The macroeconomic effects of oil supply news: Evidence from OPEC announcements

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Introduction

Motivation

- Recent turbulences in the oil market have sparked **renewed interest** in the question of how **oil prices** affect the **macroeconomy**

Motivation

- Answering this question is **challenging** because
  - Oil prices are **endogenous**
  - **Not** all oil price shocks are **alike**
- The literature has focused on **oil supply** and **demand**
- Less attention has been devoted to **oil market expectations**
  - Mainly because identifying shocks to expectations is difficult

This paper

- Propose a novel approach to identify a shock to **oil supply expectations**, exploiting **institutional features of OPEC** and **high-frequency data**
  - Isolate exogenous variation in oil price by looking at how oil futures prices change around *OPEC announcements*
  - Use as an *instrument* in an oil market VAR to identify oil market shock
- Shock is best thought of as a **news shock** about future **oil supply**

Preview of results

- **Oil supply news** leads to an *immediate* increase in **oil prices**, a *gradual* fall in **oil production**, a significant *increase* in **oil inventories** and a fall in **global activity**
- This has consequences for the **US economy**: **industrial production** falls and **consumer prices** rise significantly
- Also leads to higher **inflation expectations** and a depreciation of the **dollar** but has no effect on **uncertainty**

Related literature

- **Macroeconomic effects of oil market shocks**: Hamilton (2003); Kilian (2009); Baumeister and Peersman (2013); Kilian and Murphy (2012, 2014); Juvenal and Petrella (2015); Antolín-Díaz and Rubio-Ramírez (2018); Caldara, Cavallo, and Iacoviello (2019); Baumeister and Hamilton (2019)
- **High-frequency identification of MP shocks**: Kuttner (2001); Gürkaynak, Sack, and Swanson (2005); Gertler and Karadi (2015); Nakamura and Steinsson (2018)
- **Event studies on OPEC announcements**: Draper (1984); Loderer (1985); Demirer and Kutan (2010); Lin and Tamvakis (2010), Loutia, Mellios, and Andriosopoulos (2016)
- **News and business cycles**: Barsky and Sims (2011); Beaudry and Portier (2014); Ramey (2011); Leeper, Walker, and Yang (2013); Arezki, Ramey, and Sheng (2017); Gambetti and Moretti (2017)

Identification

Identification

- Oil market has a *peculiar* structure
  - Market dominated by big player, **OPEC**, that reveals **information** about **future supply** in **lumpy** way
  - Very **liquid** futures markets for oil

  ▸ Details
- This motivates the use of **high-frequency identification** techniques
- **Idea:** Identify **oil supply surprises** from changes in oil futures prices in tight window around OPEC announcements
- Similar to high-frequency identification of *monetary policy shocks*

Example

OPEC announcement

Having reviewed the oil market outlook, including the overall demand/supply expectations for the year 2007, in particular the first and second quarters, as well as the outlook for the oil market in the medium term, the Conference observed that market fundamentals clearly indicate that there is more than ample crude supply, high stock levels and increasing spare capacity. [...]

In view of the above, the Conference decided to reduce OPEC production by a further 500,000 b/d, *with effect from 1 February 2007, in order to balance supply and demand.*

Source: Announcement from the 143rd meeting of the OPEC conference (14 Dec 2006)

Example cont.

Market reaction

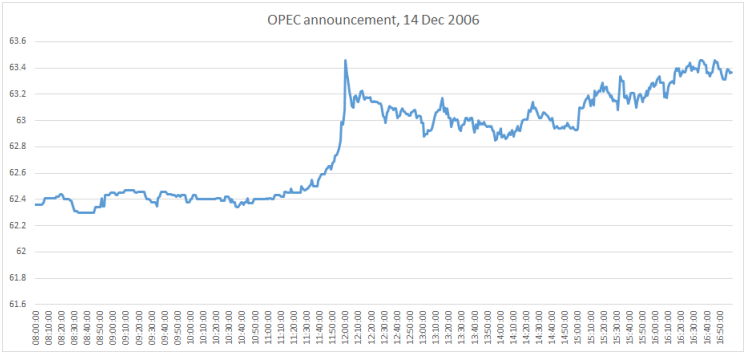


Figure 1: Oil futures prices (1-month WTI crude) around announcement on 14 December 2006

Construction of oil supply surprises

- Collected **OPEC press releases** for the period 1983-2017
  - Total of 119 announcements
- Compute **oil supply surprises**:

$$Surprise^{h}_{t,d} = F_{t+h,d} - F_{t+h,d-1},$$

where $F_{t+h,d}$ is log settlement price of h-month ahead WTI crude contract on announcement day d in month t

- Aggregate surprises to **monthly** series

$$Surprise^{h}_{t} = \begin{cases} Surprise^{h}_{t,d} & \text{if one announcement} \\ \sum_i Surprise^{h}_{t,d_i} & \text{if multiple announcements} \\ 0 & \text{if no announcements} \end{cases}$$

Construction of oil supply surprises

- Key assumptions:
  - **Announcements** *only* contain information about **future supply**
  - **Risk premia** are *constant* over window

  $\Rightarrow$ Surprise series captures *changes in expectations* driven by **news** about **future supply**

- Important choice: **maturity** of the contract, h
  - To sharpen interpretation of news shock about **future** supply, use **6-month** contract as benchmark
  - Results are *robust* to other choices

Oil supply surprise series

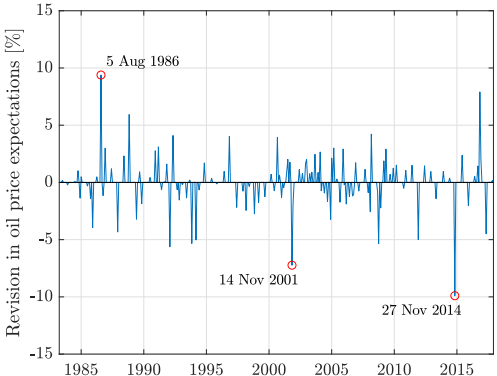


Figure 2: Oil supply surprise series constructed from changes in oil futures prices (principal component spanning first year of WTI crude term structure) around OPEC announcements

