Quantitative Effects of the Shale oil revolution on Oil Prices

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Oslo - June 2014

What is the shale oil revolution?

Oil markets have recently undergone a significant transformation with the unexpected rise in the US production of shale (light, tight) oil

- The combination of horizontal drilling techniques together with hydraulic fracturing and rising oil prices have made the exploration and exploitation of large volumes of shale oil possible.
- The production of shale oil is so far very much concentrated to the US

Significant expansion in US production

US shale-oil production is expected to reach 4 mb/d by 2018 according to EIA

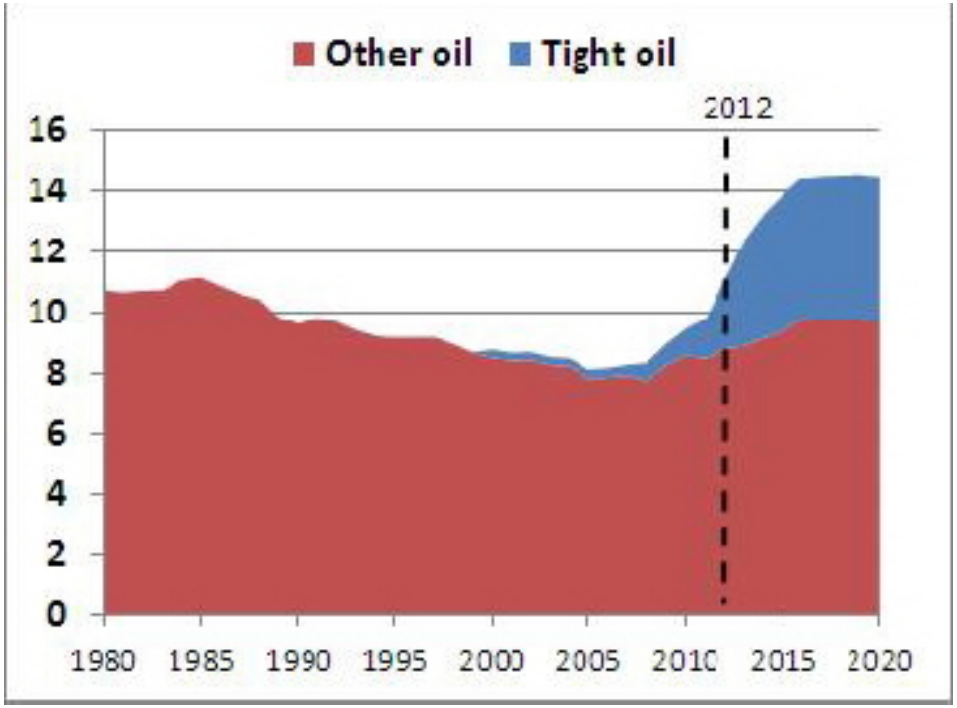


Figure: United States oil production by type (in mb/d, EIA Scenario)

This presentation: which is the oil price impact of the shale oil revolution?

We propose an analytical exercise employing a DSGE

- **Quantitative assessment** under different production scenarios.
- A critical issue is the behavior of **Saudi Arabia**

Why is Saudi Arabia so relevant?

- *"OPEC is Saudi Arabia"*

  – Mabro (1975)

- *"The Saudis have acted as what they are:*

  the leading firm in the world oil market"

