Interaction between Monetary Policy and Commodity Prices

Lutz Kilian
University of Michigan
CEPR

Percentage Growth Rates of Inflation-Adjusted Commodity Prices

	1971.11-1974.2	1977.8-1980.2	2001.6-2008.6
Crude Oil	125.3	70.7	327.5
Industrial Raw Materials	92.6	24.2	66.7
Metals	95.9	27.6	234.6

<u>This presentation:</u>
Focus on price of crude oil.

Monetary Policy and Nominal Oil Prices

<u>Gillman and Nakov (NAJEF 2009):</u>
The oil price must change to offset persistent shifts in U.S. inflation, given that the price of oil is denominated in dollars.

<u>Barsky and Kilian (NBER MA 2002):</u>
Rising dollar-denominated non-oil commodity prices are thought to presage rising U.S. inflation. (Oil prices until the early 1980s were more sluggish due to institutional constraints.)

<u>Hotelling (1931):</u>
If the marginal extraction cost is zero, the nominal price of oil will grow at the nominal rate of interest.

- ⇨ Loose monetary policy may cause rising oil prices via a monetary aggregate and/or an interest rate channel.

p-Values for Predictability from Nominal Aggregates to Nominal Price of Oil 1973-2009

Monthly Predictors:	WTI	RAC Oil Imports	RAC Composite
U.S. CPI	**0.072**	**0.024**	**0.097**
U.S. M1	**0.057**	**0.003**	**0.000**
U.S. M2	0.101	0.184	**0.062**
CRB Industrial Raw Materials Price Index	**0.000**	**0.000**	**0.002**
CRB Metals Price Index	**0.004**	**0.009**	**0.011**
U.S. 3-Month T-Bill Rate	0.232	0.438	0.377
Trade-Weighted U.S. Exchange Rate	0.736	0.725	0.706

Monetary Policy and Real Oil Prices

<u>Barsky and Kilian (NBER MA 2002):</u>

1. Low ex ante real interest rates may prompt oil producers to withhold oil from the market, causing an increase in the real price of oil.

2. Fluctuations in global real activity results in shifts in the flow demand for crude oil and affect the real price of oil.

3. Fears of inflation may cause an increase in the stock demand for crude oil and cause an increase in the real price of oil.

- ⇨ All three determinants may be affected by monetary policy.

p-Values for Predictability from Real Aggregates to Real Price of Oil 1973-2009

Monthly Predictors	WTI		RAC Oil Imports		RAC Composite	
	$p=12$	$p=24$	$p=12$	$p=24$	$p=12$	$p=24$
OECD+6 IndustrialProduction[2]						
LT	**0.001**	**0.004**	**0.002**	**0.019**	**0.001**	**0.015**
HP	**0.093**	0.196	**0.069**	0.486	**0.040**	0.404
DIF	**0.061**	0.148	0.169	0.266	**0.027**	0.757
Global Real Activity Index[3]	**0.034**	**0.002**	**0.082**	**0.007**	**0.016**	**0.005**

Monetary Policy in Net Oil-Importing Economies

Changes in the real price of oil all else equal affect the domestic economy (see, e.g., Edelstein and Kilian JME 2009; Hamilton BPEA 2009).

Policymakers respond to changes domestic real activity and inflation.

⇨ Monetary policy must account for the two-way causality between the real price of oil and the domestic economy.

Two Traditional Approaches in the Literature

1. Monetary Policy $\Rightarrow$ Real Price of Oil

Barsky and Kilian (NBER Macro Annual 2002):
Worldwide *shifts in monetary policy regimes* in the 1970s not related to the oil market played a major role in causing both the subsequent oil price increases and stagflation in many economies.

2. Real Price of Oil $\Rightarrow$ Monetary Policy

Bernanke, Gertler and Watson (BPEA 1997):
The oil price shocks of the 1970s arose exogenously with respect to global macroeconomic conditions, but their effects were amplified by the endogenous *reaction of monetary policy makers* within a given monetary policy regime.

1. The Monetary Policy Regime Shifts Hypothesis

The Great Moderation debate misses that 1990s were not so different from 1960s. Really, the 1970s were the aberration. Why?

1. The beginning of this decade coincided with a shift towards a less restrictive monetary policy regime. The breakdown of Bretton Woods loosened the remaining constraints on monetary policy.

2. As the world entered uncharted territory in the early 1970s, policy making entered a stage of experimentation and learning.

3. Central bankers felt the responsibility to stimulate employment by loosening monetary constraints, even if that meant some moderate inflation.

Consequences of Excess Liquidity

• The data show a dramatic increase in worldwide liquidity in the early (and late) 1970s:

1. If the public is slow to catch on to the shift in monetary policy regime, an unexpected monetary expansion will cause a temporary boom in output.

2. Inflation will rise slowly initially, but will continue to rise even after output has peaked. As inflation peaks, the economy goes into recession.

3. In practice, the recession may be deepened by the decision of the central bank to raise interest rates to combat the inflationary pressures it had itself unwittingly created.

Why Did Policy Makers Not Realize This?

• One reason is that the acceleration of inflation coincided with the oil price shock of 1973/74, which seemed to provide a natural explanation of the inflationary pressures at the time.

• As a result, central bankers initiated a second expansionary cycle in the mid-1970s, causing another output boom in the late 1970s.

As the public increasingly caught up to the change in regime, however, stimulative polices became less effective and inflation a growing concern.

How the Go-Stop Cycle Was Broken

- Only when Paul Volcker stepped in and insisted on the primacy of the inflation objective, this go-stop monetary policy cycle was broken.

As in the case of the initial regime shift, the public was slow to accept that a regime shift had taken place, and inflation was slow to come down, even as the economy entered a steep recession in the early 1980s.

- Given that central bankers have accepted the primacy of the inflation objective, it is not surprising that there have been no more outbreaks of stagflation.

The Effect of Regime Shifts on the Real Price of Oil

- Concerted shifts in monetary policy regimes caused an increase in global real activity and hence in the demand for oil (and other industrial commodities).

- This regime-shift hypothesis does not fit the 2003-08 data (e.g., Kilian RBA 2010; Erceg, Guerrieri and Kamin IJCB 2011).

The latter oil demand boom was caused by the unexpectedly fast oil-intensive economic growth of emerging Asia (e.g., Kilian AER 2009; Kilian and Murphy 2010, JEEA 2012; Bodenstein and Guerrieri 2012; Kilian and Hicks JForec. 2013).

Why 2003-2008 is not 1973-1979

<u>Then:</u>

Monetary expansion fuels domestic production
Most countries move in sync
Inflation expectations become unanchored

<u>Now:</u>

Monetary expansion fuels asset prices and consumption
Many countries do not move in sync
Inflation expectations remain anchored

- Did U.S. monetary expansion fuel production in China (outsourcing)?
- Analysis further complicated by fiscal-monetary link.

2. The Monetary Policy Reaction Hypothesis

- Consider an exogenous oil price shock.

- Two main channels of transmission:
  - Increased cost of domestic production (adverse AS shock)
  - Reduced purchasing power (adverse AD shock), amplified by increased precautionary savings and increased operating cost of energy using durables.