Oil supply surprise series

- Accords well with narrative accounts on **historical episodes**
- No evidence for autocorrelation
- Not forecastable by macroeconomic or financial variables
- Uncorrelated with measures of **other structural shocks** (e.g. global demand or uncertainty shocks)

▸ Properties

Background noise

- Trade-off between capturing entire response to announcement and other confounding news
- Daily surprises could be subject to background noise

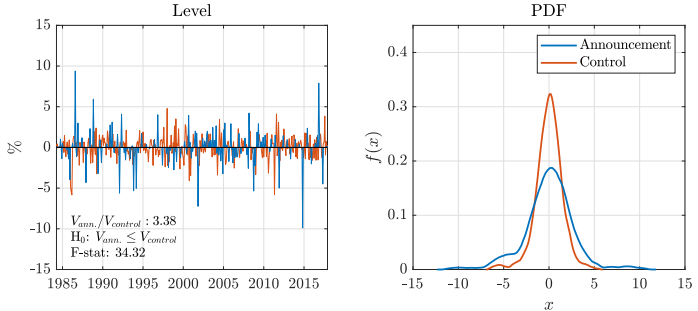


Figure 3: Announcement versus control days

- Variance on OPEC days significantly **larger**

Econometric framework

Econometric framework

- **Oil supply surprise series** has good properties but is likely only imperfect shock measure
- **Solution:** use the series as an instrument in proxy VAR to identify **oil supply news shock**
  - Allows for *measurement error* in the instrument
  - Can trace out responses of financial and macro variables jointly

Proxy VAR

- Structural VAR

$$\mathsf{y}_t = \mathsf{b} + \mathsf{B}_1 \mathsf{y}_{t-1} + \cdots + \mathsf{B}_p \mathsf{y}_{t-p} + \mathsf{S}\boldsymbol{\varepsilon}_t, \qquad \boldsymbol{\varepsilon}_t \sim N(0, \boldsymbol{\Omega})$$

- Identification based on **external instruments** (Stock and Watson, 2012; Mertens and Ravn, 2013)
  - **External instrument:** variable *correlated* with the **shock of interest** but *not* with the **other shocks**

$$\mathbb{E}[z_t \varepsilon_{1,t}] = \alpha \neq 0 \qquad \text{(Relevance)}$$
$$\mathbb{E}[z_t \boldsymbol{\varepsilon}_{2:n,t}] = 0, \qquad \text{(Exogeneity)}$$

- Use **oil supply surprise series**, $\mathit{Surprise}_t^h$, as *external instrument*, z_t, for **oil price**

Model specification

- y_t includes real oil price, world oil production, world oil inventories, world industrial production, US IP, US CPI
- Estimation sample: 1974M1-2017M12
- Identification sample: 1983M2-2017M12
- VAR is estimated in (log) levels
- Lag order: $p = 12$

▸ Data

Results

First stage

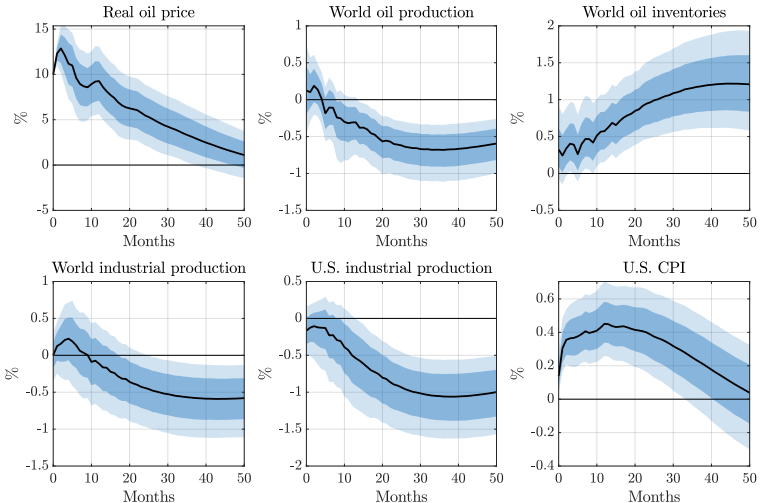
Table 1: Strength of the instrument

	1M	2M	3M	6M	9M	12M	COMP
Coefficient	0.946	0.981	1.016	1.070	1.123	1.098	1.085
F-stat	24.37	24.25	24.33	22.90	22.35	13.58	22.67
F-stat (robust)	12.01	11.86	11.92	11.32	11.11	7.49	10.55
R^2	4.53	4.51	4.52	4.27	4.17	2.57	4.22
R^2 (adjusted)	4.34	4.32	4.33	4.08	3.98	2.38	4.04
Observations	516	516	516	516	516	516	516

Notes: First-stage regressions of oil price residual on proxies. F-stats above 10 indicate strong instruments.

- High-frequency surprises are **strong instruments** for oil price

Baseline results



First stage regression: F: 22.67, robust F: 10.55, R^2: 4.22%, Adjusted R^2: 4.04%

Figure 4: IRFs to oil supply news shock (one sd). Dashed lines are 90% CIs.

Baseline results

- Shock leads to a large, **immediate increase** in oil prices, **sluggish fall** in oil production and significant **increase** in oil inventories
  $\Rightarrow$ consistent with interpretation of a **news shock** about oil supply
- Global activity falls persistently
- This has consequences for the U.S. economy:
  - Industrial production **falls** and consumer prices **rise** significantly
- Changes in **oil supply expectations** have **powerful effects** even if current oil production does not move

Historical decomposition

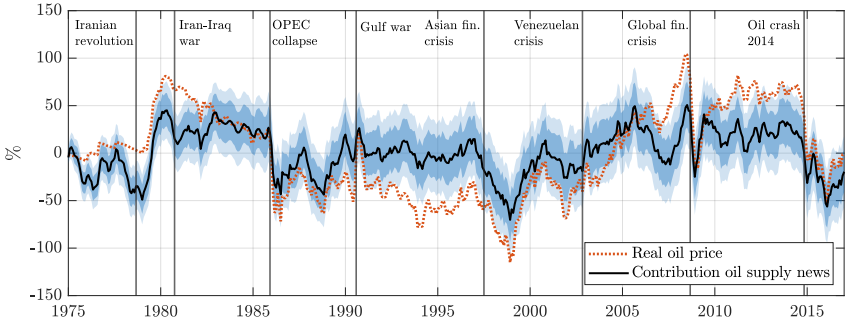


Figure 5: Historical decomposition. Dashed lines are 90% CIs.

