OPEC vs US shale: Analyzing the shift to a market-share strategy

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Plan for this talk

1. **Motivation**
2. Simple theory
3. Oil market developments since 2014
4. Empirical calibration
5. Conclusion

OPEC's strategy shift since 2014

November 2014: OPEC decides against output cuts—despite weak demand, US shale growth & falling prices

Mr Al-Naimi, (former) Saudi Arabia Oil Minister:

> *"In a situation like this, it is difficult, if not impossible, for the kingdom or for OPEC to take any action that would reduce its market share and increase the shares of others..." (December 2014)*

> *"Saudi Arabia ... enjoys very low production costs. And we are more efficient than other producers. It is an advantage we will use, as any producer would..." (March 2015)*

December 2015: OPEC reiterates commitment to "market share" strategy; OPEC production rose in 2015

Sheikhs vs shale?

Source: *The Economist*, 6 December 2014

Goals for this paper

Understand the drivers of such a "regime switch" by OPEC

1. **Develop simple new model of the crude oil market**
   - OPEC has market power with a choice between two strategies:
     1. "Accommodate" (price strategy)
     2. "Squeeze" (market-share strategy)
2. **Empirically calibrate model to recent oil market data**

$\Longrightarrow$ Were OPEC actions rational behaviour or "hara kiri"?

Contributions of the analysis

1. Theory shows that either strategy can be optimal for OPEC, depending on market fundamentals
   - Factors favouring the market share strategy are *qualitatively* consistent with market developments leading up 2014
   - Variation on standard IO theory of "limit pricing"
2. Calibration can *quantitatively* rationalize OPEC's regime switch in late 2014 from an *ex ante* perspective
   - Calibration does a reasonable job at capturing:
     1. Oil market data before regime switch (2012–2014)
     2. Market factors that generate a regime switch (2014)
     3. Oil forecasts & futures prices (2020)

Related literature

1. **OPEC behaviour & oil market structure**
   - *Longer-term*: Smith (2005); Brémond et al. (2012); Nakov & Nuño (2013); Almoguera et al. (2011); Huppmann & Holz (2012); Toews & Naumov (2016)
   - *Since late 2014*: Fattouh, Poudineh & Sen (2016); Verleger (2016)
2. **Limit pricing**
   - Classic IO theory
   - Andrade de Sa & Daubanes (2016)
3. **2014-15 oil price crash**
   - Baumeister & Kilian (2016); Baffes et al (2015); Hamilton (2015); IMF World Economic Outlook 2015; lots of policy discussion
     - Relative contributions of supply & demand factors

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Setup of the model

Supply

OPEC has a degree of market power

- Capacity K_i with marginal cost C_i

Non-OPEC producers are price takers

- Producer $n \in N$ has capacity K_n with marginal cost C_n
  - Sell up to capacity as long as $P > C_n$ (otherwise zero sales)
- US shale has highest cost $C_j \equiv \max_{n \in N} \{C_n\} > C_i$
- Capacity of all non-OPEC, non-US shale players $K_\ell \equiv \sum_{n \in N \setminus \{j\}} K_n$

Demand

Global demand is linear $D(P) = (\alpha - P)/\beta$

Setup of the model

OPEC chooses between two strategies

1. "Accommodate": Maximizing profits taking as given that US shale produces up to its capacity level K_j;
2. "Squeeze": Lowering the market price to C_j, thus squeezing US shale out of the market.

OPEC's pricing power

- Reduced-form $\lambda \in (0, 1]$ under accommodation strategy
  - Efficient cartel if $\lambda = 1$ (facing a competitive fringe)
  - Lower $\lambda \Longrightarrow$ weaker pricing power

Parameter assumptions

- **A1**. $(C_j - C_i) < \lambda[(\alpha - C_j) - \beta(K_j + K_\ell)]$
  - US shale viable under accommodation
- **A2**. $(\alpha - C_j) \leq \beta(K_i + K_\ell)$
  - OPEC has sufficient capacity to squeeze

Analysis of OPEC's strategies: Accommodation

OPEC faces residual demand $\{D(P) - K_j - K_\ell\}$ so chooses price (*equivalently*, output) to:

$$\max_P \Pi_i(P) \equiv \{D(P) - K_j - K_\ell\}(P - C_i)$$

Parameter $\lambda \in (0, 1]$ captures OPEC's pricing power $\Longrightarrow$ first-order condition $0 = \{\lambda[(\alpha - P) - \beta(K_j + K_\ell)] - (P - C_i)\}$

