The Impact of Forward Guidance on the Crude Oil Market

Xiaohan Ma[1] **Xuhui (Nick) Pan**[2]

[1]Texas Tech University

[2]University of Oklahoma

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Motivation: Transmissions of Monetary Policy

- How monetary policies transmit in the real economy and financial markets?
  - Uncertain answers despite decades of empirical research and many methodological advances
- Crude oil provides an unique opportunity to address this question.
  - Real oil price is an important economic state variable
  - Crude oil has the largest and most liquid commodity derivatives market
- Main challenges:
  - Both monetary policies and oil prices are endogenously determined in the economy
  - Measuring monetary policy shocks (MPS) is difficult, especially after the Zero Lower Bound (ZLB)

Our Approach

- Infer the causality from monetary policy shocks to oil price changes.
  - Differentiate conventional vs. unconventional monetary policy shocks (Swanson, 2021)
  - High-frequency regression around the FOMC announcement window
  - High-frequency identification of a structural VAR model
  - Contrast pre- with post-ZLB periods
- Investigate the impact of monetary policy shocks on the crude oil futures market.

Main Results

- Unconventional monetary policy, especially forward gudiance, has significant impacts on the crude oil market after the ZLB period.
- An unexpected easing in forward guidance
  - raises oil prices around the FOMC annuncement window
  - increases real oil prices in SVAR and the impacts last up to one year
  - predicts higher crude oil futures returns, even after controlling for other predictors
- We rationalize these empirical findings with a calibrated New-Keynesian model.

Related Literature

- Transmissions of monetary policies, especially forward guidance, in the real economy and financial markets (including oil)
  - Gertler and Karadi (2015); Paul (2020); Coibion, Georgarakos, Gorodnichenko, and Weber (2020); Gürkaynak, Karasoy-Can, and Lee (2022)
  - Basistha and Kurov (2015); Rosa (2014); Anzuini, Lombardi, and Pagano (2013)
- How do macroeconomic news affect the crude oil market?
  - Kilian and Vega (2011); Datta, Johannsen, Kwon, and Vigfusson (2021); Känzig (2021)
- The interaction between crude oil futures and real economy
  - Hong and Yogo (2012); Gao, Hitzemann, Shaliastovich, and Xu (2022); Christoffersen, Jacobs, and Pan (2022)

Monetary Policy Shocks

- Swanson (2021) constructed monetary policy shocks for each FOMC announcement using a baseket of high-frequency interest rate derivatives
  - Shocks in federal fund rate (FFR): short-term
  - Shocks in forward guidance (FG): the future path of the FFR over the next several quarters
  - Shocks in large-scale asset purchases (LSAPs): longer term
- July 1991 to June 2019, 241 FOMC announcements in total

Oil Market Data

- Oil market
  - Global supply and demand
  - Real oil price (inflation-adjusted acquisition cost of U.S. crude oil imports)
- Crude oil futures
  - High frequency data of the front month contract
  - End-of-day data from the CME (to construct oil futures returns with various maturities)
  - Other control variables