- **Oil supply news** have contributed meaningfully to historical variations in oil price
- Events in the Middle East affect the oil price not only through *current* supply but also changes in **supply expectations**

Propagation channels

- To get a better understanding on **how** the **shock propagates**, study the effects on a **wide range** of financial and macroeconomic variables
- Implemented by augmenting baseline VAR by one variable at a time and computing impulse response

Propagation channels

Oil supply news lead to

- higher oil price and inflation expectations, but do not affect uncertainty
- higher consumer prices, even after excluding energy
- lower economic activity, broadly defined
- depreciation of dollar and deterioration of terms of trade and trade balance

News versus uncertainty

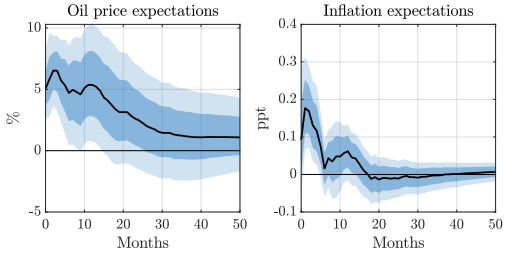


Figure 6: Expectations and uncertainty measures ▸ More

Propagation channels

Oil supply news lead to

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Prices

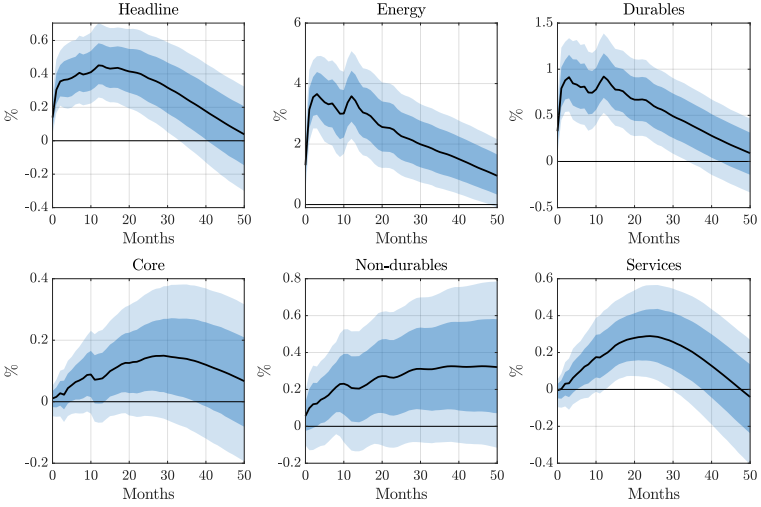

Figure 7: Core CPI and CPI components

Propagation channels

Oil supply news lead to

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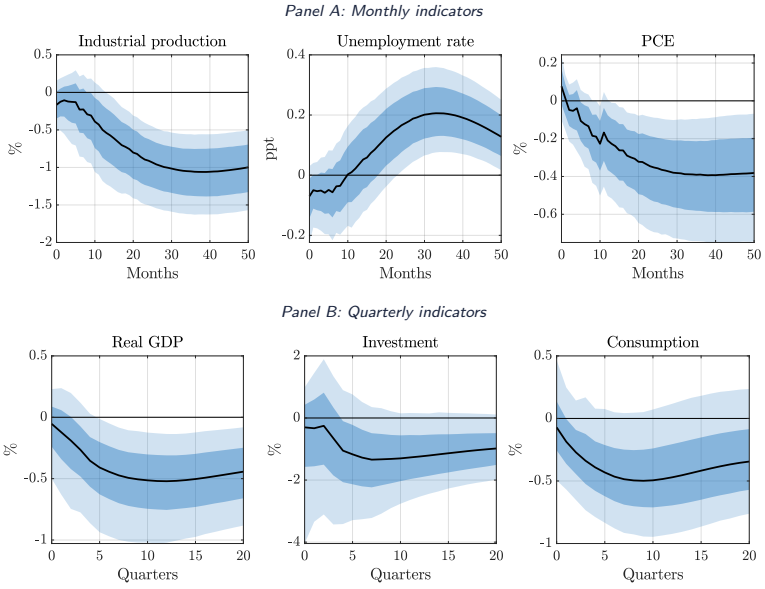
- lower economic activity, broadly defined
- depreciation of dollar and deterioration of terms of trade and trade balance

Economic activity



Propagation channels

Oil supply news lead to

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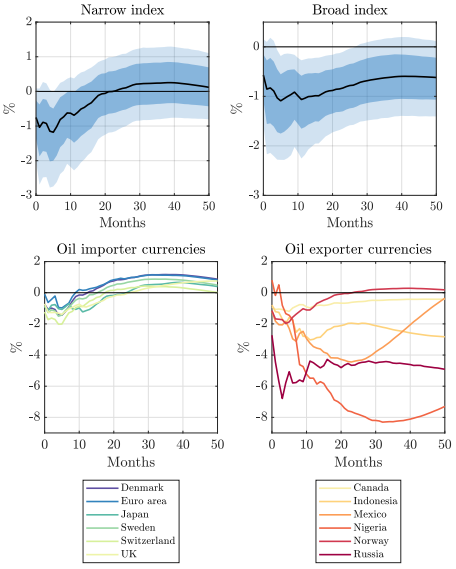
Exchange rates and trade



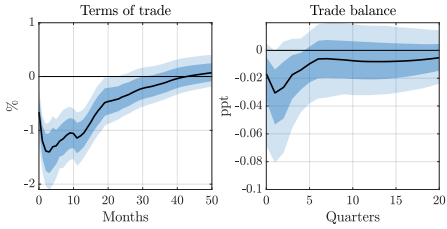


Figure 10: Exchange rates and trade

Robustness

Perform a battery of robustness tests

- **Identification**: Background noise, informationally robust instrument, futures contract, announcement type, two-shock proxy VAR, placebo

  ▸ Details on identification

- **Model specification**: local projections, variable selection, controls

  ▸ Details on specification

- **Sample period**: excluding 70s, pre-Great Recession, pre-Shale oil revolution

  ▸ Sub-sample analysis

$\Rightarrow$ Results turn out to be robust

Conclusion

Conclusion

- Propose a novel approach to identify **oil supply news** shocks, *combining* HFI literature with traditional oil market VARs
- Evidence for a **strong channel** operating through **supply expectations**
- Provides **new insights** to the debate on the **drivers** of **oil price** fluctuations and their **effects** on the **macroeconomy**
- Underlines the potential of the high-frequency identification approach

Thank you!