- Supply channel is weak. The literature on sectoral responses shows that the demand channel dominates (e.g., Lee and Ni JME 2002; Kilian and Park IER 2009).

Bernanke, Gertler and Watson (BPEA 1997):

• Take the stand that the AS shock interpretation is dominant.

• Assert that this shock triggers strong inflationary pressures, while the recessionary impact is weak.

• A hawkish central banker will fight the inflationary pressures by raising the interest rate, thereby deepening the recession.

Why this interpretation?

1. Standard models of the transmission of oil price shocks cannot explain large recessions in the data.
2. The monetary policy reaction serves as an amplifier.

Problem 1: No Rationale for a Monetary Tightening

1. Are exogenous oil price shocks inflationary?

AS shock: $Y\downarrow, P\uparrow$ versus AD shock: $Y\downarrow, P\downarrow$

2. What happened to the dual objective of the Fed?

3. Inflation hawks in the 1970s?

Problem 2: Specification of the Econometric Model

BGW's VAR evidence is based on *censored* oil price changes:

1. Their estimates are <u>inconsistent</u> (see Kilian and Vigfusson QE 2011, MD 2011).

2. Why asymmetry? No evidence for asymmetric responses.

Problem 3: Questionable Identification

BGW's evidence rests squarely on the 1979 oil price shock episode.

Key Issue: Did Volcker raise interest rates in 1979 to fight domestic inflation unrelated to oil prices or in response to the 1979 oil price shock?

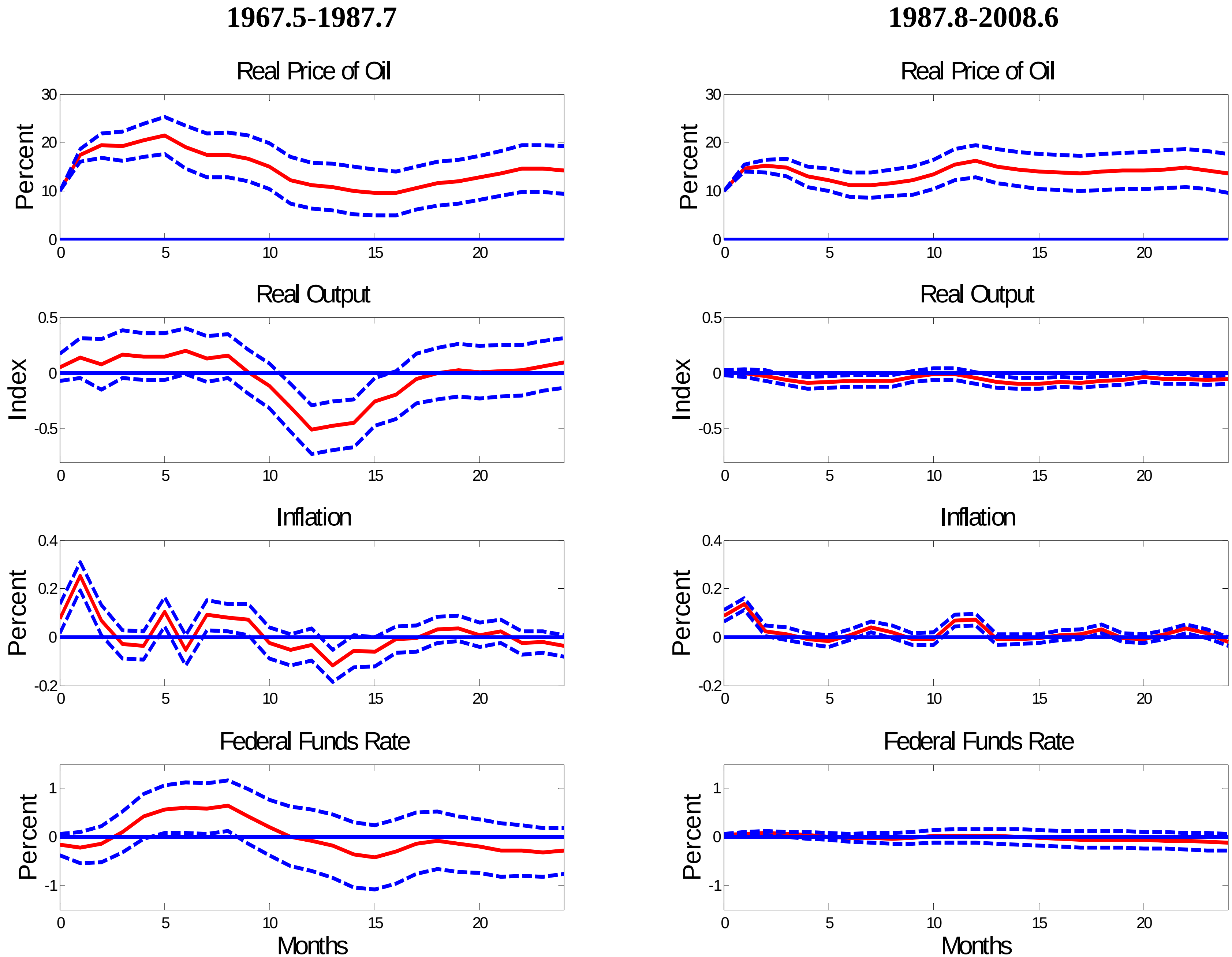
Problem 4: Interest Rate Rule Not a Good Description of Monetary Policy in the 1970s

Barsky and Kilian NBER MA 2002;
Kozicki and Tinsley JME 2009

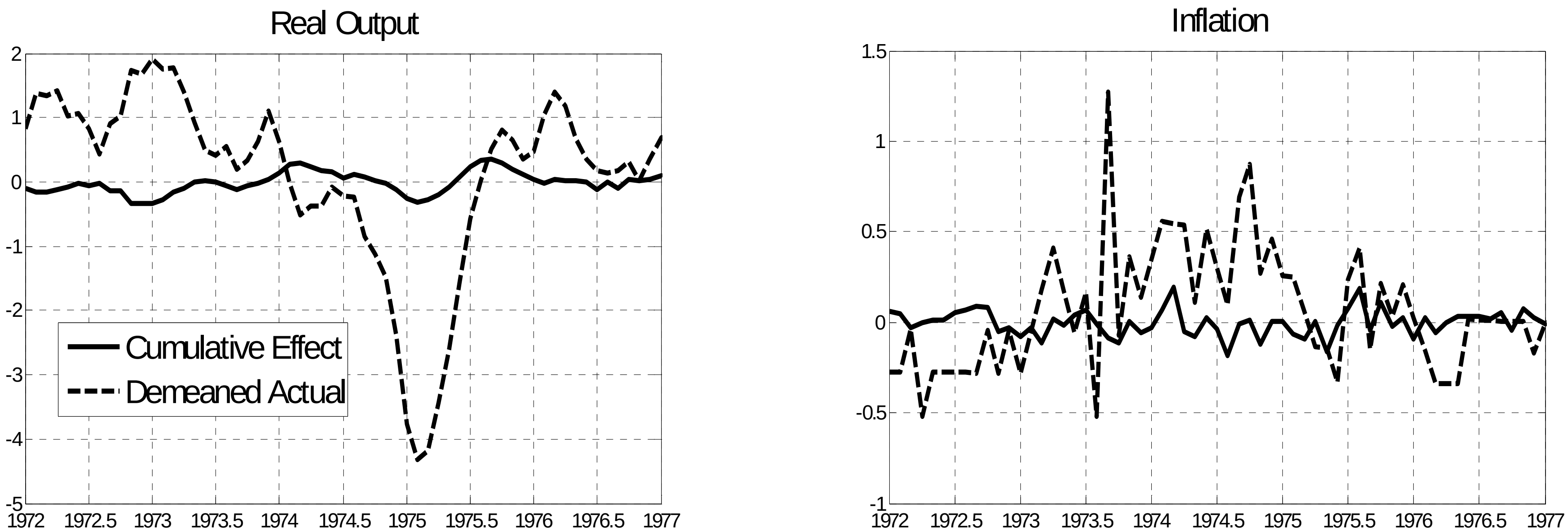
Problem 5: The Policy Reaction Hypothesis Does Not Fit the Data