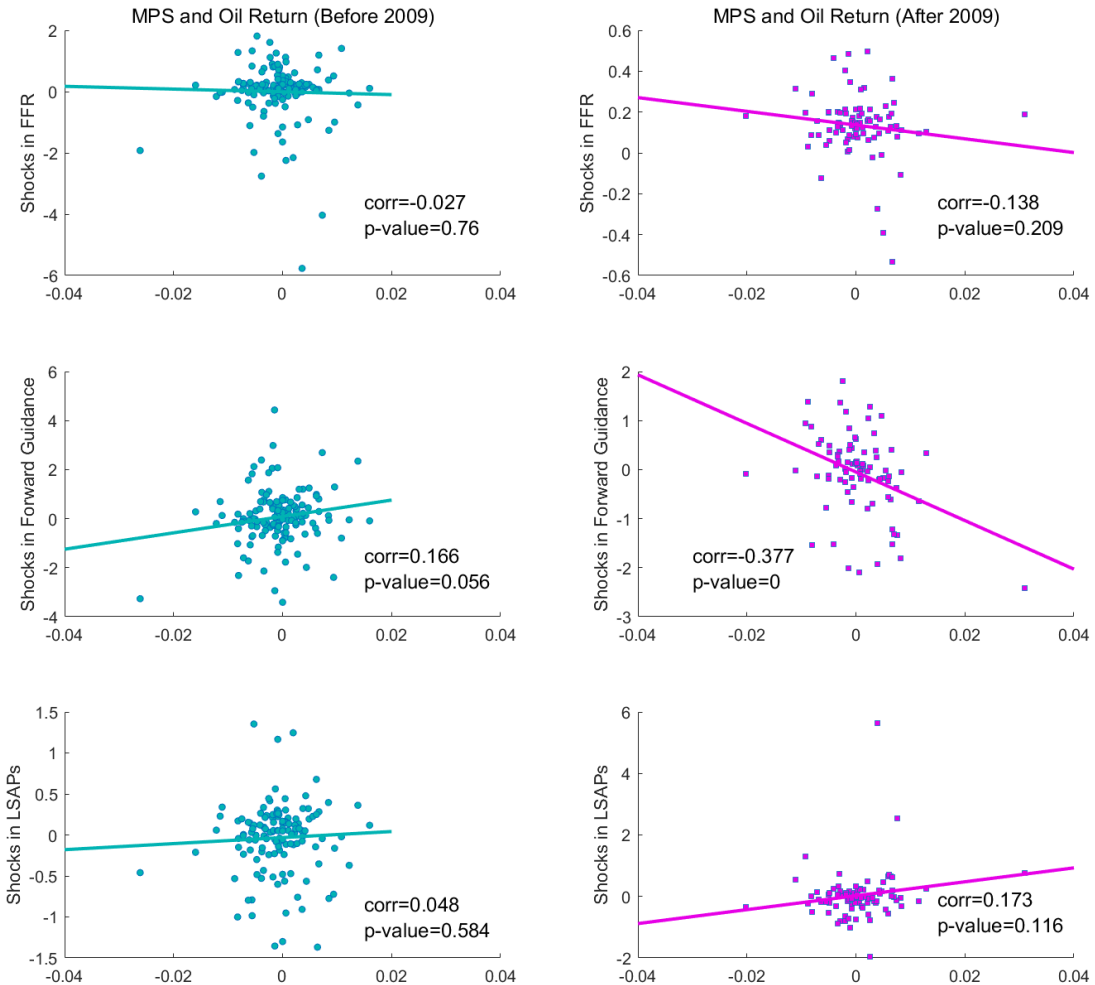
Monetary Policy Shocks and Oil Returns

Summary Statistics around the FOMC Announcement Window.

	Mean	Std Dev	AR(1)	Corrlation with		
				Oil Ret	FFR	FG
Panel A: 1993m1 -2008m12						
Oil Ret	-0.070%	0.006	-0.002	1		
FFR	-0.005	0.943	-0.055	-0.027	1	
FG	0.065	1.126	-0.131	0.166	-0.091	1
LSAPs	-0.035	0.430	0.202	0.048	0.090	0.266
Panel B: 2009m1 - 2019m6						
Oil Ret	0.052%	0.006	-0.100	1		
FFR	0.134	0.152	0.036	-0.138	1	
FG	-0.074	0.821	-0.085	-0.377	-0.018	1
LSAPs	0.035	0.820	-0.133	0.173	-0.346	-0.347

Monetary Policy Shocks and Oil Returns

Scatter Plots around the FOMC Announcement Window.



High Frequency Regression

- We estimate the OLS regression:

$$OilRet_t = \alpha + \beta * MPS_t + \varepsilon_t,$$

  where oil return is measured 10 minutes before to 20 minutes after the FOMC announcement; *MPS* are monetary policy shocks associated with each FOMC announcement t.

- Similar to Nakamura and Steinsson (2018); Swanson (2021)

High Frequency Regression (Crude Oil)

Regression Results, β.

	Panel A: Univariate Regression			**Panel B:** Multivariate Regression		
	FFR	FG	LSAPs	FFR	FG	LSAPs
1993m1 - 2008m12						
	-0.0317	0.0799		-0.0232	0.0781	
	(-0.47)	(1.17)		(-0.35)	(1.11)	
Adj. R-squared	-0.48%	1.81%		1.21%		
2009m1 - 2015m11						
		-0.3199**	0.1315**		-0.3141**	0.0108
		(-2.28)	(2.03)		(-2.07)	(0.23)
Adj. R-squared		14.53%	1.94%		12.91%	
2015m12 - 2019m6						
	-0.3071	-0.1982**	0.1411	-0.4357	-0.2376***	0.2750
	(-0.69)	(-2.19)	(0.36)	(-1.27)	(-3.18)	(0.64)
Adj. R-squared	-2.58%	5.39%	-3.20%	2.56%		

High Frequency Regression (Natural Gas)

Regression Results, β.

	Panel A: Univariate Regression			**Panel B:** Multivariate Regression		
	FFR	FG	LSAPs	FFR	FG	LSAPs
1993m1 - 2008m12						
	-0.1025**	0.0131		-0.1019**	0.0054	
	(-2.27)	(0.32)		(-2.21)	(0.13)	
Adj. R-squared	0.89%	-0.72%		0.14%		
2009m1 - 2015m11						
		-0.0144	0.0507		0.0157	0.0568
		(-0.21)	(1.03)		(0.19)	(0.94)
Adj. R-squared		-1.86%	-1.40%		-3.32%	
2015m12 - 2019m6						
	-0.1288	0.0893	0.6066	0.0171	0.0436	0.5763
	(-0.27)	(1.57)	(1.63)	(0.04)	(1.46)	(1.46)
Adj. R-squared	-3.37%	-0.56%	12.28%	6.01%		

High Frequency Regression (Other MPS)

Regression Results, β.

	MPS_BS	MPS_BS_O	MPS_NS	MPS_NS_O
1993m1 - 2008m12				
	0.7016	-0.2666	0.0700	0.0463
	(0.58)	(-0.22)	(1.04)	(0.56)
Adj. R-squared	0.01%	-0.70%	1.44%	-0.54%
2009m1 - 2015m11				
	-9.0653**	7.9058	-0.4654**	0.5545
	(-2.19)	(0.97)	(-2.20)	(1.36)
Adj. R-squared	13.69%	1.51%	12.72%	4.26%
2015m12 - 2019m6				
	-4.7552**	-3.8517	-0.2880**	-0.1952
	(-2.26)	(-0.36)	(-2.42)	(-0.35)
Adj. R-squared	6.26%	-3.02%	8.35%	-2.94%

MPS_BS: Bauer and Swanson (2023)
MPS_NS: Nakamura and Steinsson (2018)

SVAR Model

- We specify the dynamics for a vector X_t as

$$X_t = \alpha + \sum_{k=1}^{L} A_k X_{t-k} + u_t.$$

- The vector X_t contains six variables in the order of:
  1) growth in global oil production
  2) global real economic activity (proxy for aggregate demand)
  3) real oil price
  4) the shadow federal funds rate
  5) the one-year Treasury yield
  6) the ten-year Treasury yield

- Gertler and Karadi (2015), Bauer and Swanson (2023), and Swanson (2024)