Institutional background

- **OPEC** is an intergovernmental organization of *oil producing nations*
  - Accounts for about **44%** of **world oil production**
  - Founded in 1960 by Iran, Iraq, Saudi Arabia and Venezuela
- Supreme authority is the **OPEC conference**, consisting of delegations headed by oil ministers of member countries
  - Meets *several times a year* to agree on **oil production plans**, including **production quotas** for the organization and its members
  - Decisions of the conference take the form of an **announcement**, issued shortly after the meeting

Institutional background

- Crude oil is an *internationally* traded commodity $\Rightarrow$ **liquid futures markets**
- Most widely traded contracts: WTI crude and Brent crude futures
- Focus on **WTI crude**
  - First traded futures on crude oil, **longest history** (started trading in 1983)
  - Most *liquid* and largest volume market for crude oil (currently trading nearly 1.2 million contracts a day)
  - Relevant benchmark for the US

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Surprise series: autocorrelation

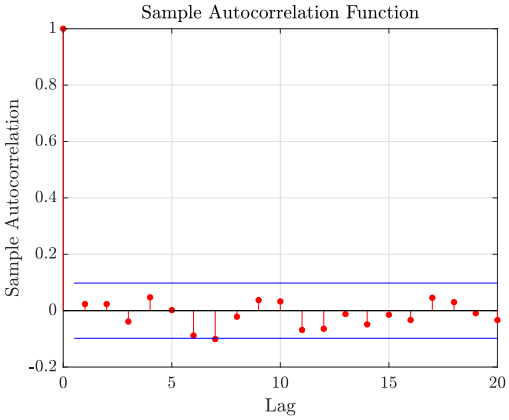

Figure 11: The autocorrelation function of the oil supply surprise series

Surprise series: forecastability

Table 2: Granger causality tests

Variable	p-value
Instrument	0.3749
Oil price	0.4846
World oil production	0.7481
World oil inventories	0.6882
World industrial production	0.9502
US industrial production	0.9342
US CPI	0.7641
Fed funds rate	0.8849
S&P 500	0.1865
NEER	0.7282
Geopolitical risk	0.1526
Joint	0.7342

Surprise series: correlation with other shocks

Shock	Source	ρ	p-value	n	Sample
Panel A: Oil shocks					
Oil price	Hamilton (2003)	0.06	0.17	492	1977M01-2017M12
Oil supply	Kilian (2008)	-0.05	0.38	369	1974M01-2004M09
	Caldara et al. (2019)	-0.02	0.74	372	1985M01-2015M12
	Baumeister and Hamilton (2019)	-0.08	0.09	515	1975M02-2017M12
	Kilian (2009)	0.08	0.09	395	1975M02-2007M12
Global demand	Kilian (2009)	0.03	0.51	395	1975M02-2007M12
Oil-specific demand	Kilian (2009)	0.17	0.00	395	1975M02-2007M12
Panel B: Other shocks					
Productivity	Basu et al. (2006)	-0.04	0.66	152	1974Q1-2011Q4
	Smets and Wouters (2007)	-0.06	0.50	124	1974Q1-2004Q4
News	Barsky and Sims (2011)	-0.14	0.12	135	1974Q1-2007Q3
	Kurmann and Otrok (2013)	-0.03	0.76	126	1974Q1-2005Q2
	Beaudry and Portier (2014)	0.04	0.61	155	1974Q1-2012Q3
Monetary policy	Gertler and Karadi (2015)	0.07	0.20	324	1990M01-2016M12
	Romer and Romer (2004)	-0.00	0.99	276	1974M01-1996M12
	Smets and Wouters (2007)	0.04	0.64	124	1974Q1-2004Q4
Uncertainty	Bloom (2009)	0.01	0.87	522	1974M07-2017M12
	Baker et al. (2016)	0.07	0.15	390	1985M07-2017M12
Financial	Gilchrist and Zakrajšek (2012)	0.02	0.70	498	1974M07-2015M12
	Bassett et al. (2014)	0.12	0.30	76	1992Q1-2010Q4
Fiscal policy	Romer and Romer (2010)	0.03	0.77	136	1974Q1-2007Q4
	Ramey (2011)	0.07	0.39	148	1974Q1-2010Q4
	Fisher and Peters (2010)	0.05	0.55	140	1974Q1-2008Q4

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Data

Table 3: Data description and sources

Identifier	Variable name	Source
Instrument		
NCLC.0h (PS)	WTI crude *h*th contract (settlement price)	Datastream
NCLC.0h (VM)	WTI crude *h*th contract (traded volume)	Datastream
Baseline variables		
WTISPLC	WTI spot crude oil price, deflated by US CPI	FRED
EIA1955	World oil production	Datastream
OILINV	OECD oil inventories (proxy)	Kilian & Murphy
OECD+6IP	IP of OECD and 6 major countries	Baumeister & Hamilton
INDPRO	US industrial production index	FRED
CPIAUCSL	US CPI for all urban consumers: all items	FRED

