it} - q_{it} \qquad \forall i \in I \quad \forall t \in T$$

$$p_t = \beta_{1t} + \beta_{2t} \sum_{i \in I} q_{it} \qquad \forall t \in T$$

$$p_t + (1 - f)\beta_{2t} q_{kt} - \eta_{kt} MC_{kt} \leq r_{kt} BIG \qquad \forall k \in K \quad \forall t \in T$$

$$\kappa_{it} - q_{it} \leq (1 - r_{kt}) BIG \qquad \forall k \in K \quad \forall t \in T$$