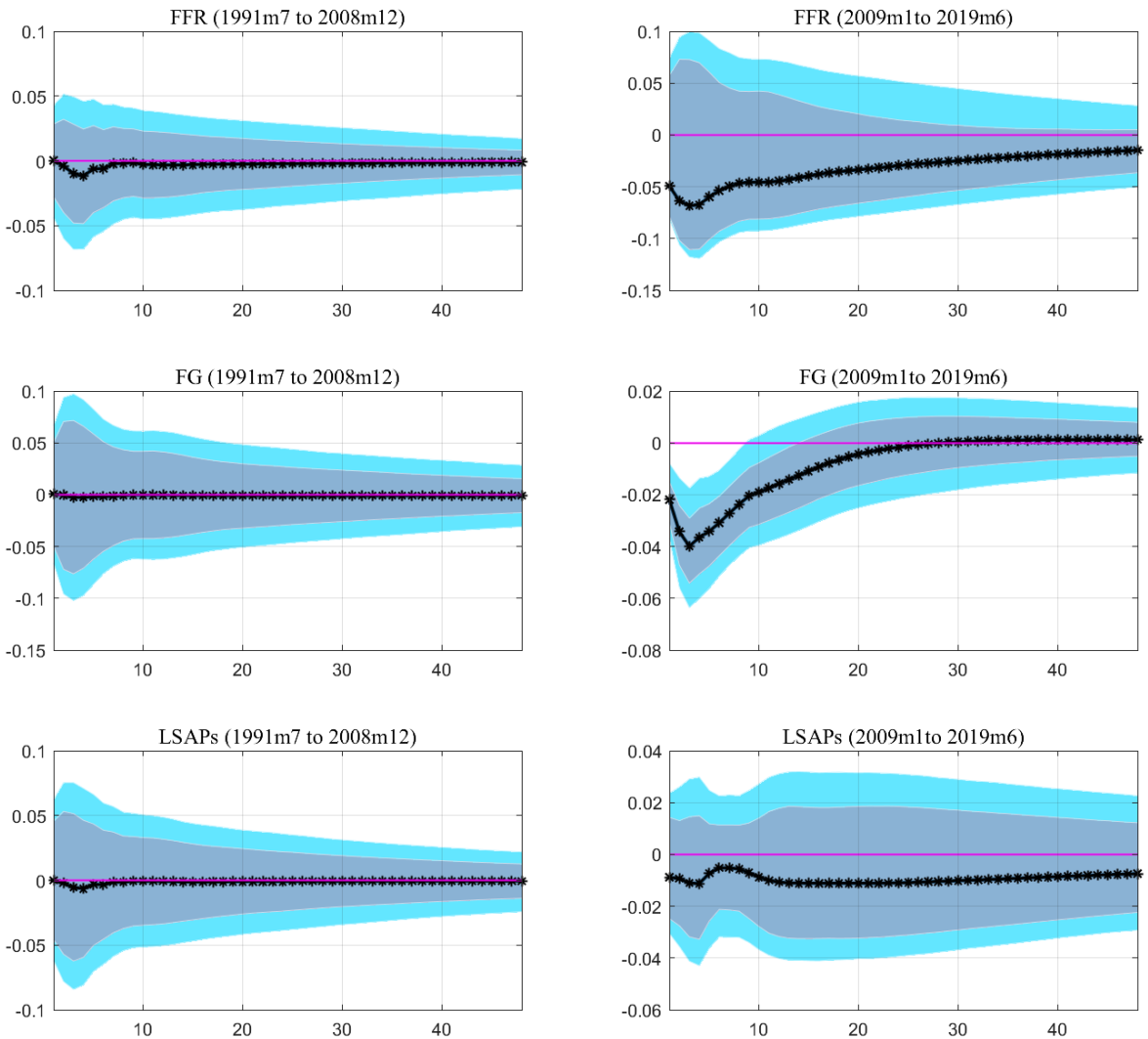
SVAR Model

- The vector ε_t captures serially uncorrelated and independent structural shocks.
- y_t: high-frequency surprise changes in monetary policy tools around the FOMC announcements.
- y_t are valid instruments to the structural shocks ε_t.

  1) $i = 1, 2, 3$ denotes the FFR, FG, and LSAPs.
  2) $E[y_t^i \varepsilon_t^i] \neq 0$ for each i.
  3) $E[y_t^i \varepsilon_t^{-i}] = 0$, where ε_t^{-i} denotes structural shocks from other elements.

Impulse Responses

Impulse Responses of Real Oil Prices to Monetary Policy Shocks.



Oil Futures Returns

Predict Crude Oil Futures Returns Using Forward Guidance Shocks.

	1-mon	3-mon	6-mon	12-mon	24-mon	36-mon	60-mon
Panel A: One-month ahead							
Forward Guidance	-0.0078	-0.0094	-0.0096	-0.0095*	-0.0084	-0.0064	-0.0049
	(-0.95)	(-1.28)	(-1.52)	(-1.70)	(-1.61)	(-1.41)	(-1.04)
Adj. R-squared	-0.5%	-0.1%	0.2%	0.7%	1.0%	0.8%	0.2%
Panel B: Two-month ahead							
Forward Guidance	-0.0223	-0.0214	-0.0210*	-0.0188*	-0.0154**	-0.0130*	-0.0116*
	(-1.50)	(-1.63)	(-1.79)	(-1.89)	(-2.00)	(-1.99)	(-1.93)
Adj. R-squared	1.0%	1.2%	1.7%	1.9%	2.2%	2.6%	2.6%
Panel C: Three-month ahead							
Forward Guidance	-0.0411*	-0.0385*	-0.0350*	-0.0300*	-0.0246**	-0.0202**	-0.0210**
	(-1.91)	(-1.94)	(-1.95)	(-1.94)	(-1.99)	(-2.07)	(-2.40)
Adj. R-squared	3.0%	3.0%	3.0%	3.0%	3.3%	3.6%	5.4%
Panel D: Six-month ahead							
Forward Guidance	-0.0435*	-0.0392*	-0.0361*	-0.0308	-0.0247	-0.0186	-0.0165
	(-1.77)	(-1.73)	(-1.72)	(-1.66)	(-1.62)	(-1.42)	(-1.38)
Adj. R-squared	1.1%	1.0%	1.1%	1.0%	1.0%	0.7%	0.6%

Oil Futures Returns

Predict Crude Oil Futures Returns Using Forward Guidance Shocks.