Data

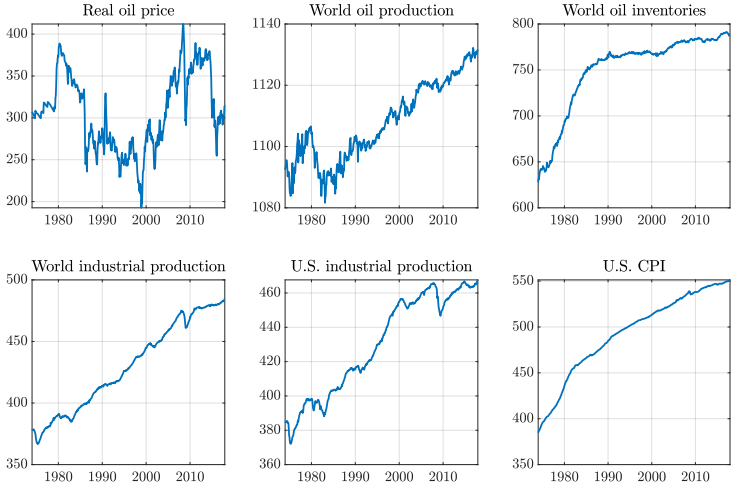

Figure 12: Series included in the VAR over the sample period 1974-2015

Inflation expectations

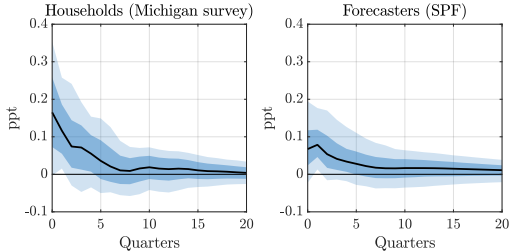

Figure 13: Inflation expectations

- **Differential** effects between **households** and **professional forecasters**
- Response of SPF expectations **much weaker**, in line with recent literature on role of oil prices and expectations in inflation dynamics (Coibion, Gorodnichenko, and Kamdar, 2018; Hasenzagl et al., 2018)

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Economic activity

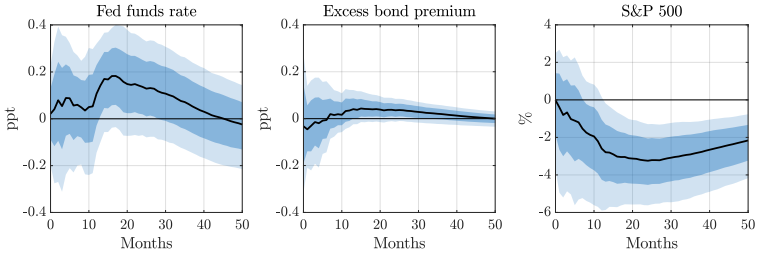


Figure 14: Monetary policy and financial variables

- No significant effects on **monetary policy** and **financial conditions**
- Significant fall of **stock market index**

Economic activity

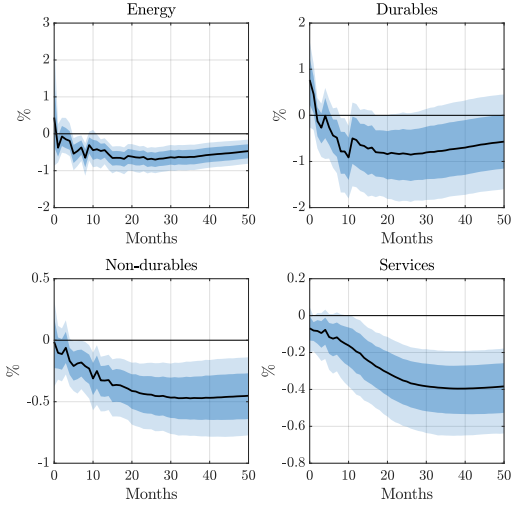


Figure 15: Consumption expenditures

Back

Background noise

- Could other shocks during the event window confound the surprise series?
  - Potentially relevant as we are using daily event window
- Formally account for background noise using heteroskedasticity-based identification strategy à la Rigobon (2003)

Background noise

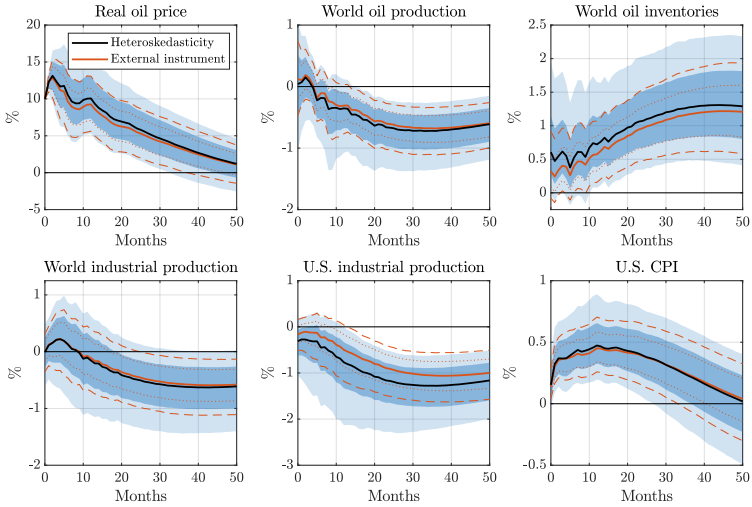


Figure 16: Heteroskedasticity-based identification

Informationally robust instrument

- Do announcements **only** contain **news about future supply**?
  - For interpretation, it is *crucial* that they do **not** contain new information about **other factors**, e.g. **global oil demand**
- To mitigate this concern, construct **informationally robust** instrument, akin to Romer and Romer (2004) refinement of monetary policy shocks

Informationally robust instrument

Two steps

- Collect OPEC's **global demand forecasts** published in OPEC oil market reports
- Construct **refined instrument** as residual of the following regression

$$Surprise_m = \alpha_0 + \sum_{j=-1}^{2} \theta_j F_m^{OPEC} y_{q+j} + \sum_{j=-1}^{2} \varphi_j [F_m^{OPEC} y_{q+j} - F_{m-1}^{OPEC} y_{q+j}] + IRS_m$$