Market price & OPEC supply ($\rightsquigarrow$ profits Π_i^*):

$$P^* = \frac{C_i + \lambda[\alpha - \beta(K_j + K_\ell)]}{(1 + \lambda)} > C_j \text{ (by A1)}$$

$$S_i^* = \{D(P^*) - K_j - K_\ell\} = \frac{[\alpha - \beta(K_j + K_\ell) - C_i]}{(1 + \lambda)\beta}$$

- "Swing producer" with $-dS_i^*/d(K_j + K_\ell) = 1/(1 + \lambda) \in (\frac{1}{2}, 1)$

Analysis of OPEC's strategies: Squeeze

By construction, OPEC chooses price $P^{**} = C_j$ (equivalently, output)

- US shale oil sells zero
- Global demand $D(P^{**}) = (\alpha - C_j)/\beta$

OPEC supply ($\rightsquigarrow$ profits Π_i^{**})

$$S_i^{**} \equiv \{D(P^{**}) - K_\ell\} = \left(\frac{(\alpha - C_j)}{\beta} - K_\ell\right) \leq K_i \text{ (by A2)}$$

For identical parameters, OPEC supply is now higher $S_i^{**} > S_i^*$

Proposition 1: Comparative statics

Proposition

The "squeeze" strategy becomes relatively more attractive compared to the "accommodate" strategy, in that it offers relatively higher profits (that is, higher $\Delta\Pi_i$), for OPEC under the following conditions:
(i) the production capacity of high-cost player j (K_j) is larger;
(ii) the internal cohesiveness of OPEC λ is lower;
(iii) the global demand for crude oil α is lower;
(iv) the marginal cost of player j (C_j) is higher;
(v) the production capacity of other non-OPEC players K_ℓ is larger.

Proposition 2: Threshold US shale capacity

Proposition

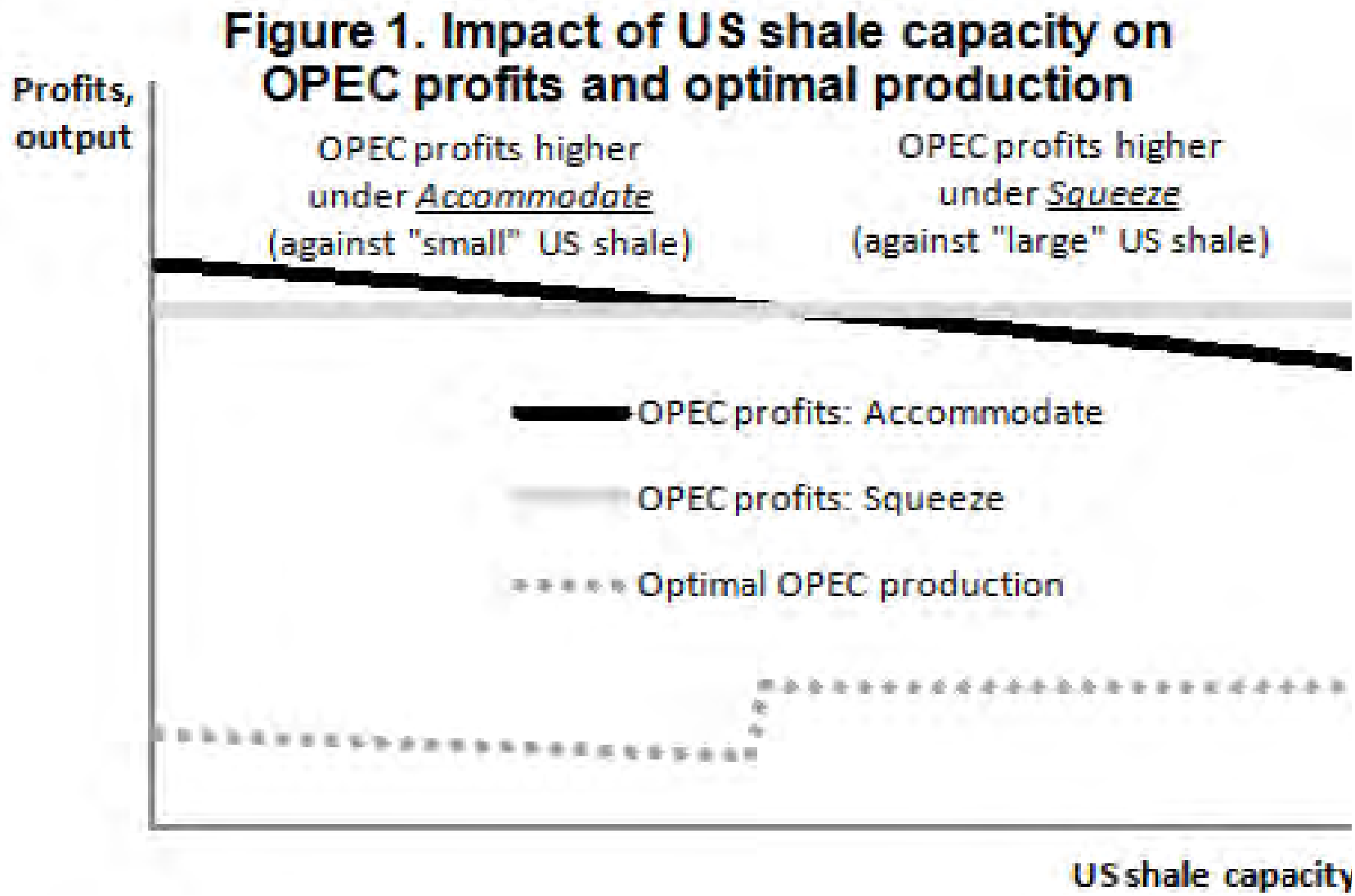
OPEC prefers the squeeze strategy (that is, $\Delta\Pi_i > 0$) whenever the production capacity of high-cost player j is sufficiently large,