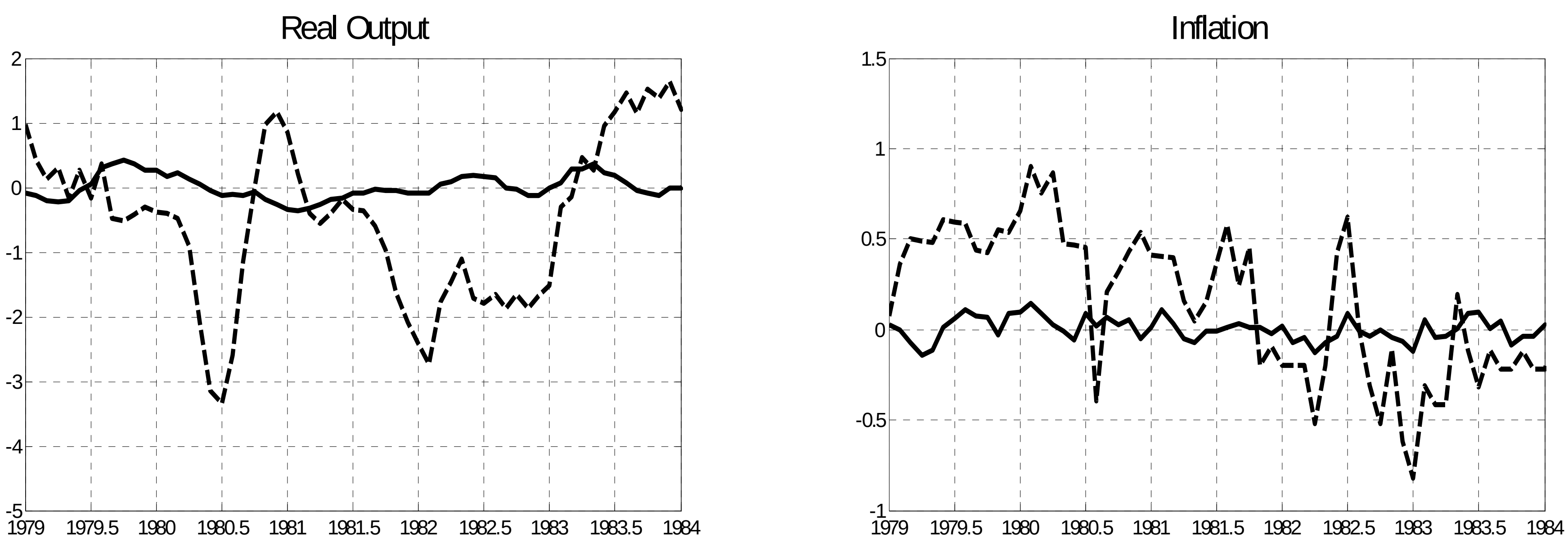
Kilian and Lewis EcJ 2011

U.S. Responses to Real Oil Price Shocks (with One-Standard Error Bands)



Cumulative Effect of Real Oil Price Shocks: Selected Episodes





Why does this model not work better?

The coefficient on the oil price variable in the policy rule is statistically insignificant and close to zero.

This reflects the fact that higher oil prices may reflect different structural shocks in oil markets, some of which stimulate the domestic economy and some of which slow it down.

Hence, the average impact response depends on the sample period, tends to be unstable over time, and is close to zero for sufficiently long samples.

⇨ A mechanical response to the price of oil as though it were exogenous is inadvisable.

This Insight Is Not New

Kilian (AER 2009):

1. Oil price innovations violate the *ceteris paribus* premise.
2. Source of shocks matters for oil price dynamics.

The real price of oil is merely a symptom of deeper causes. Policy makers need to respond directly to these structural causes, not to the symptom.

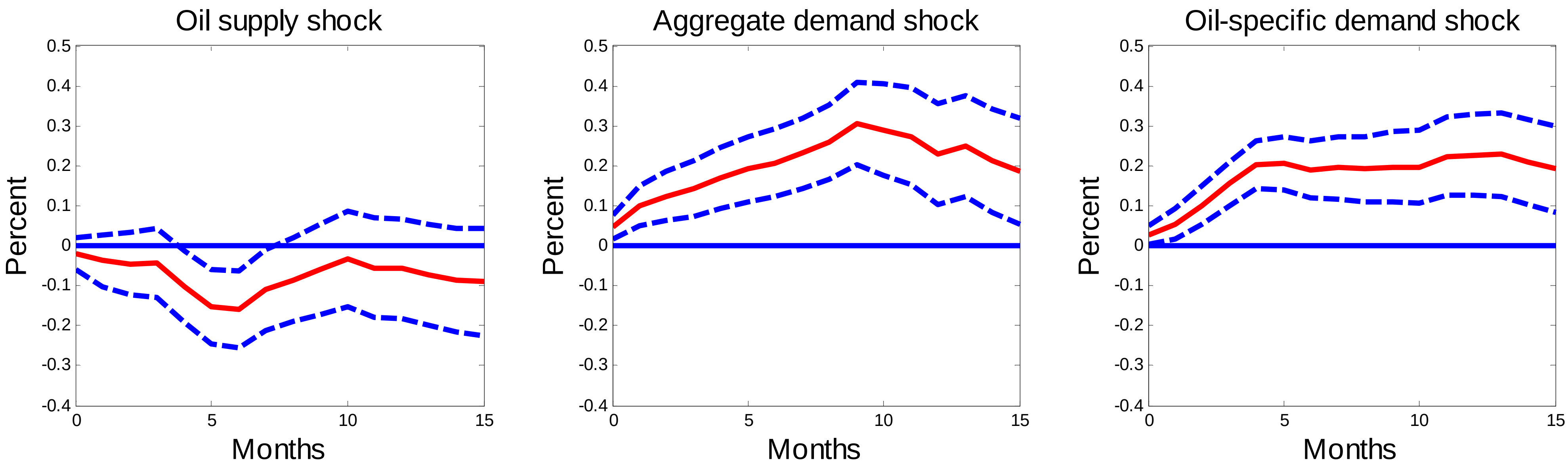
Nakov and Pescatori (JMCB 2010):

It is not welfare-maximizing for policy makers to respond mechanically to oil price fluctuations.