	1-mon	3-mon	6-mon	12-mon	24-mon	36-mon	60-mon
Panel A: One-month ahead							
Forward Guidance	-0.0093	-0.0119	-0.0130*	-0.0136**	-0.0127**	-0.0100**	-0.0080*
	(-1.03)	(-1.48)	(-1.87)	(-2.26)	(-2.45)	(-2.29)	(-1.92)
Controls	Y	Y	Y	Y	Y	Y	Y
Adj. R-squared	4.8%	2.8%	1.6%	2.6%	5.9%	4.6%	4.3%
Panel B: Two-month ahead							
Forward Guidance	-0.0249	-0.0246	-0.0247*	-0.0233*	-0.0203**	-0.0172**	-0.0153**
	(-1.35)	(-1.50)	(-1.69)	(-1.90)	(-2.18)	(-2.19)	(-2.26)
Controls	Y	Y	Y	Y	Y	Y	Y
Adj. R-squared	1.1%	-1.0%	-1.4%	-0.2%	3.4%	6.6%	10.3%
Panel C: Three-month ahead							
Forward Guidance	-0.0475*	-0.0450*	-0.0410*	-0.0359*	-0.0302*	-0.0244**	-0.0249**
	(-1.68)	(-1.72)	(-1.74)	(-1.79)	(-1.91)	(-1.99)	(-2.32)
Controls	Y	Y	Y	Y	Y	Y	Y
Adj. R-squared	-1.2%	-1.3%	-1.5%	-1.3%	0.5%	3.1%	8.3%
Panel D: Six-month ahead							
Forward Guidance	-0.0452	-0.0410	-0.0388*	-0.0355*	-0.0319**	-0.0276**	-0.0267**
	(-1.59)	(-1.62)	(-1.71)	(-1.84)	(-2.11)	(-2.18)	(-2.38)
Controls	Y	Y	Y	Y	Y	Y	Y
Adj. R-squared	-5.8%	-5.6%	-5.4%	-4.8%	-3.2%	-1.8%	1.0%

Control variables: storage level, basis, growth in open interest, moving average of oil returns, speculation index, and changes in crude oil option-implied volatility.

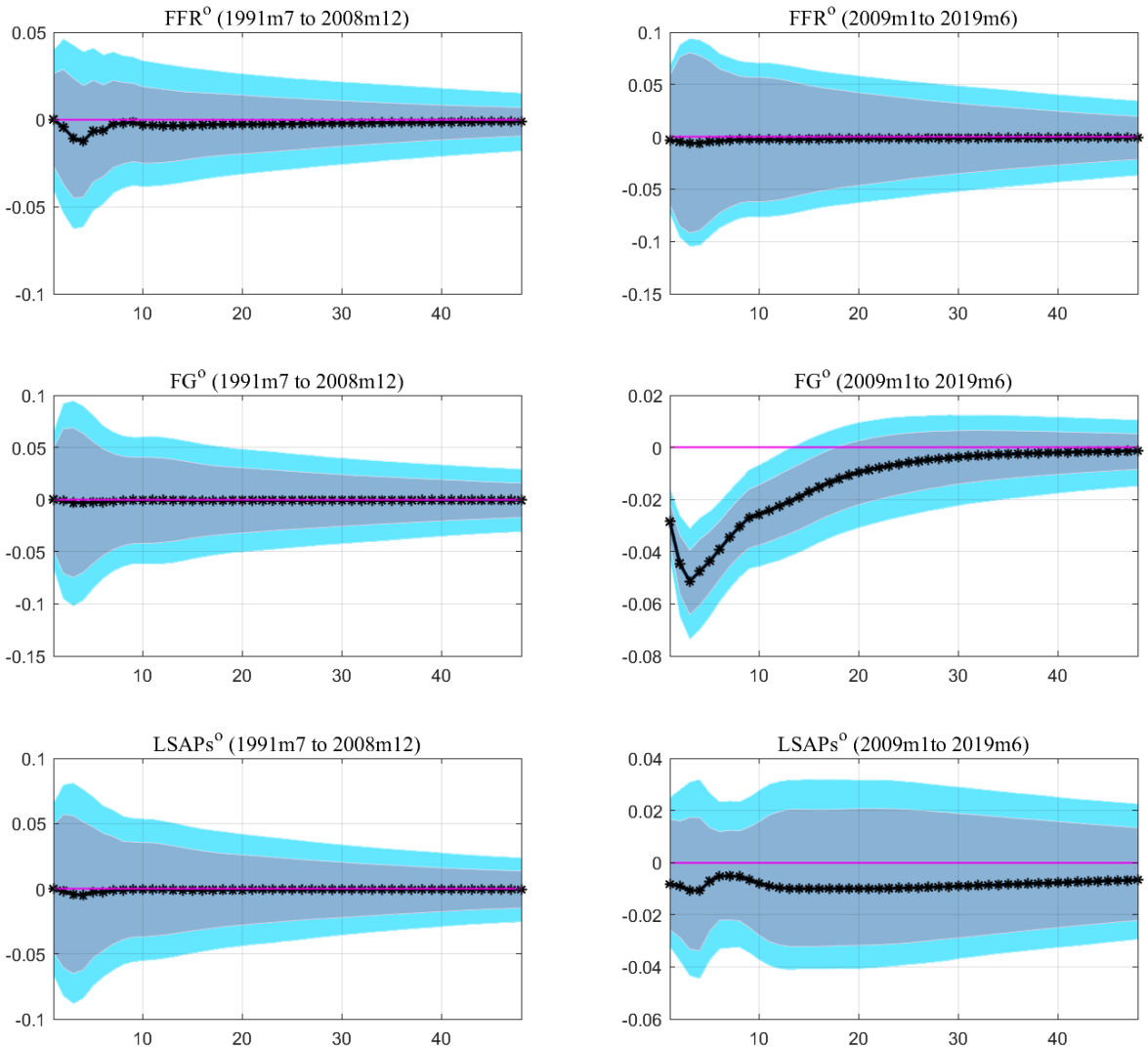
Orthogonalized Monetary Policy Shocks

- Monetary policy shocks can be correlated with macroeconomic info available before the FOMC announcements (Bauer and Swanson, 2023).