$$K_j > \left[\frac{1}{\beta}\left((\alpha - C_i) - (1+\lambda)\sqrt{\frac{1}{\lambda}\left[(\alpha - C_j) - \beta K_\ell\right](C_j - C_i)}\right) - K_\ell\right] \equiv \overline{K}_j$$

and otherwise accommodates if $K_j \leq \overline{K}_j$. At this "regime switch", the oil price falls discontinuously from $P^*(\overline{K}_j) = C_i + \sqrt{(1/\lambda)\left[(\alpha - C_j) - \beta K_\ell\right](C_j - C_i)}$ to $P^{**} = C_j$.

NB. Market-share strategy does *not* rely on a subsequent "harvesting" period with again-higher prices

Impact of US shale growth on OPEC's strategy



Proposition 3: Drivers of OPEC supply increase

Proposition

(i) Suppose that an increase in capacity of player j, from $K_j' \leq \overline{K}_j$ to $K_j' > \overline{K}_j$, induces a regime switch from accommodate to squeeze. This leads to an increase in OPEC's production, $S_i^{**} > S_i^*$.
(ii) Suppose that a decline in global oil demand, from α' to α'', induces a regime switch from accommodate to squeeze, that is, $K_j \leq \overline{K}_j(\alpha')$ but $K_j > \overline{K}_j(\alpha'')$. This leads to an increase in OPEC's production, $S_i^{**} > S_i^*$, as long as the demand decline $\Delta\alpha \equiv (\alpha' - \alpha'')$ is not too large.