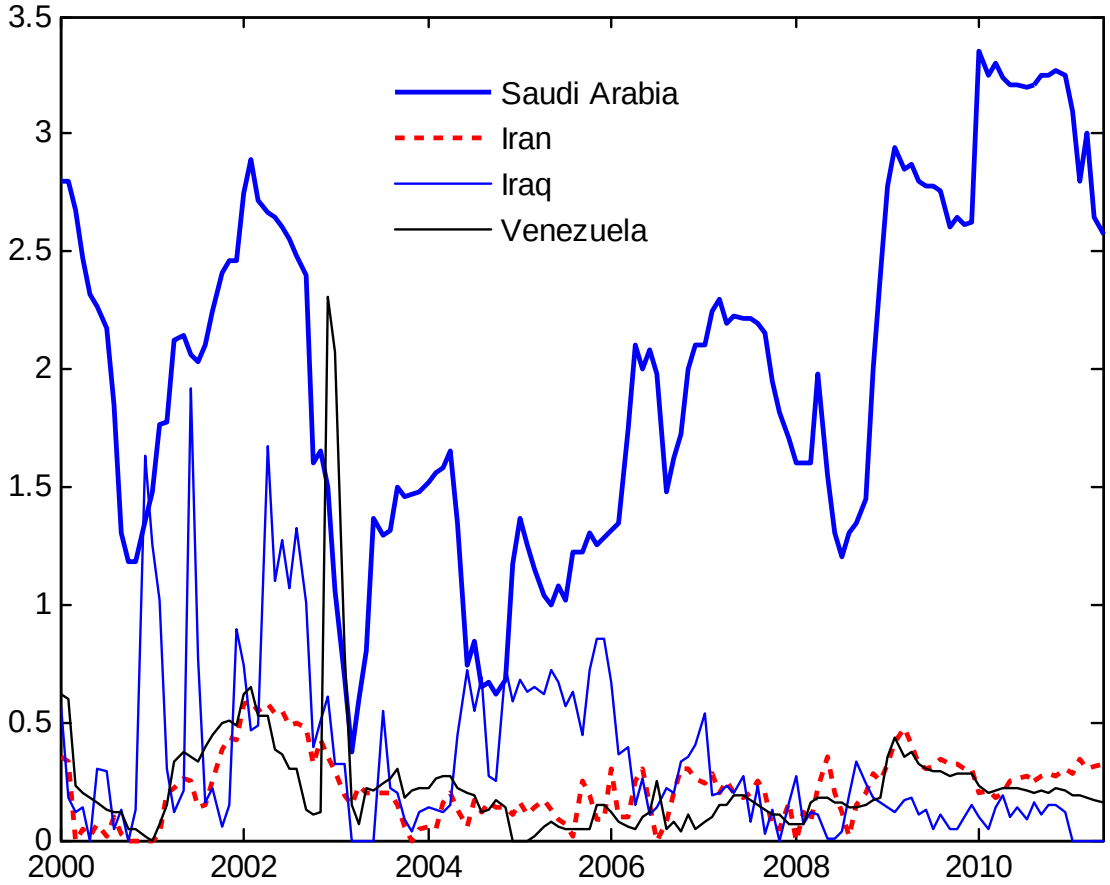
  – Adelman (1995)

Saudi Arabia is not a price-taker in the oil market

- Saudi Arabia is the world's largest oil exporter and owns the largest known oil fields
- Saudi Arabia is the only producer which "shuts in" significant spare capacity (Smith, 2009)
- Saudi Arabia's oil output has been highly volatile despite the lack of domestic shocks

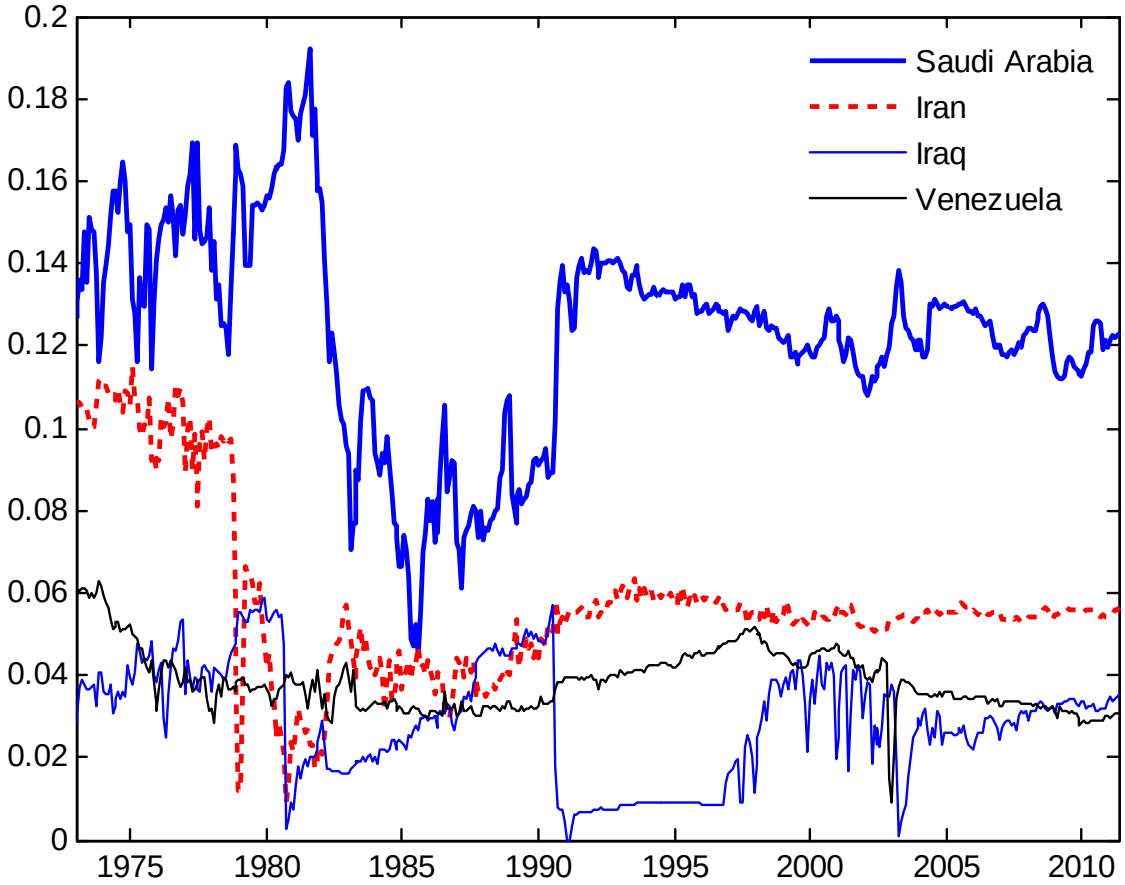
Saudi Arabia maintains ample spare capacity