Kilian and Park (IER 2009), Kilian and Lewis (EJ 2011):

Empirical evidence that the Fed has been responding differently to demand and supply shocks in oil markets.

Estimated Response of the Effective Federal Funds Rate to Oil Demand and Oil Supply Shocks



Summary of the Evidence for the BGW Model

1. There is no empirical support for the BGW hypothesis in pre-1987 data (e.g., Hamilton and Herrera JMCB 2004; Kilian and Lewis EJ 2011).

2. There is no empirical support for the BGW hypothesis in post-1987 data (e.g., Herrera and Pesavento MD 2009; Kilian and Lewis EJ 2011).

Towards a New Class of Structural Models

1. The traditional policy reaction model is empirically unsuccessful and lacks theoretical support.

2. The policy regime shift hypothesis does not speak to the problem faced by monetary policy makers.

3. We need a different class of structural models to address this question than the models customarily used by policy makers:

Endogenous determination of the real price of oil
Model of world economy
Explicit role for monetary policy

⇨ DSGE model of Bodenstein, Guerrieri & Kilian (forthcoming: IMF ER)

Some Predecessors of Our Analysis

1. DSGE models with monetary policy responses under counterfactual premise of exogenous real price of oil:

    Leduc & Sill 2004; Carlstrom & Fuerst 2006; Kormilitsina 2011; Natal 2012.

2. DSGE models with endogenous real price of oil, but without monetary policy:

    Backus & Crucini 1998; Balke, Brown, & Yücel 2010; Bodenstein, Erceg & Guerrieri 2011; Nakov & Nuño 2011.

3. DSGE models with endogenous real price of oil and monetary policy, but without global economy framework:

    Bodenstein, Erceg & Guerrieri 2008; Nakov & Pescatori 2010a,b.

Our DSGE model

Based on Bodenstein & Guerrieri (2011), who build on Backus & Crucini (1998), Christiano, Eichenbaum & Evans (2005) and Smets & Wouters (2007):

- Two blocs with symmetric structure: U.S. and ROW. Country-specific values for the parameters allow for differences in population size, oil intensities, oil endowments, and in nonoil and oil trade flows.

- While asset markets are complete at the country level, asset markets are incomplete internationally.

The model is estimated by MLE on data for 1984.I-2008.III.

DSGE Model: Production and Trade

● In each country, a continuum of firms produces differentiated varieties of an intermediate good under monopolistic competition.

● These firms use capital, labor and oil as factor inputs.

● Goods prices are determined by Calvo-Yun staggered contracts.

DSGE Model: Households

● Households supply differentiated labor services under monopolistic competition. They consume oil and the nonoil consumption good, they save, and they invest.

● Wages are determined by Calvo-Yun staggered contracts.

DSGE Model: Oil Market

● The two-country blocs are endowed with a nonstorable supply of oil each period.

● Both oil and nonoil goods are traded across countries.

● Focus on the oil demand side - consistent with all empirical work. No endogenous oil production decisions.

● With foreign and domestic oil production determined exogenously, the real price of oil adjusts endogenously to clear the oil market.

Alternative Approaches We Do Not Consider

- Related studies of imperfect competition:
  Nakov & Pescatori 2010; Nakov & Nuño 2011
- Little direct empirical evidence for such models:
  Smith 2005; Almoguera, Douglas, & Herrera 2011
- Paucity of global data on oil investment decisions:
  Balke, Brown & Yücel 2008

DSGE Model: Monetary Policy

● Monetary policy follows a modified version of the interest rate rule suggested by Taylor (1993):

$$i_{US,t} = \overline{i_{US}} + \gamma^{i}_{US}(i_{US,t-1} - \overline{i_{US}}) + (1-\gamma^{i}_{US})\left[(\pi^{core}_{t} - \overline{\pi^{core}_{US}}) + \gamma^{\pi}_{US}(\pi^{core}_{US,t} - \overline{\pi^{core}_{US}}) + \gamma^{y}_{US} y^{gap}_{US,t}\right] + \varepsilon^{i}_{US,t}$$

Bars indicate steady-state values. y^{gap}_{t} denotes the log deviation of gross output from the value of gross output in the same model when excluding all nominal rigidities.

● Coefficient estimates: $\gamma^{i}_{US} = 0.65, \gamma^{\pi}_{US} = 0.19, \gamma^{y}_{US} \approx 0.$

DSGE Model: Structural Shocks

Fifteen separate sources of shocks. Some examples:

- U.S. and foreign technology
- U.S. and foreign oil supply
- U.S. and foreign autonomous spending
- U.S. and foreign consumption preferences
- U.S. and foreign wage and price markup
- U.S. and foreign labor supply
- U.S. and foreign monetary policy

The foreign oil intensity shock is the primary driver of real price of oil during 2003-08.