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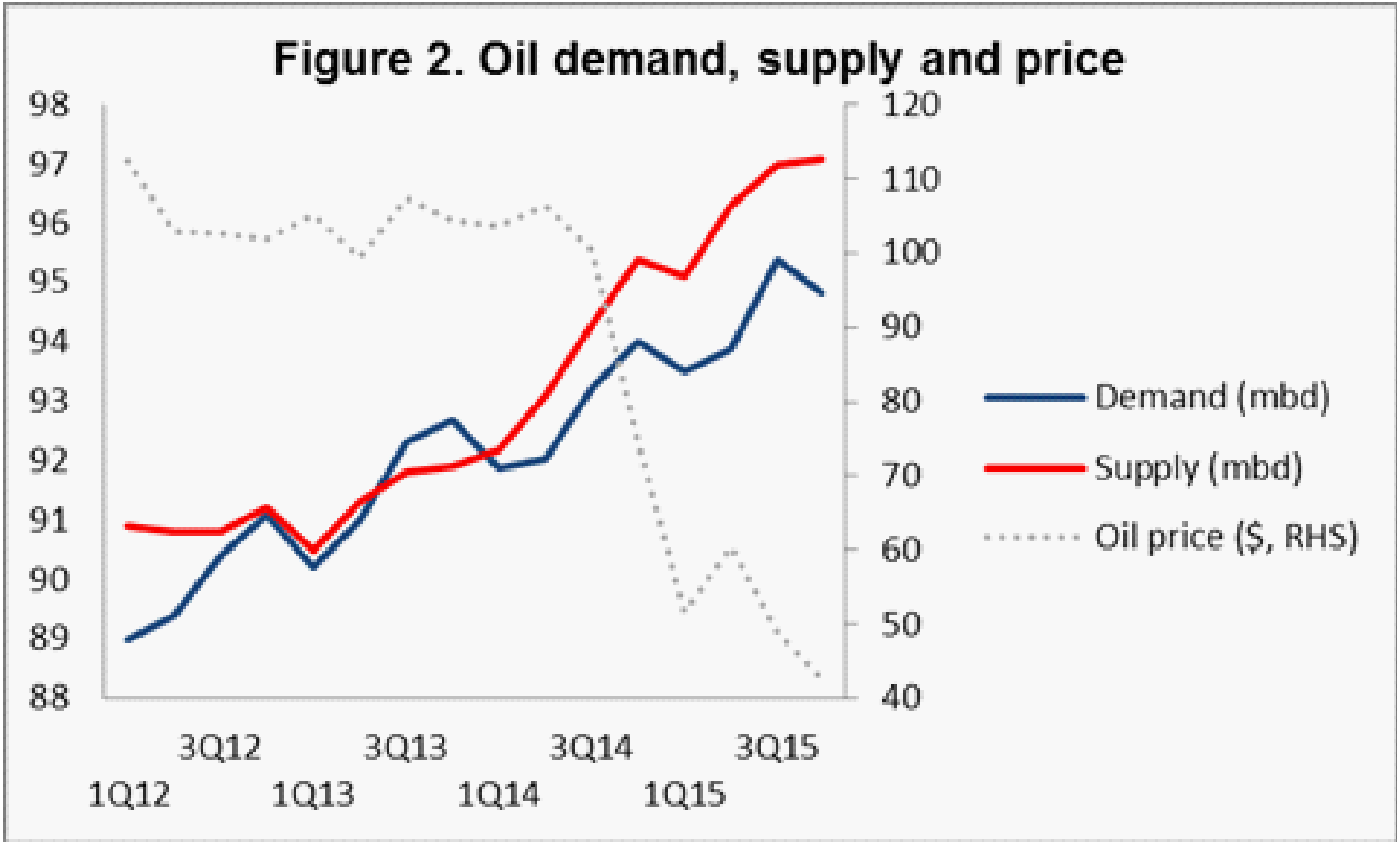
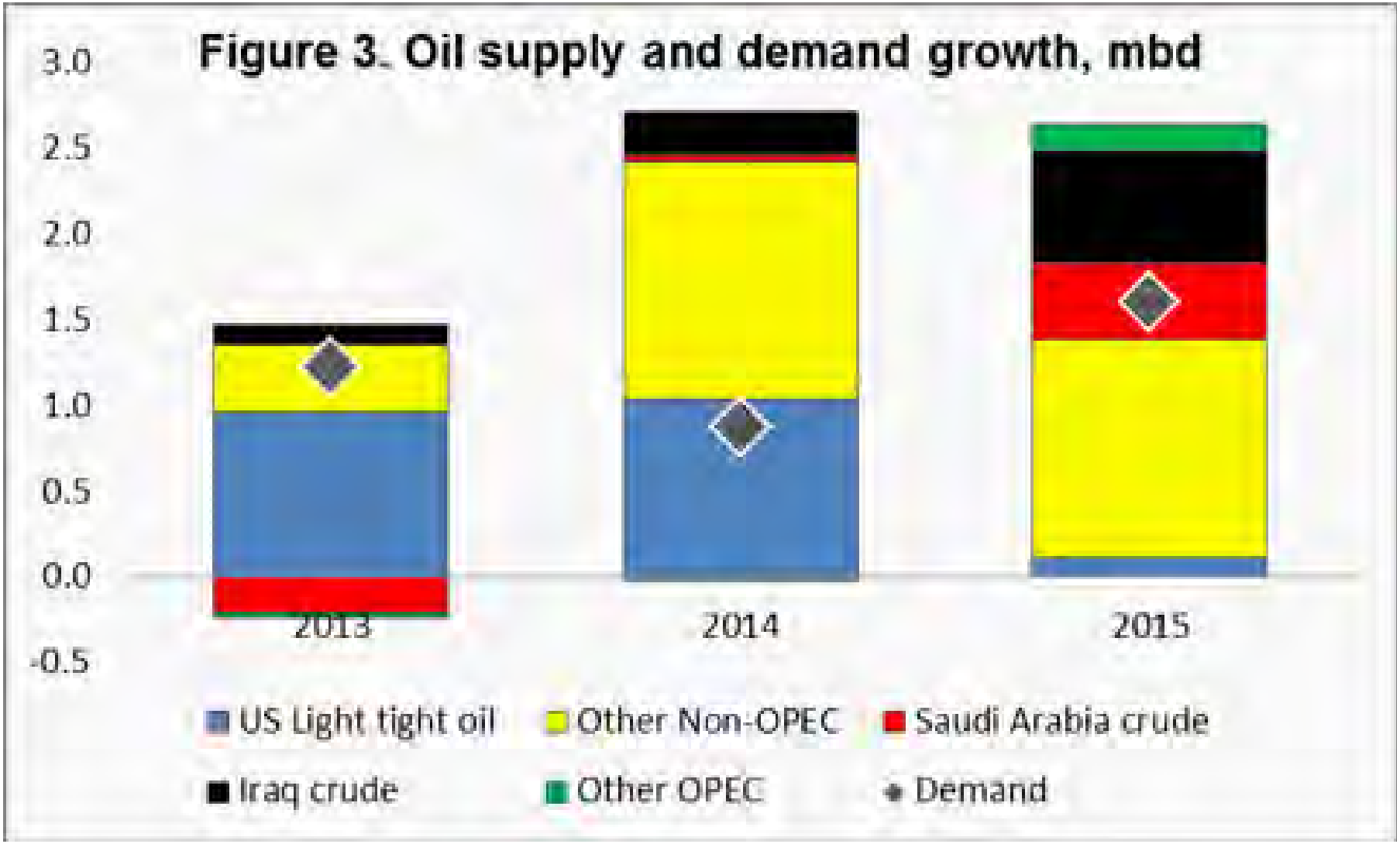
Supply overtook demand & prices crashed in 2014–15