Spare capacity of the four major OPEC producers. In million barrels per day



Saudi Arabia's oil output has been highly volatile ...

Market shares of the four major OPEC producers. Individual production over world production



... even if the Kingdom has been an "island of stability"

Instances when Saudi production was directly affected by exogenous events

- 1977 fire at the Abqaiq facilities
- 1984 several Saudi tankers destroyed during the Iran-Iraq war
- 1991 attacks by Iraqi missiles during the Gulf war

"Official Oil Market Chronology"
– U.S. Energy Information Administration

Apart from these episodes, changes in Saudi oil output were the result of production decisions; not the consequence of disruptions in its production capabilities

We employ the DSGE model from Nakov and Nuño

"Saudi Arabia and the Oil Market"(Economic Journal, 2014)

- Saudi Arabia is a dominant firm, with the rest of oil producers as a competitive fringe (*Dynamic Stackelberg game*)
- The behavior of the dominant firm can be seen as a profit maximizing response
- Spare capacity allows fast adjustment of output as necessary in response to demand and supply shocks

The model in a nutshell

- Three regions: one oil-importing and two oil-exporting ones
  - The oil-importer uses oil in consumption (gasoline)
- Oil is a homogeneous commodity supplied by two types of producers: a dominant firm and a "competitive fringe"
  - The fringe takes the oil price as given
  - The dominant producer faces a downward sloping "residual demand" curve, picking profit-maximizing points
- No borrowing across regions and abstract from monetary and exchange rate factors)