Informationally robust instrument

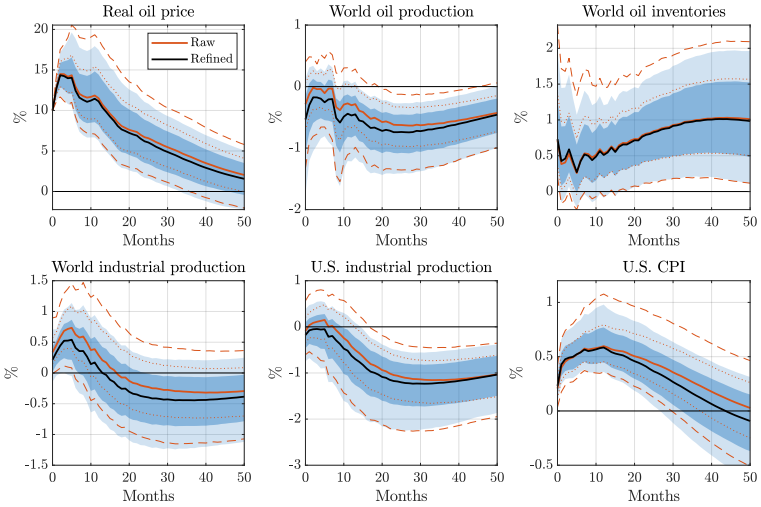
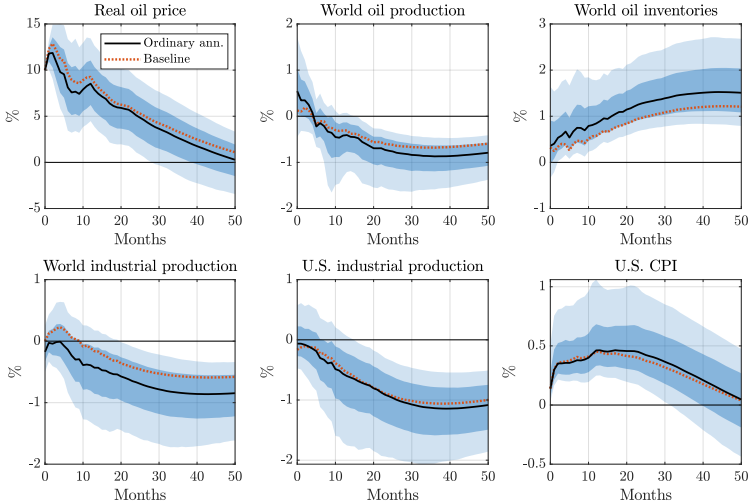


Figure 17: Refined, informationally robust surprise series

Ordinary announcements

- Large part of the OPEC meetings were **extraordinary** meetings, scheduled *in response* to macroeconomic or geopolitical developments
  $\Rightarrow$ Potential endogeneity problem
- As robustness, only use **ordinary** meetings

Ordinary announcements



First stage regression: F: 9.75, robust F: 4.46, R^2: 1.86%, Adjusted R^2: 1.67%

Figure 18: Ordinary announcements only

News and surprise shocks

- Is the instrument **only correlated** with oil supply **news shock**? Or does it also capture conventional, **unanticipated supply shocks**?

  $\Rightarrow$ Exogeneity assumption might be violated
- To mitigate this concern, **identify an oil supply surprise and news shock jointly**, using Kilian's (2008) exogenous supply shock measure and my oil supply surprise series
  - Additional identifying assumption: oil supply news shock does **not** affect oil production **on impact**

News and surprise shocks

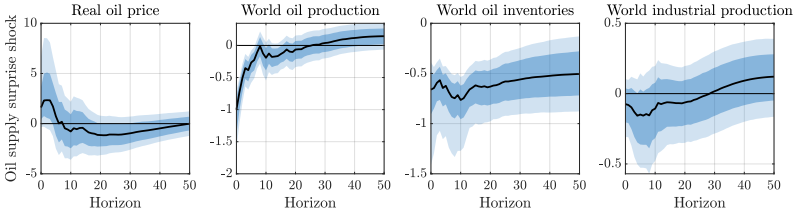


Figure 19: Oil supply surprise and news shocks

Futures contracts

- A crucial choice was the maturity of the futures contract
  - As a benchmark, used **6-month** contract
- Are results robust to using **other maturities**?

Futures contracts

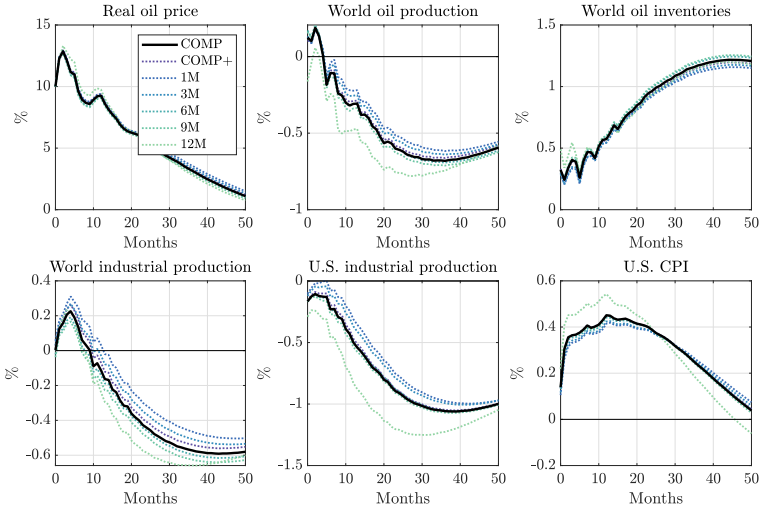
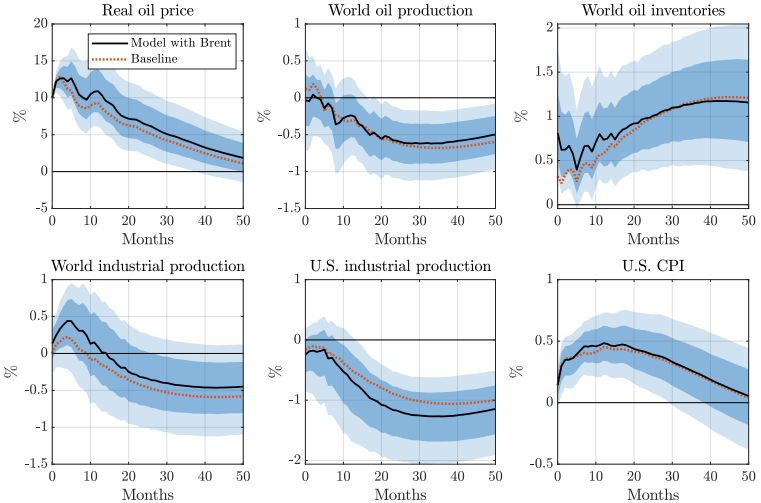


Figure 20: Different maturities of futures contracts

Futures contracts

- Since the shale oil revolution, WTI has become less representative for the global price of oil
- Are the results robust to using Brent instead?