Supply growth from US shale & Iran



Drivers of a regime switch

1. Global demand weakened ($\rightsquigarrow$ *squeeze*)
   - Slow GDP growth, with downward revisions; energy efficiency
2. US shale output rose ($\rightsquigarrow$ *squeeze*)
   - Output beat EIA forecasts; successive upward revisions
3. Non-US output rose ($\rightsquigarrow$ *squeeze*)
   - Production increased mostly by Brazil & Canada
4. OPEC coordination difficulties intensified ($\rightsquigarrow$ *squeeze*)
   - Mounting fiscal revenue pressures; role of Iraq; time-varying λ-estimates
5. US marginal costs declining ($\rightsquigarrow$ *accommodate*)

Plus:

- OPEC spare capacity rose ($\rightsquigarrow$ *squeeze*, indirectly via A2)
  - Higher Iraq capacity vs Libya & Iran outages
  - Spare capacity = sustainable capacity − call on OPEC crude

OPEC coordination?

He [Mr Al-Naimi] used to arrive early for such gatherings and mingle with officials; in June [2014], he turned up at the last minute and attended one session. . .
There is no point in talking. . . as everyone does as they please. (Wall Street Journal)

Oil market responses following end 2014

1. US shale showed *some* signs of scaling back
   - Rig counts down by 62% over next 12 months to end-2015
   - Output down but only modestly so far (relative to 2014 or forecasts)
     - Cost savings (supply chain squeeze) & hedging effects

2. Other non-OPEC supply showed mixed responses
   - Non-OPEC investment ($\approx$ future supply) cut drastically
   - Non-OPEC output rose in 2015—produce "as flat out as you can" (Shell CFO)
3. Demand accelerated only slightly with lower prices