The model is able to replicate the main stylized facts of the market

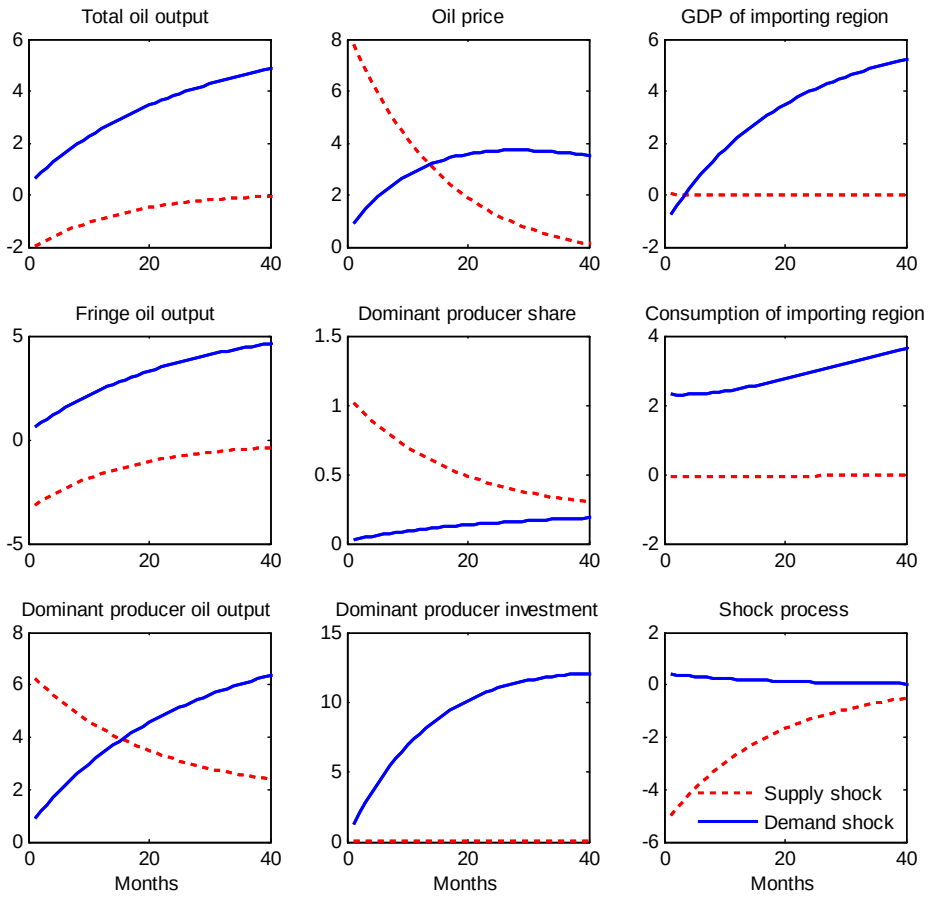
Data and model standard deviations*

		Oil price	Oil output	Fringe output	Saudi output
Data		8.5	1.6	1.5	6.6
Model	High elasticity	8.1	2.2	3.3	6.5