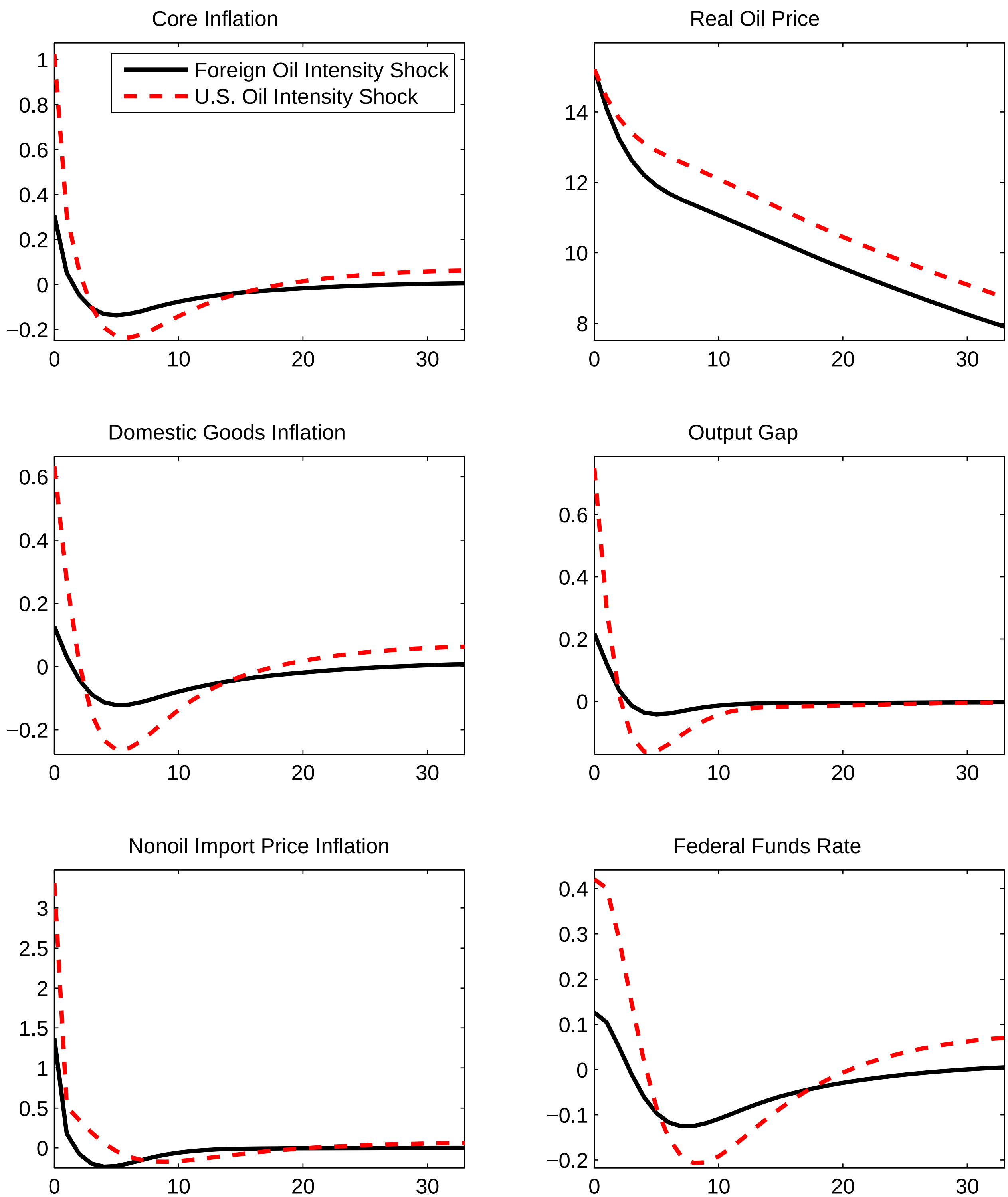
I. Model with Estimated Policy Rule

a. How the Same Shock Has Different Effects Depending on Where in the World it Arises

Example:

Foreign and Domestic Oil Intensity Shock

The U.S. oil intensity shock is scaled such that the impact response of the real price of oil is identical to that of a foreign oil intensity shock.



Core Inflation
Foreign Oil Intensity Shock
U.S. Oil Intensity Shock
1
0.8
0.6
0.4
0.2
0
−0.2
0
10
20
30
Real Oil Price
14
12
10
8
0
10
20
30
Domestic Goods Inflation
0.6
0.4
0.2
0
−0.2
0
10
20
30
Output Gap
0.6
0.4
0.2
0
0
10
20
30
Nonoil Import Price Inflation
3
2.5
2
1.5
1
0.5
0
0
10
20
30
Federal Funds Rate
0.4
0.3
0.2
0.1
0
−0.1
−0.2
0
10
20
30

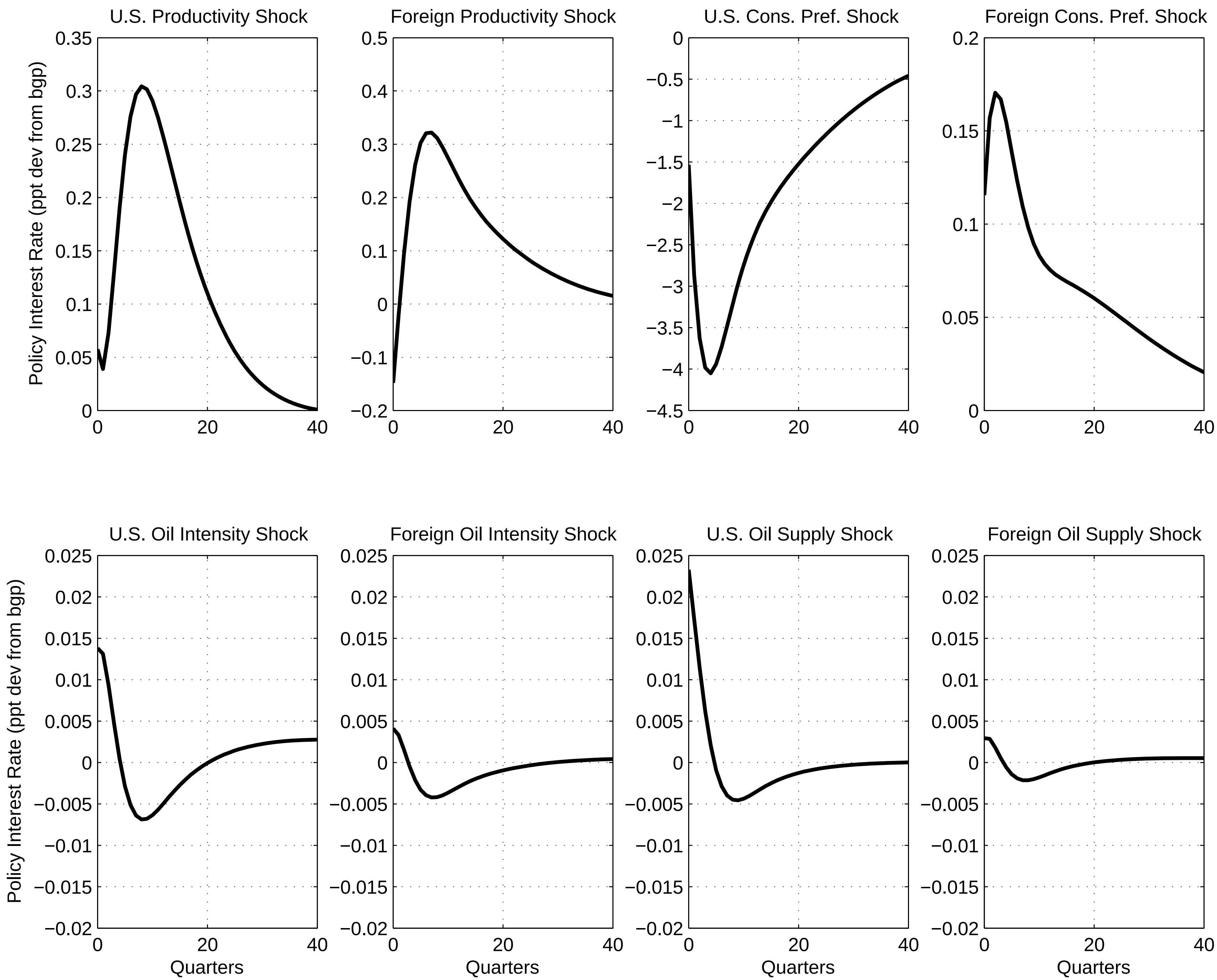
b. No Two Shocks Have the Same Effect

Blanchard and Gali (2010, p. 384):
"If the price of oil rises as a result of, say, higher Chinese demand, this is just like an exogenous oil supply shock for the remaining countries"

This conjecture is not correct, even controlling for the initial oil price increase.