Futures contracts



First stage regression: F: 10.27, robust F: 5.56, R^2: 1.96%, Adjusted R^2: 1.77%

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Figure 21: Brent spot and futures prices

Local projections

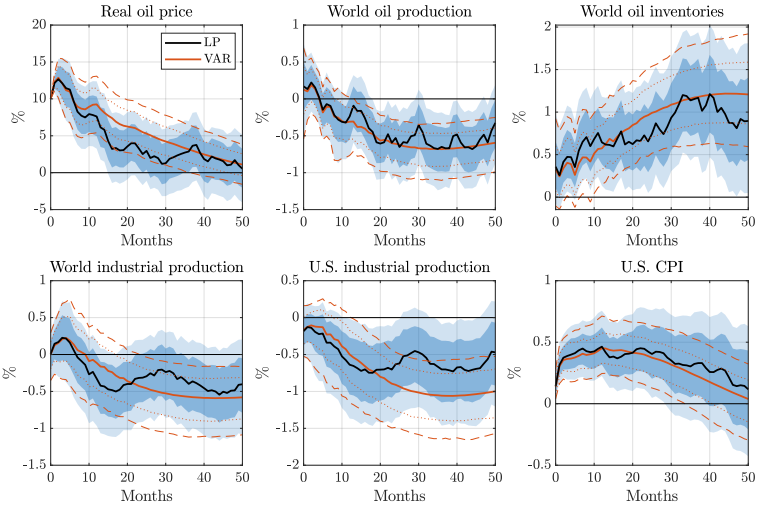


Figure 22: Local projections on shock series

Local projections

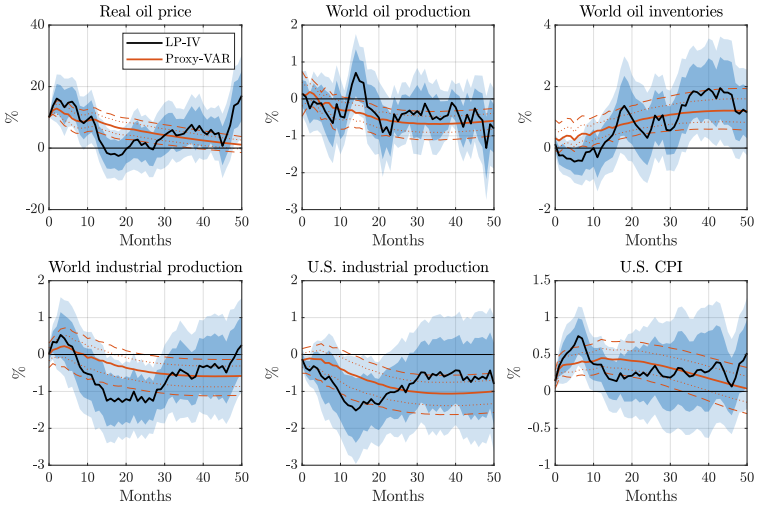
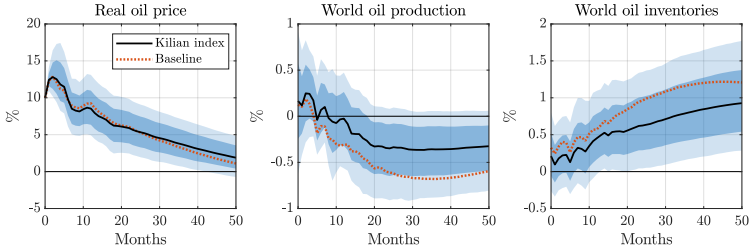


Figure 23: LP-IV using surprise series

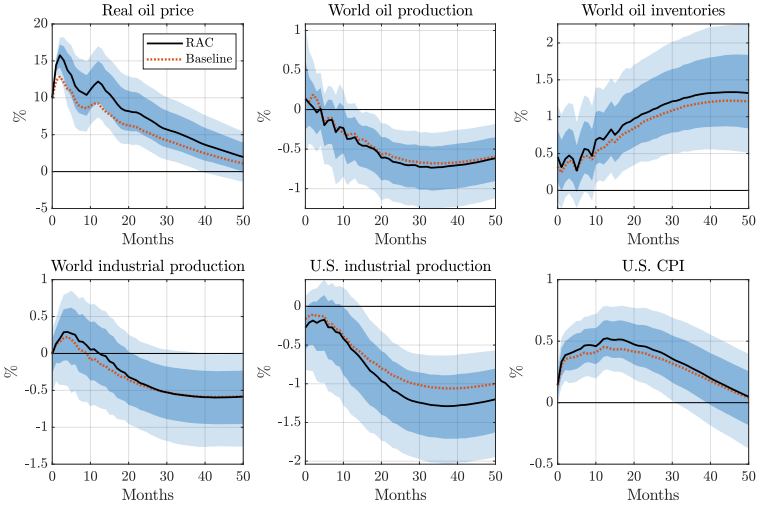
Variable selection



First stage regression: F: 22.05, robust F: 13.63, R^2: 4.41%, Adjusted R^2: 4.21%

Figure 24: Kilian's (2009) global activity indicator

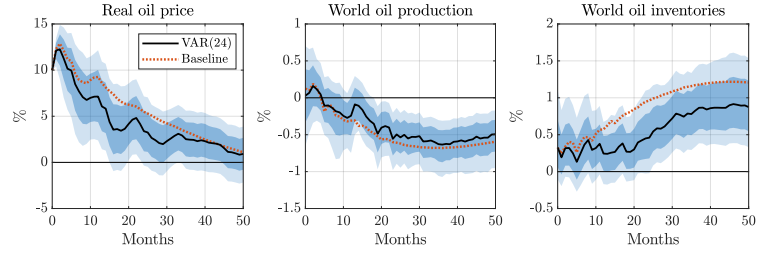
Variable selection



First stage regression: F: 15.19, robust F: 9.55, R^2: 2.87%, Adjusted R^2: 2.68%