	Low elasticity	8.3	1.2	1.7	6.4

*Standard deviations, in percentage points, of first log differences.

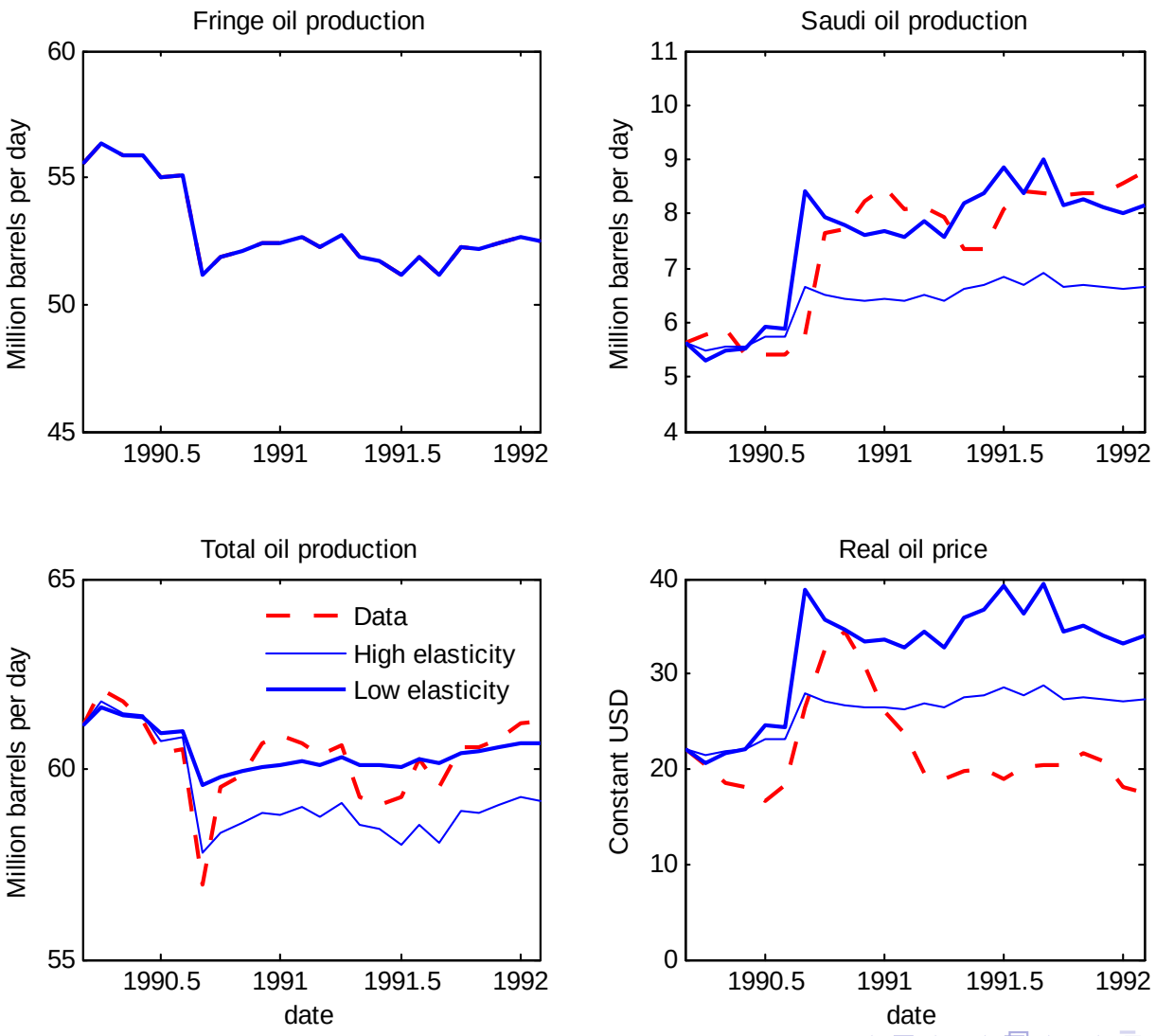
The volatility in the dominant supplier is consistent with the response of a monopolist