Intuition:

1. Each shock induces different dynamics.
2. Ceteris paribus assumption violated.



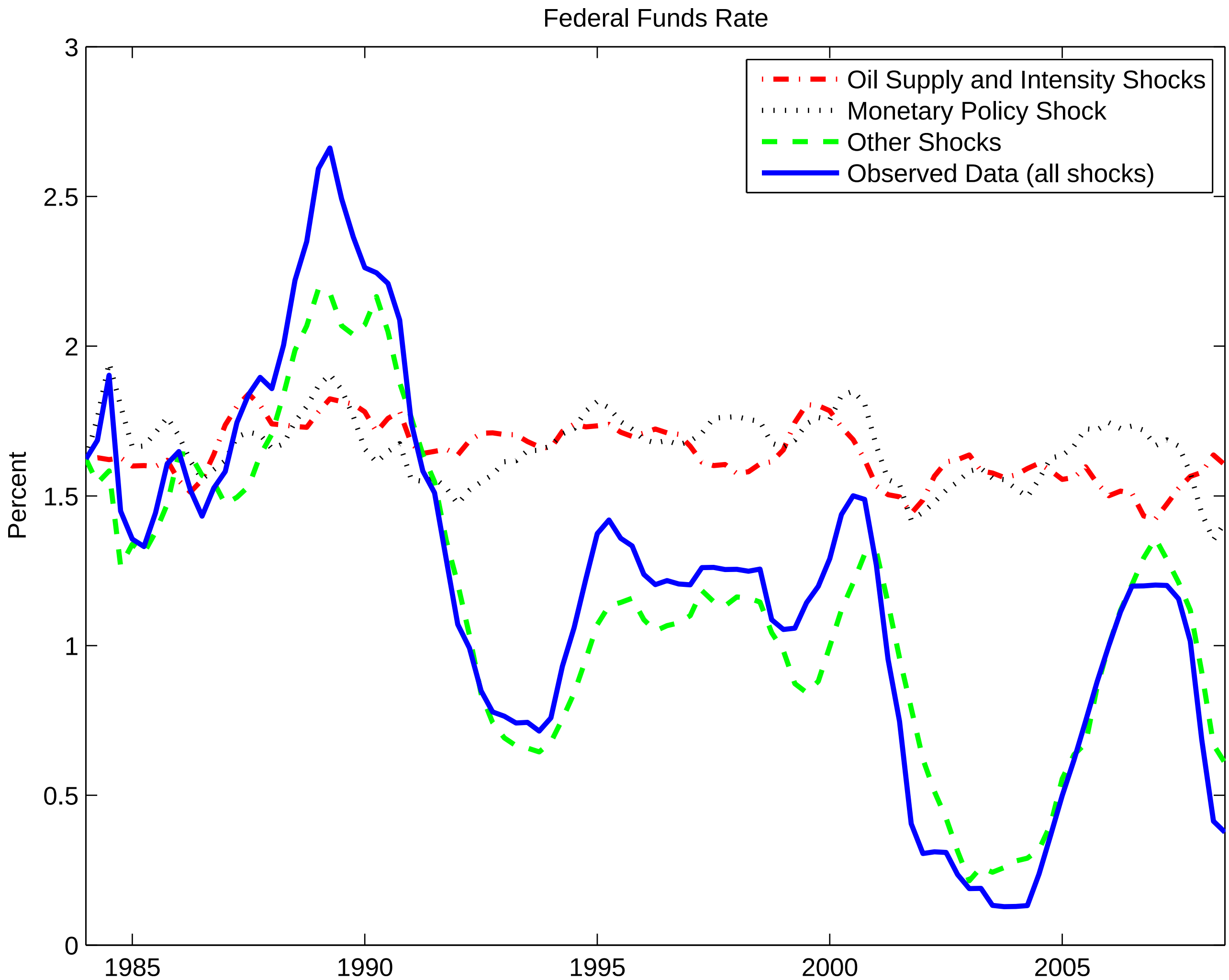
U.S. Productivity Shock
Foreign Productivity Shock
U.S. Cons. Pref. Shock
Foreign Cons. Pref. Shock
U.S. Oil Intensity Shock
Foreign Oil Intensity Shock
U.S. Oil Supply Shock
Foreign Oil Supply Shock
Policy Interest Rate (ppt dev from bgp)
Quarters

c. The Evolution of the U.S. Federal Funds Rate

Bodenstein and Guerreri (2011):
Oil intensity shocks account for the bulk of the evolution of the real price of oil

This paper:
What accounts for the bulk of the evolution of the U.S. federal funds rate?

Oil supply and oil intensity shocks?
Monetary policy shocks?
Other shocks?



Federal Funds Rate
Oil Supply and Intensity Shocks
Monetary Policy Shock
Other Shocks
Observed Data (all shocks)
Percent
3
2.5
2
1.5
1
0.5
0
1985
1990
1995
2000
2005

II. Model with Optimized Policy Rule

Expanded Policy Rule:

$$i_{US,t} = \overline{i_{US}} + \gamma_{US}^{i}(i_{US,t-1} - \overline{i_{US}})$$

$$(1-\gamma_{US}^{i})\begin{bmatrix} (\pi_{t}^{core} - \overline{\pi_{US}^{core}}) + \gamma_{US}^{\pi}(\pi_{US,t}^{core} - \overline{\pi_{US}^{core}}) + \gamma_{US}^{y} y_{US,t}^{gap} \\ +\gamma_{US}^{o}(\pi_{US,t}^{o} - \overline{\pi_{US}^{o}}) + \gamma_{US}^{w}(\omega_{US,t} - \overline{\omega_{US}}) \end{bmatrix} + \varepsilon_{US,t}^{i}$$

<u>Additions:</u>

Oil price inflation

Wage inflation

a. Optimized Parameters in Policy Rule

- Choose $\gamma_{US}^{i}, \gamma_{US}^{\pi}, \gamma_{US}^{y}, \gamma_{US}^{o}, \gamma_{US}^{w}$ so as to maximize the expected utility of the representative household.
- The monetary policy rule in the rest of the world is taken as given (for now).
- Agents internalize changes in the policy rule.

Optimized and Estimated Coefficients in Benchmark Model

	γ_{US}^{i}	γ_{US}^{π}	$\gamma_{US}^{y} \times 10^{6}$	γ_{US}^{o}	γ_{US}^{w}
Estimated	0.655	0.19	0.00	-	-
Optimized	0.000	0.02	1.67	0.01	0.003

b. Welfare Analysis

Which policy rule is best on average over the sample?