	Panel A: Univariate			**Panel B:** Multivariate		
	FFR^o	FG^o	$LSAPs^o$	FFR^o	FG^o	$LSAPs^o$
1993m1 - 2008m12						
	-0.066	0.071		-0.053	0.064	
	(-1.20)	(1.13)		(-1.01)	(1.04)	
Adj. R-squared	0.33%	1.13%		1.07%		
2009m1 - 2015m11						
		-0.368***	0.130**		-0.359***	0.021
		(-2.67)	(2.00)		(-2.50)	(0.43)
Adj. R-squared		19.64%	1.76%		18.18%	
2015m12 - 2019m6						
	-0.272	-0.189**	0.152	-0.326*	-0.230***	0.415
	(-1.23)	(-2.20)	(0.47)	(-1.73)	(-2.61)	(1.11)
Adj. R-squared	-1.42%	4.74%	-3.01%	4.10%		

Orthogonalized Monetary Policy Shocks

Impulse Responses of Real Oil Prices to Monetary Policy Shocks.



Model

- Representative household makes optimal choices on consumption C_t (non-oil goods $C_{Y,t}$ and oil $C_{E,t}$), investment I_t, labor L_t, and purchases of risk-free bonds B_{t+1}.
- The non-oil final goods firms produce Y_t by combining a continuum of intermediate goods.
- Intermediate goods firms produce by using oil E_t, capital K_t, and labor L_t.
- Competitive oil storers choose oil storage S_t to maximize their profit.
- Market clearing condition

$$C_{E,t} + E_t = O_t + (1 - \delta_O) S_{t-1} - S_t,$$

we assue the endowment of oil, O_t, is exogenous.

Model

- The norminal interest rate is determined following a Taylor-type rule, subject to the zero lower bound.

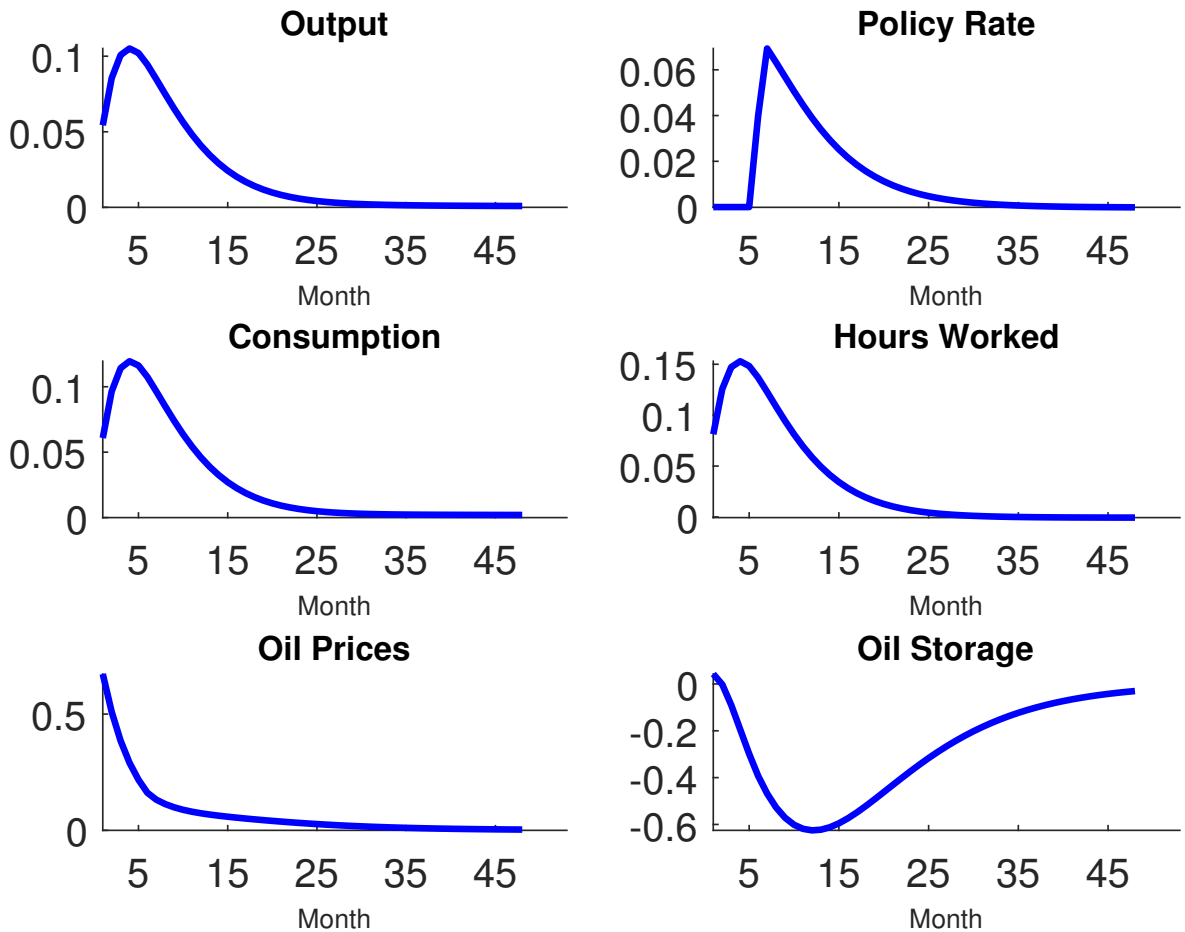
$$
\begin{aligned}
log(R_t^R) = \phi_R \log(R) + (1-\phi_R)(\phi_\pi(\log(\Pi_t) - \log(\Pi))) \\
+\phi_Y(\log(Y_t) - \log(Y_{t-1})) + m_t, \\
m_t = \rho_m m_{t-1} + \varepsilon_{m,t}, \quad \varepsilon_{m,t} \sim N(0, \sigma_m^2),
\end{aligned}
$$