Impulse responses to a supply and a demand shock



Event study: the Persian Gulf war of 1990-91

The model explains the dynamics of Saudi Arabia production (only 1 shock: fringe supply)



We consider three scenarios

Anticipated shocks

1. **Baseline scenario**: shale oil production in the US increases from roughly zero in 2010 to 2.7 mb/d in 2014 and reaches a peak of 4 mb/d in 2018. *Data from EIA May 2014*
   1. Current law and regulations affecting the energy sector remain in place throughout the projection horizon.
   2. Production of shale oil remains concentrated in the US and does not extend significantly to other countries before 2020.
2. **Lower shale production scenario**: political, technical or environmental constraints limit US shale production which remains broadly flat across the period 2014-2018.
3. **Higher shale production scenario**: technological progress, political will and economic incentives push up US shale production, which reaches 6 mb/d by the end of the decade

Differential effect of different oil shale production scenarios

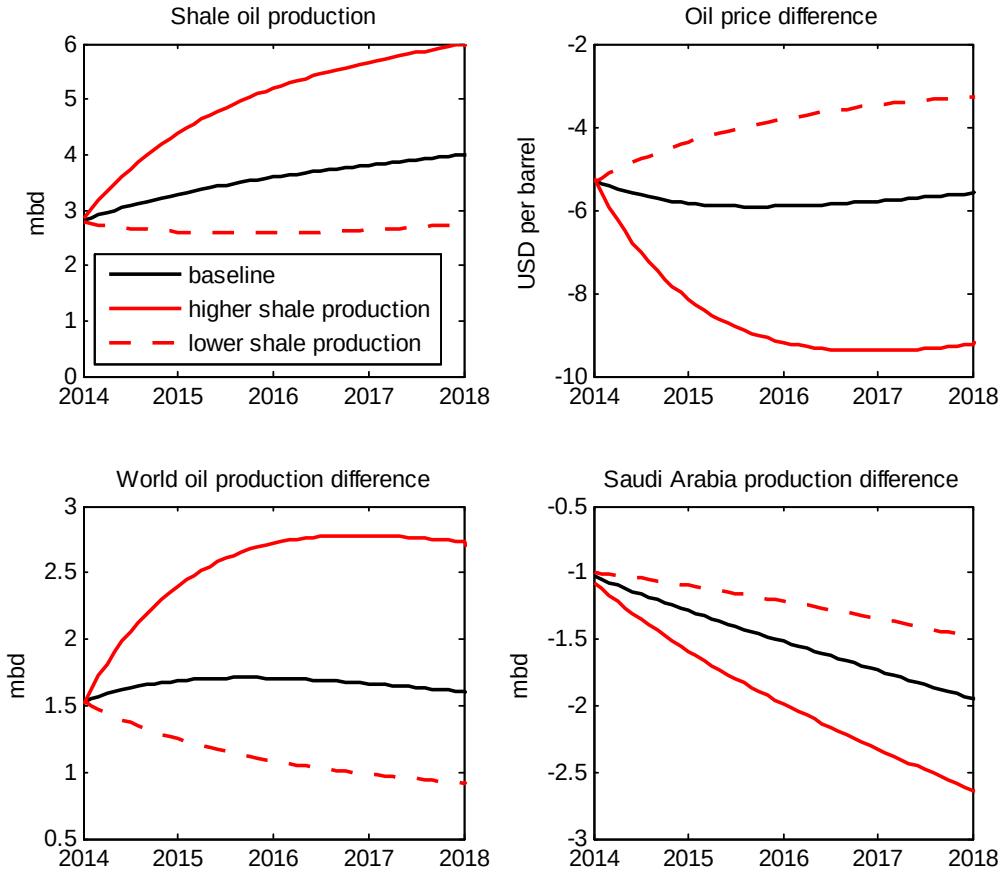


Figure: Differential effect of different oil shale production scenarios All the figures represent differences compared to the counterfactual scenario of no shale production

Take away

1. Most of the shale oil revolution is already **priced in**.
2. Even considerable changes in the scale of the production will have **only a small effect on prices**.
    1. The oil price impact of the increase in supply under the different scenarios by 2018 amounts to changes of less than ±USD4 per barrel. This is small compared to the average oil price volatility.

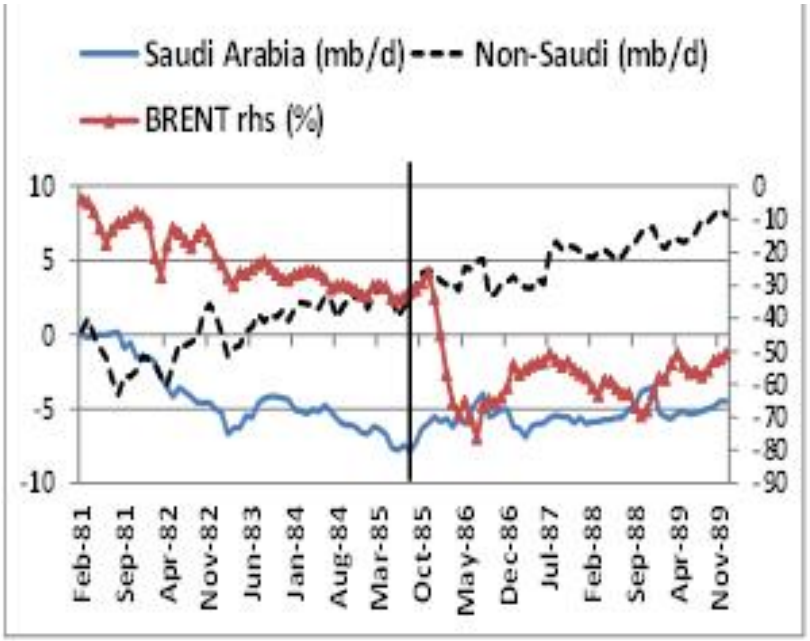
What if Saudi Arabia deviates from its optimal rule?

Saudi Arabia lowers its production in order to partially offset the increase in global supply