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Overview of data sources

- **Prices & demand**
  - IMF World Economic Outlook database; IEA Medium-Term & Monthly Oil Market Reports (2015, 2016)
- **Supply**
  - IEA Medium-Term & Monthly Oil Market Reports (2015, 2016)
- **Capacity**
  - IEA Medium-Term Oil Market Reports (2015, 2016); EIA
- **Costs**
  - Industry reports (various)
    - Significant uncertainty around US shale costs

Calibration I: Accommodation scenarios (2012–14)

	Scenario	1A (2012)	1B (2014Q2)
P	Price ($/barrel)	105	106
D	Demand (mbd)	90.7	92.0
	[Demand elasticity	–.14	–.14]
α	Demand intercept	831	843
S	Global supply (actual)	90.9	95.4
S_i	OPEC supply (actual)	37.6	36.4
S_i^*	OPEC supply (accommodate)	37.4	33.1
S_i^{**}	OPEC supply (squeeze)	41.2	39.7
K_i	OPEC capacity (mbd)	41.3	41.4
K_j	US shale capacity (mbd)	2.0	4.0
K_ℓ	ROW capacity (mbd)	51.3	55.0
C_i	OPEC marginal cost	10	10
C_j	US shale marginal cost	90	85
λ	OPEC pricing power	.32	.36
$\overline{K}_j$	Critical US shale size	3.8	5.5

Calibration II: Squeeze scenarios (2014Q2)

	Scenario	**2A** (High K_j)	**2B** (Low λ)	**2C** (Multiple)
P	Price ($/barrel)	85	85	55
D	Demand (mbd)	94.7	94.7	94.4
	[Demand elasticity	−.11	−.11	−.07]
α	Demand intercept	843	843	810
S	Global supply (actual)			
S_i	OPEC supply (actual)			
S_i^*	OPEC supply (acc.)	32.0	34.2	32.8
S_i^{**}	OPEC supply (squeeze)	39.7	39.7	39.4
K_i	OPEC capacity (mbd)	41.4	41.4	41.4
K_j	US shale capacity (mbd)	5.5	4.0	5.5
K_ℓ	ROW capacity (mbd)	55.0	55.0	55.0
C_i	OPEC marginal cost	10	10	10
C_j	US shale marginal cost	85	85	55
λ	OPEC pricing power	.36	.32	.21
$\overline{K}_j$	Critical US shale size	5.5	4.0	5.5

Calibration III: Future squeeze scenarios (2020)

	Scenario	3A	3B
P	Price ($/barrel)	58	58
D	Demand (mbd)	100.5	100.5
	[Demand elasticity	−.07	−.07]
α	Demand intercept	862	862
S	Global supply (actual)	100.5	100.5
S_i	OPEC supply (actual)		
S_i^*	OPEC supply (accommodation)	34.8	38.0
S_i^{**}	OPEC supply (squeeze)	41.6	38.6
K_i	OPEC capacity (mbd)	43.5	43.5
K_j	US shale capacity (mbd)	5.6	3.0
K_ℓ	ROW capacity (mbd)	58.9	58.9
C_i	OPEC marginal cost	10	10
C_j	US shale marginal cost	58	58
λ	OPEC pricing power	.21	.17
$\overline{K}_j$	Critical US shale size	5.6	3.0

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Further model application: natural gas markets

Natural gas shares various structural features with oil markets:

1. High degree of supplier concentration
2. "Dominance" of Gazprom in European market
3. Recent market entry of US as exporter of liquefied natural gas (LNG) from shale gas plays
    - Likely higher (transport) costs than Gazprom for Europe

Recent industry discussions suggest Gazprom should start a "price war" to squeeze out higher-cost LNG (Henderson/OIES 2016)

$\Longrightarrow$ Our model could quantify when a squeeze is optimal for Gazprom...

Conclusions

Theory

- New model of how market developments can rationalize OPEC's regime switch as Π-maximizing
  - Raising supply as an optimal response to higher competitor supply and weaker demand

Calibration

- Accommodation of US shale optimal until 2014Q2; under plausible conditions, a switch to squeeze preferred thereafter
  - Squeeze may be better of two evils given declining market fundamentals

Will this logic play out?

- US shale has cut back—but not as much as expected; large cost reductions were difficult to foresee
  - Further decline in internal OPEC coordination power?