$$
log(R_t) = \max(log(\underline{R}), log(R_t^R)).
$$

- Forward guidance shock
  - When the rate is not at the ZLB, $\varepsilon_{m,t}$ is the conventional monetary policy shock.
  - When the rate is at the ZLB, a shock to this policy rule can lower the future policy rate, while keeping the current policy rate unchanged. The shock is defined as the forward guidance shock (Bundick and Smith, 2020).

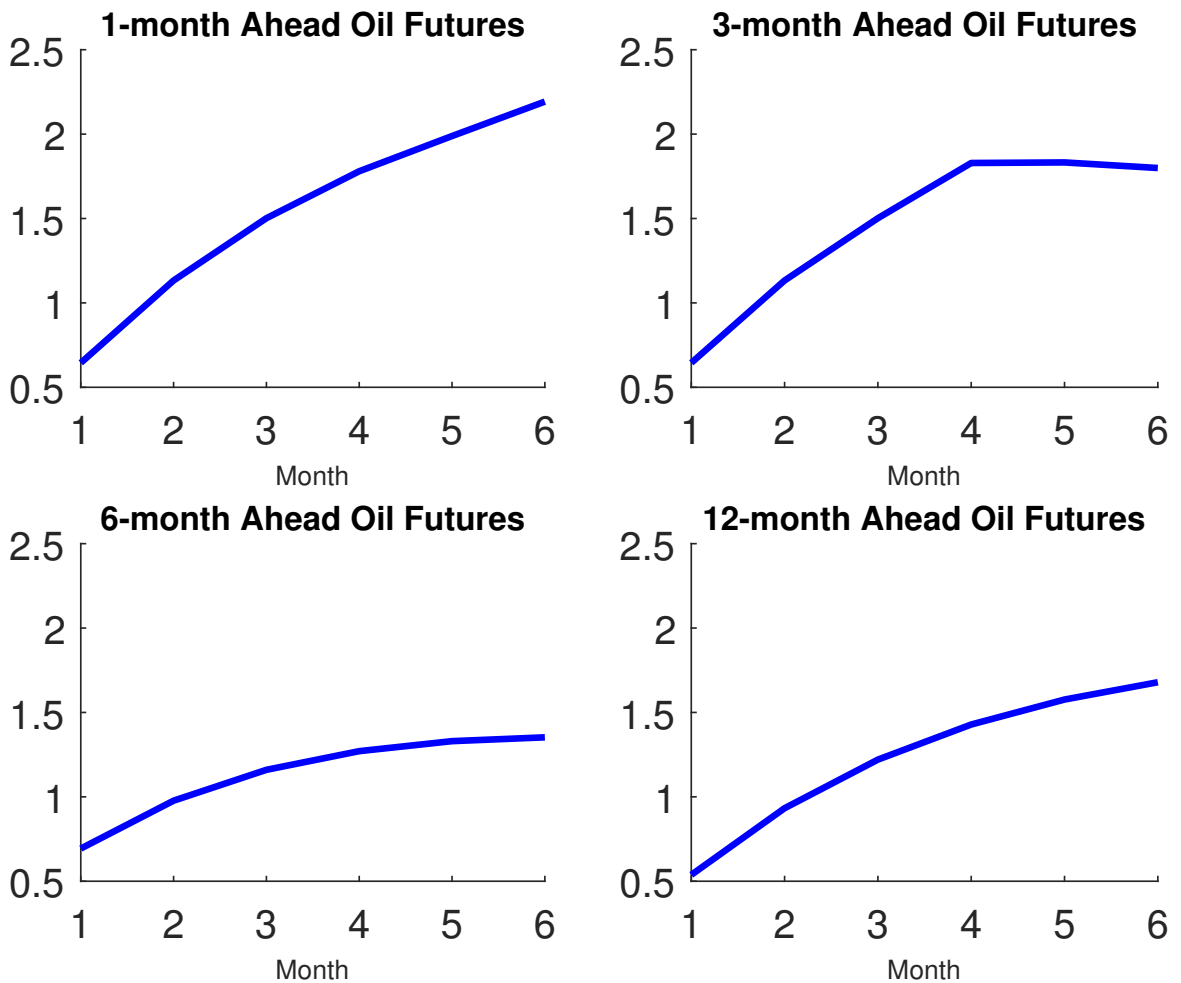
Simulation Results

Model-Based Impulse Responses to Forward Guidance Shocks:
Baseline



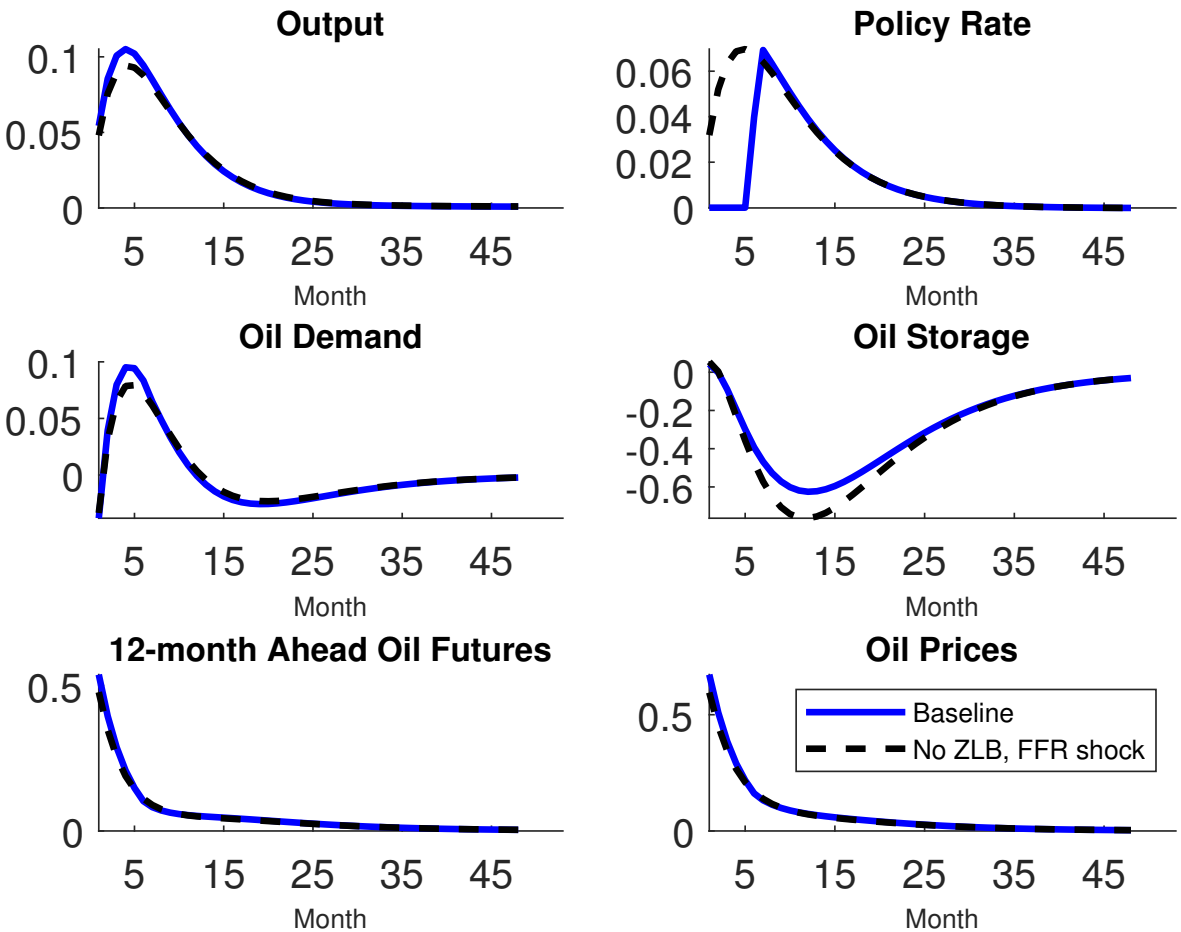
Simulation Results

Model-Based Impulse Responses to Forward Guidance Shocks:
The Cumulative Impact on Oil Futures Prices