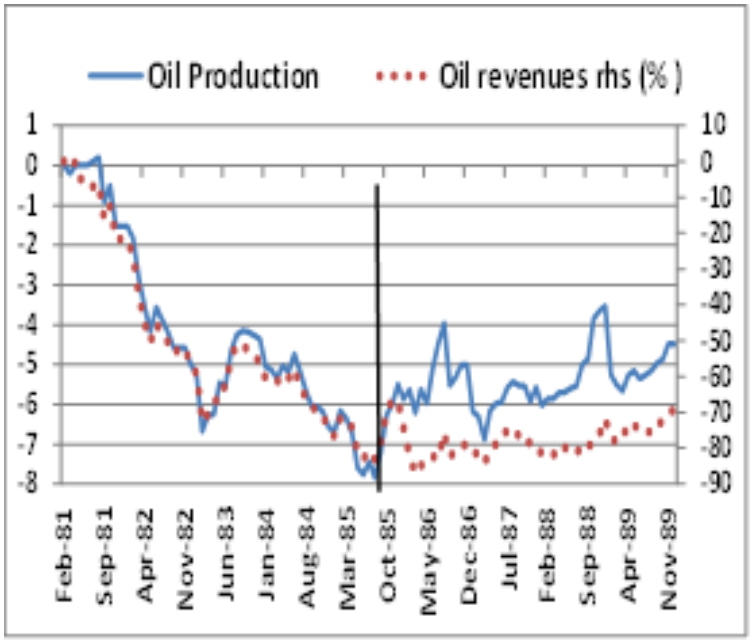
- However, Saudi Arabia can deviate from its profit-maximizing path and instead maintain or even increase production.
- This would preserve its oil revenues and may push shale oil producers off the market.

Are there similarities with the 3rd oil shock of the mid-1980s?

Saudi Arabia maximizing revenues instead of profits



Total oil production and oil prices (monthly absolute differences with respect Jan 1981)



Saudi Arabia oil production and oil revenues (monthly data changes)

We analyze the case of Saudi Arabia maximizing revenues instead of profits

In an alternative scenario

- The **profit maximizing scenario** corresponds to the higher shale production scenario above (worst-case).
- Alternative scenario (**revenue scenario**): Saudi Arabia deviates from the profit-maximizing path by keeping approximately constant its revenues (since the end of 2013).
  - Commitment of Saudi Arabia to defend its revenues is public information: the rest of agents in the economy are aware of it since 2013 and may form expectations (and take actions) accordingly