<u>Comparison:</u>
Changes in expected welfare for the estimated rule relative to optimized rule

(expressed in terms of the equivalent change in permanent consumption, as a percentage of steady state consumption)

Table 5: A Comparison of Alternative Monetary Policy Rules: Sensitivity Analysis*

Rule	U.S. Welfare Loss (change from optimized)	U.S. Core Infl. Std. Dev.	U.S. Wage Infl. Std. Dev.	U.S. Output Gap Std. Dev.
Benchmark Model				
Estimated	2.99	3.41	6.24	1.15
Optimized	0	2.67	0.98	0.00
4-quarter Calvo Contracts				
Estimated	1.39	3.87	11.85	0.69
Optimized	0	2.91	3.12	0.00
No Price and Wage Markup Shocks				
Estimated	0.11	3.13	4.93	0.87
Optimized	0	1.93	0.53	0.00
4-quarter Calvo Contracts and No Price and Wage Markup Shocks				
Estimated	0.12	3.58	7.91	0.50
Optimized	0	1.94	0.99	0.00
No Oil Supply and No Oil Intensity Shocks				
Estimated	2.99	3.36	6.16	1.13
Optimized	0	2.60	0.76	0.00
Oil Supply and Oil Intensity Shocks Only				
Estimated	0.0012	0.51	1.11	0.28
Optimized	0	0.46	0.39	0.08

* The losses reported are expressed as a percent of steady state consumption. The inflation measures are annualized.

Key Insights:

- Estimated rule is suboptimal (too sluggish to compensate for effects of nominal frictions)

- Ideal solution: Prevent the output gap from opening up.

- Full stabilization of the output gap does not mean that we do not care about inflation.

Without wage and price markup shocks welfare gains from optimization largely vanish, but we still get reduction in inflation volatility.

c. Responses under the Optimized Rule

- Welfare summary statistics does not convey differences in policy responses.

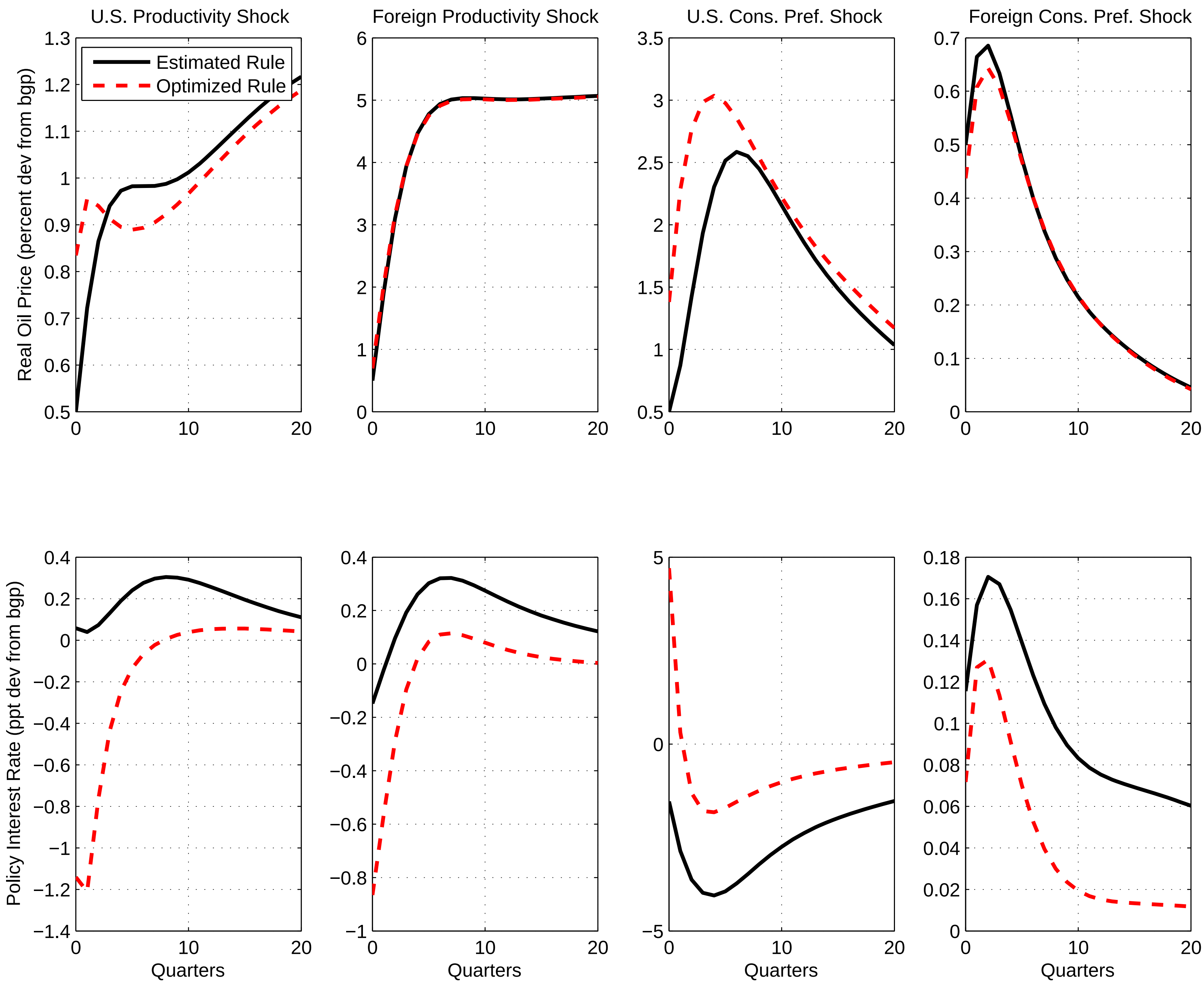
- We show responses of:

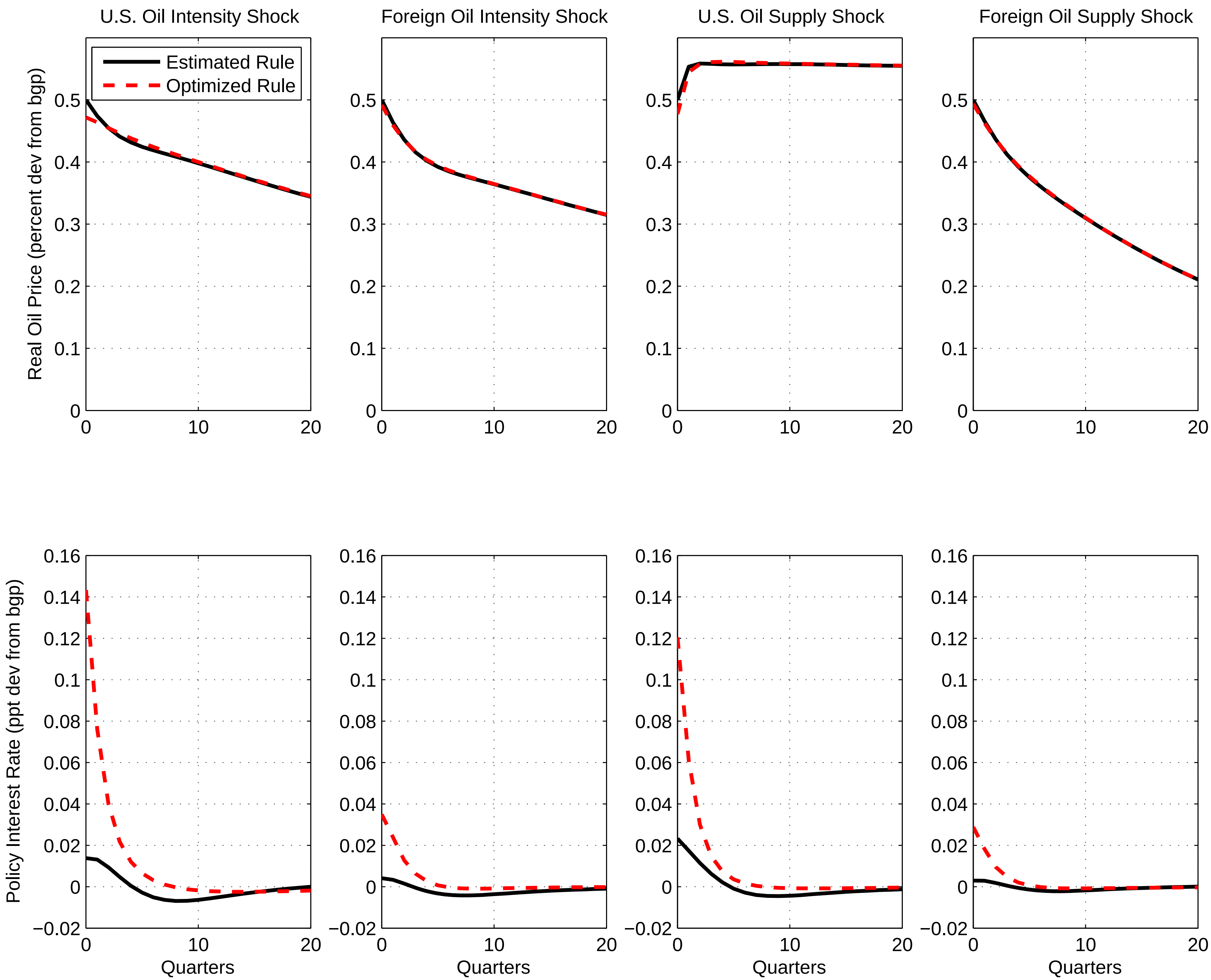
  Real price of oil (upper panel)