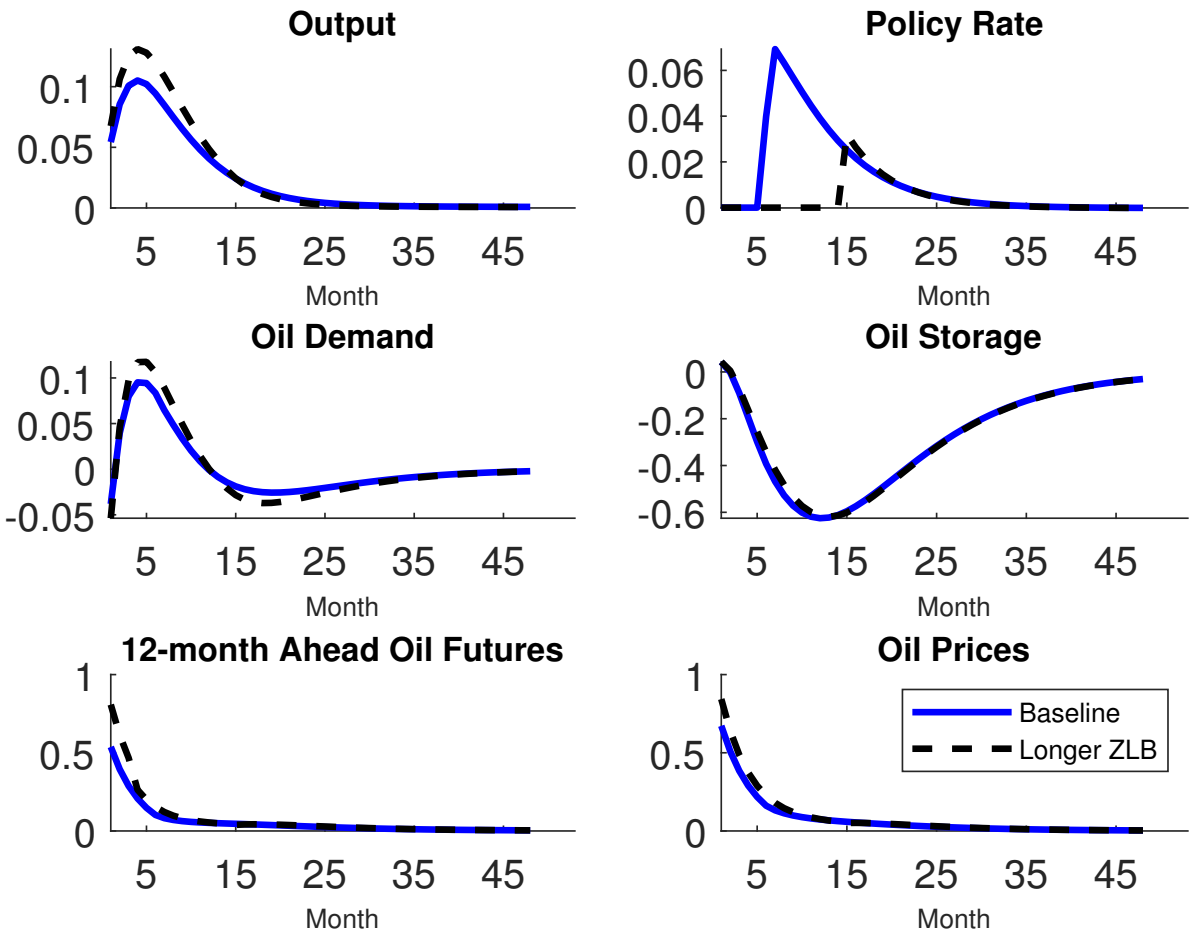
Simulation Results

Model-Based Impulse Responses to Policy Shocks:
Forward Guidance Shocks vs. Conventional Policy Shocks



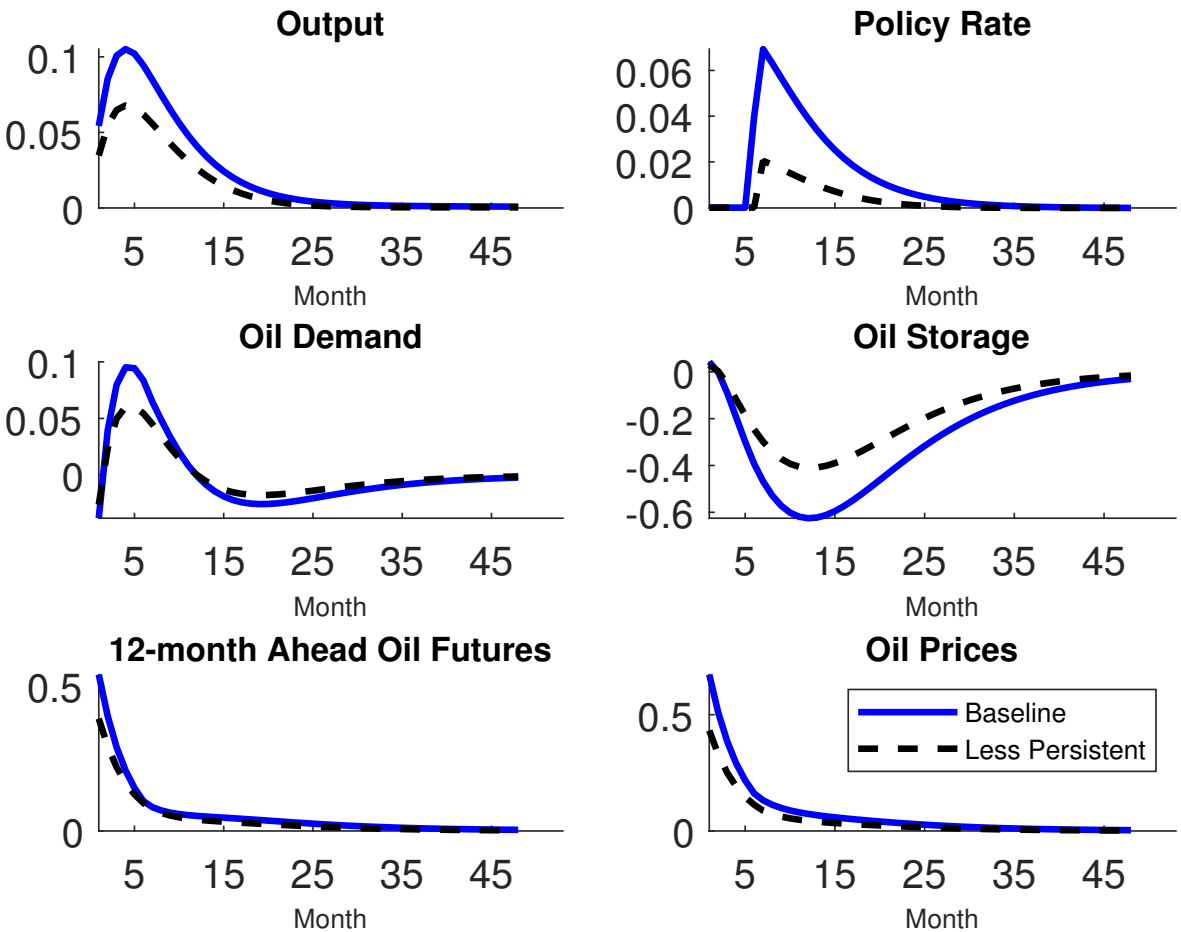
Simulation Results

Model-Based Impulse Responses to Forward Guidance Shocks:
Length of the ZLB Period



Simulation Results

Model-Based Impulse Responses to Forward Guidance Shocks:
Persistency of Forward Guidance



Conclusion

- Forward guidance shocks have significant impacts on the crude oil market after the ZLB period.
- An unexpected easing in forward guidance
  - raises oil price around the FOMC announcement window
  - increases real oil prices for up to one year
  - predicts higher crude oil futures returns
- We develop and simulate a New-Keynesian model to rationalize our empirical findings.

Conclusion

- Forward guidance shocks have significant impacts on the crude oil market after the ZLB period.
- An unexpected easing in forward guidance
  - raises oil price around the FOMC announcement window
  - increases real oil prices for up to one year
  - predicts higher crude oil futures returns
- We develop and simulate a New-Keynesian model to rationalize our empirical findings.
- Should the Fed incorporate the reaction of oil prices to monetary policy tools (e.g., forward guidance) in their objective function?
  - We do not know.