The impact on prices is still moderate

Less than USD1 pb by 2018

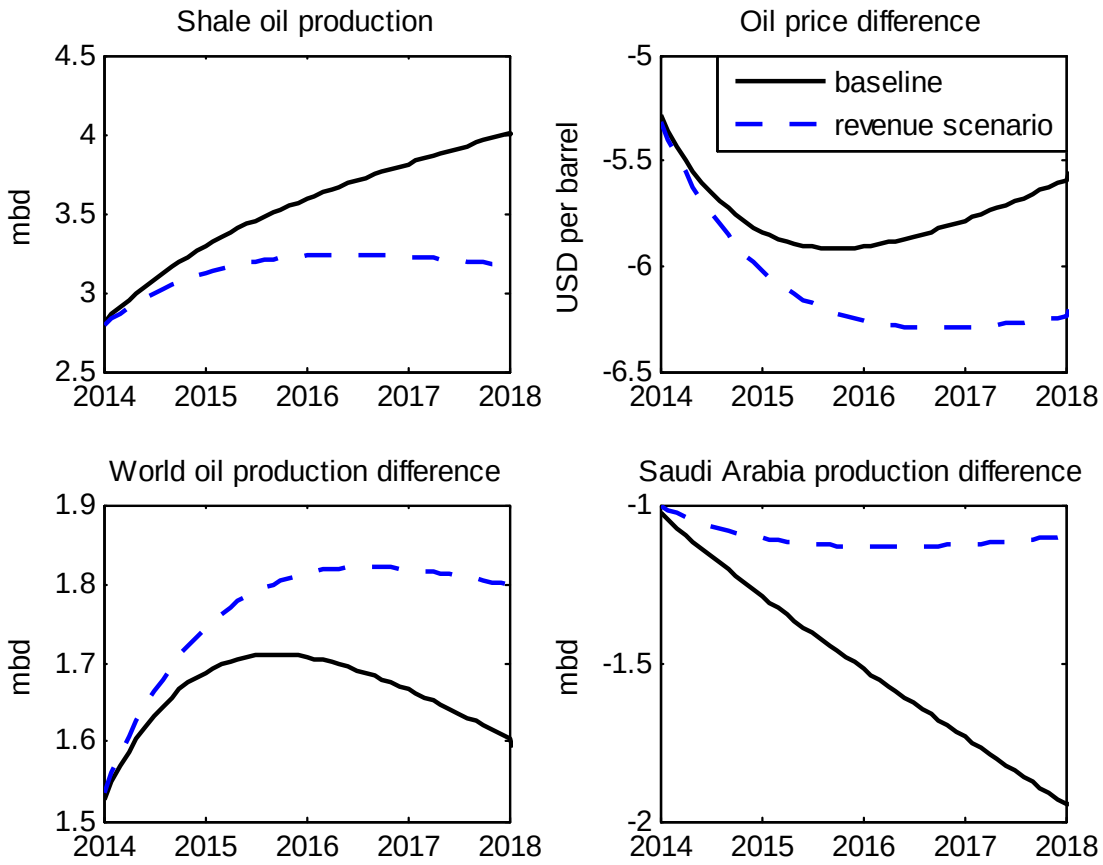


Figure: Differential effect of alternative Saudi Arabia production scenarios All the figures represent differences compared to the counterfactual scenario of no shale production.

Saudi Arabia's profits would sufffer in this case

Due to the increase in costs

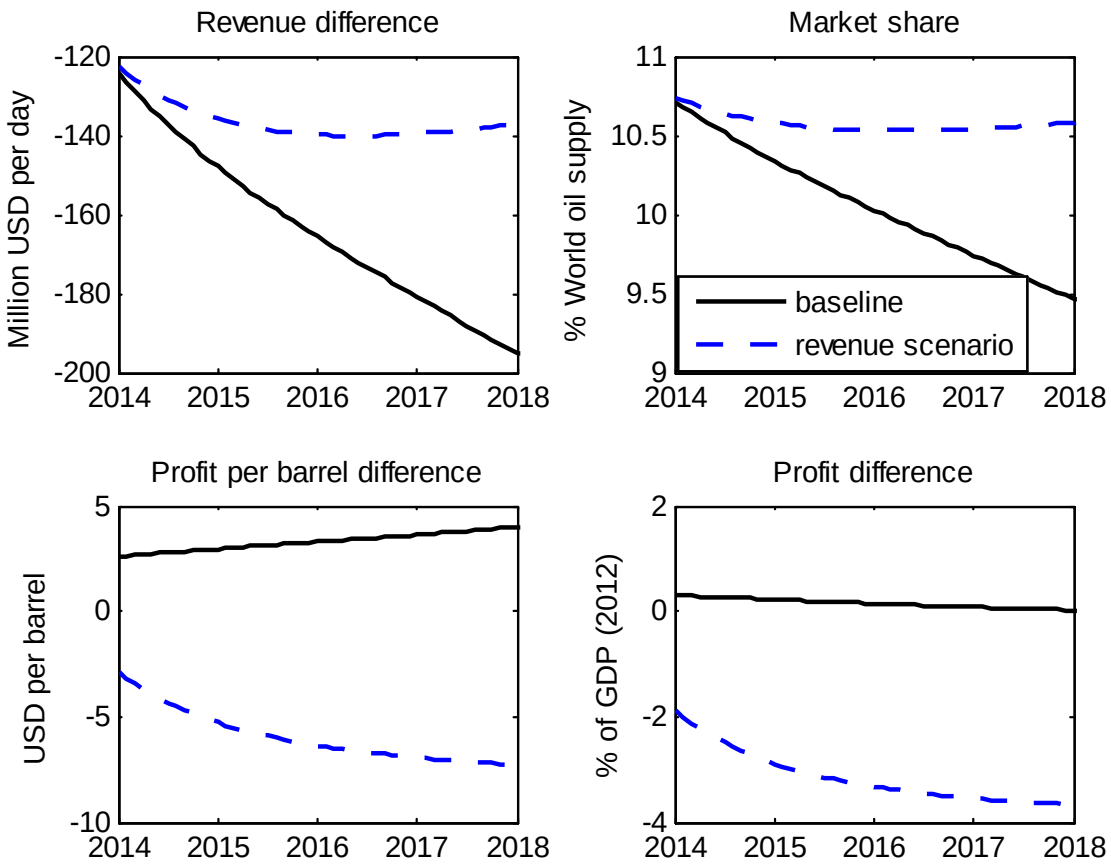


Figure: Domestic effect of alternative Saudi Arabia production scenarios.

Conclusions

- The shale oil revolution may have a major role in the US economy, but its impact on the oil market is expected to be moderate.
- Numerical estimates using a DSGE model suggest that it has produced a fall in prices of USD5 per barrel, already priced in.
- Looking forward, different scenarios by 2018 imply changes of less than ±USD4 per barrel.