Figure 25: Refiner acquisition costs as oil price indicator

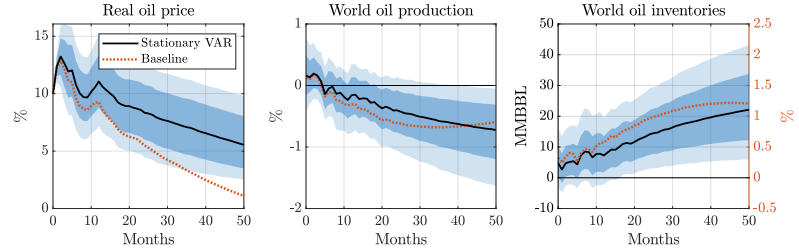
Lag order



First stage regression: F: 20.98, robust F: 11.17, R^2: 4.01%, Adjusted R^2: 3.82%

Figure 26: Lag order: 24 lags

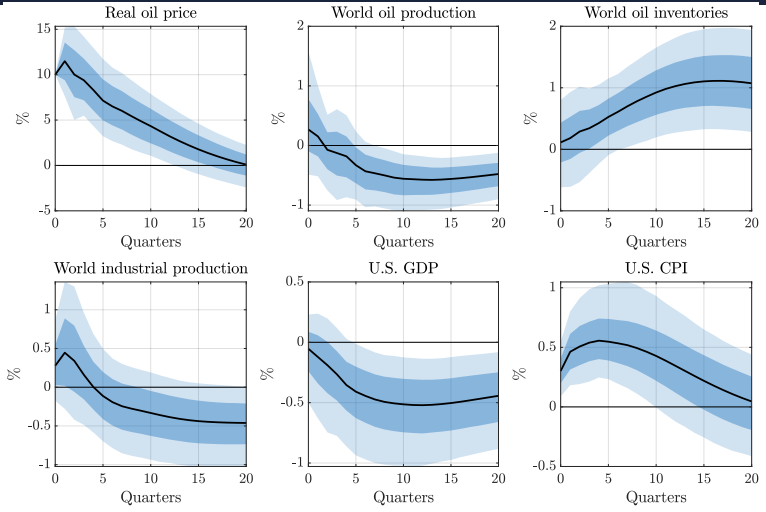
Stationary VAR



First stage regression: F: 22.89, robust F: 11.60, R^2: 4.26%, Adjusted R^2: 4.08%

Figure 27: Stationary VAR

Quarterly model

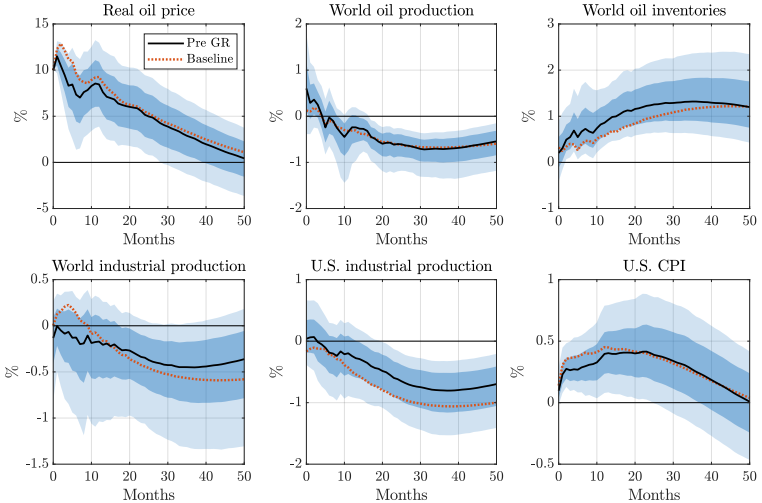


First stage regression: F: 10.92, robust F: 6.96, R^2: 6.03%, Adjusted R^2: 5.48%

Figure 28: Quarterly data

Back

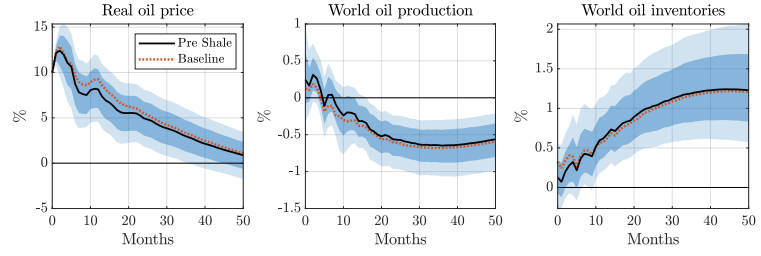
Sub-sample analysis: pre Great Recession



First stage regression: F: 15.79, robust F: 8.66, R^2: 3.85%, Adjusted R^2: 3.61%

Figure 29: Exclude Great Recession period

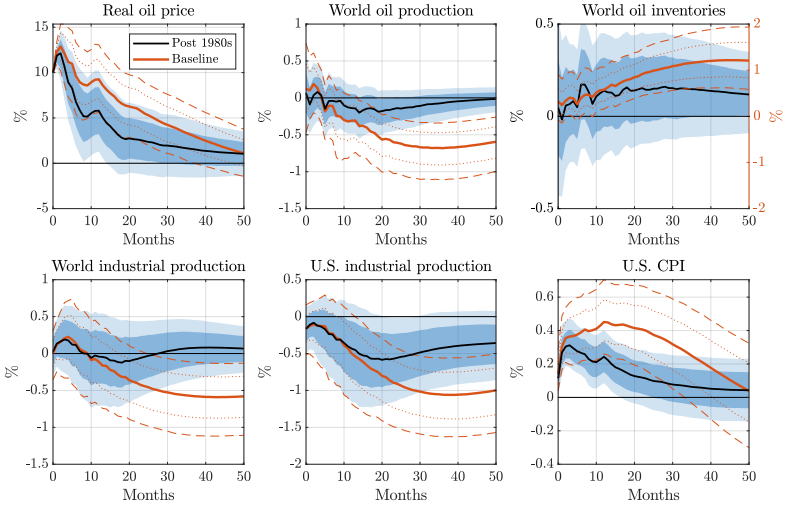
Sub-sample analysis: pre shale oil



First stage regression: F: 29.13, robust F: 18.65, R^2: 6.35%, Adjusted R^2: 6.13%

Figure 30: Exclude shale oil revolution

Sub-sample analysis: post 70s



First stage regression: F: 19.78, robust F: 11.51, R^2: 4.55%, Adjusted R^2: 4.32%

Figure 31: Exclude the 1970s