  Policy interest rate (lower panel)

  to a variety of shocks that affect the real price of oil.

- Each shock has been rescaled to induce a ½ percent increase in the real price of oil on impact.


U.S. Productivity Shock
Foreign Productivity Shock
U.S. Cons. Pref. Shock
Foreign Cons. Pref. Shock
Estimated Rule
Optimized Rule
Real Oil Price (percent dev from bgp)
Policy Interest Rate (ppt dev from bgp)
Quarters


U.S. Oil Intensity Shock
Foreign Oil Intensity Shock
U.S. Oil Supply Shock
Foreign Oil Supply Shock
Estimated Rule
Optimized Rule
Real Oil Price (percent dev from bgp)
Policy Interest Rate (ppt dev from bgp)
Quarters

d. Other Simple Policy Rules

Headline inflation vs. core inflation

The optimized policy rule depends on a model-specific and unobservable output gap measure.

Practical alternatives?

- Output gap vs. real GDP growth
- No output gap

Table 6: A Comparison of Alternative Monetary Policy Rules[1]

Rule	γ_1^i	γ_1^π	γ_1^y	γ_1^o	γ_1^w
Estimated	0.655	0.19	0.00	-	-
Optimized	0.000	0.02	1.67	0.01	0.00
Taylor with Core	0	0.5	0.125	0	0
Core Infl. Only	0	2	0	0	-0.07
Taylor with Headline[2]	0	0.5	0.125	0	0
Headline Infl. Only[2]	0	2	4.90	0	0
GDP Growth[3]	0.000	2.76	0.00	-	-
No Output Gap[4]	0.028	0.00	-	0.01	3.65×10^5

Rule	U.S. Welfare Loss (rel. to optimized)	U.S. Core Infl. Std. Dev.	U.S. Wage Infl. Std. Dev.	U.S. Output Gap Std. Dev.
Estimated	2.99	3.41	6.24	1.15
Optimized	0	2.67	0.98	0.00
Taylor with Core	2.45	2.75	3.95	0.75
Core Infl. Only	2.44	1.59	4.72	1.14
Taylor with Headline[2]	2.50	2.77	3.95	0.75
Headline Infl. Only[2]	2.52	1.68	4.90	1.22
GDP Growth[3]	2.42	1.35	5.17	1.29
No Output Gap[4]	0.09	2.97	0.00	0.20

[1] The optimized rule belongs to the following class:

$$
\begin{aligned}
i_{1,t} &= \bar{\imath}_1 + \gamma_1^i (i_{1,t-1} - \bar{\imath}_1) \\
&+ (1-\gamma_1^i) \left[\begin{array}{c} (\pi_{1,t}^{core} - \bar{\pi}_1^{core}) + \gamma_1^\pi (\pi_{1,t}^{core} - \bar{\pi}_1^{core}) + \gamma_1^y y_{1,t}^{gap} \\ \gamma_1^o (\pi_{1,t}^o - \bar{\pi}_1^o) + \gamma_1^w (\omega_{1,t} - \omega_1^o) \end{array} \right] + \epsilon_{1,t}^i.
\end{aligned}
$$

The losses reported are expressed as a percent of steady state consumption. The inflation measures are annualized.

[2] For these rules, headline inflation replaces core inflation.

[3] For this rule, GDP growth replaces the output gap and the coefficients are re-optimized.

[4] For this rule, the output gap is excluded and the coefficients are re-optmized.

III. International Monetary Policy Coordination

DSGE Model: Nash and Cooperative Equilibria

The large gains relative to simple rules remain sizable also when the foreign bloc is allowed to choose its policy rule coefficients:

1. We consider the best response to the best response (competitive Nash equilibrium).

2. We also consider a cooperative equilibrium in which the coefficients of the domestic and foreign rule are chosen to maximize the joint domestic and foreign welfare (Obstfeld and Rogoff 2002).

Welfare Losses from Non-Cooperation across Blocs

Rule	Joint Welfare Loss (Nash relative to cooperative equilibrium)
Baseline	0.11
Model without oil	0.02

NOTE: All losses are expressed as a percentage of steady-state consumption.

Conclusions

1. A large array of shocks influences the real price of oil.

2. All shocks in our global DSGE model, but the oil supply shocks are oil demand shocks.

3. Each shock implies a different response of monetary policy, when policy follows an interest rate rule.

4. The optimized policy rule is aggressive in closing the output gap and does not smooth interest rates.

5. Rules without the output gap, but with wage inflation work almost as well in practice.

6. We found unusually large gains from optimizing the policy rule relative to standard rules. Most of these gains stem from large mark-up shocks.

7. Gains from policy cooperation are at least an order of magnitude higher than typically reported.

Future Extensions of the DSGE Model

1. Endogenous Oil Production Decisions
   Balke, Brown & Yücel 2008; Nakov & Pescatori 2010; Nakov & Nuño 2011.

2. Speculative demand for storage
   Alquist & Kilian 2010; Kilian & Murphy 2010.

3. Valuation effects in the BOP
   Kilian, Rebucci & Spatafora 2009.

4. Disaggregation of ROW:
   OPEC, OECD (other than U.S.), emerging economies

5. Modeling Oil Exporters
   Fiscal policy model required