High Frequency Identification of Monetary Non-Neutrality: The Information Effect

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January 2018

THE QUESTION

How large are the effects of monetary policy on the real economy?

- Empirical challenge:
  - Monetary policy is endogenous
  - Example: Fed may wish to counteract a shock to the financial sector by lowering interest rates

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- Empirical challenge:
  - Monetary policy is endogenous
  - Example: Fed may wish to counteract a shock to the financial sector by lowering interest rates
- Most common existing approach to identification:
  - Controlling for confounding variables (e.g., Romer-Romer 04, Christiano-Eichenbaum-Evans 99)
- Worry: Some endogeneity bias may remain (e.g., 9/11)

High Frequency Identification

- Discrete amount of monetary news at time of FOMC announcements
- Allows for discontinuity based identification

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- We study the response of **real** interest rates to monetary news in the 30-minute window around FOMC announcements
    - Real yields and forwards (from TIPS)

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- We study the response of **real** interest rates to monetary news in the 30-minute window around FOMC announcements
  - Real yields and forwards (from TIPS)
- Identifying assumption:
  - Unexpected changes in interest rates at these times are due to actions and statements of the Fed
  - Not a response to other events that occurred in this narrow window

WHY REAL RATES?

- What can response of real rates tell us?
  - Real rates affect output in **all** models (RBC and NK)
  - Controversy is over whether monetary policy affect **real** (as opposed to only nominal) rates
- Response of real interest rates measurable at high frequency
  - High frequency data key for discontinuity-based identification
  - Allows for greater precision than for variables that do not respond at high frequency (e.g., output and inflation)

MAIN EMPIRICAL FINDINGS

1. Nominal and real rates move one-for-one several years into the term structure
2. Small response of break-even inflation

We show how under **conventional interpretation of monetary shocks**:

- Implies prices are very sticky (flat Phillips curve)

Main Empirical Findings

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We show how under **conventional interpretation of monetary shocks**:

- Implies prices are very sticky (flat Phillips curve)

3. **But**: Tightening of policy **raises** expected output growth (Blue Chip)
    - Inconsistent with standard models of monetary policy
    - Need new model of monetary policy with “information effects”

FED INFORMATION MODEL

- FOMC announcements affect private sector beliefs...
  - Not only about monetary policy (conventional view)
  - But also about exogenous fundamentals (e.g. productivity) (as in Romer-Romer 00)

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- New model of "Fed Information"
- Estimate large information effect
  - 2/3 of shocks are changes in beliefs about exogenous fundamentals
- Fed has great deal of power over private sector beliefs
- Fed "fights against itself" by increasing pessimism when it unexpectedly loosens policy

RELATED LITERATURE

- Fed information effect
  - Empirical: Romer-Romer 00, Faust-Swanson-Wright 04, Campbell et al. 12
  - Theoretical: Cukierman-Meltzer 86, Ellingen-Soderstrom 01, Berkelmans 11, Melosi 16, Tang 15, Frankel-Kartik 15, Andrade et al. 16
- High-frequency identification of monetary shocks
  - Cook-Hahn 89, Kuttner 01, Cochrane-Piazzesi 02, Gurkaynak-Sack-Swanson 05, Hansen-Stein 15, Gertler-Karadi 15.
- New Keynesian models of monetary policy:
  - Rotemberg-Woodford 97, Clarida-Gali-Gertler 99, Woodford 03, Christiano-Eichenbaum-Evans 05

High Frequency Estimation of the Effects of Monetary Shocks

Forward Guidance

- Fed uses post-meeting statements to manage expectations about what it is going to do in the future
- Example: January 28, 2004
  - No change in Fed Funds Rate, fully anticipated
  - Unexpected change in Fed Funds Rate: 0 bp
  - However, FOMC statement dropped the phrase: "policy accommodation can be maintained for a considerable period"
  - Two- and five-year yields jumped 20-25 bp

  (Discussed in Gurkaynak-Sack-Swanson 05)

Implication:

- Measures of monetary shock should incorporate "forward guidance"

Policy News Shock

We follow GSS 05 in basing policy indicator on changes in 5 interest rate futures:

- Fed Funds future for current month (scaled)
- Fed Funds future for month of next FOMC meeting (scaled)
- 3-month Eurodollar futures at horizons of 2Q, 3Q, 4Q

Policy News Shock:

- First principle component of change in these 5 interest rate futures over 30 minute window around scheduled FOMC announcements (also consider 1-day window)

(Similar to GSS 05 "path factor")

Dependent Variables

- Nominal Treasury zero-coupon yields (Gurkaynak-Sack-Wright 07)
- Real TIPS zero-coupon yields (Gurkaynak-Sack-Wright 10)
  - TIPS started trading in 1997
- Daily data for sample period Jan-2000 to Mar-2014
  - Baseline sample drops 2008:07 - 2009:06
  - Results robust to including apex of crisis or ending sample in 2007

EFFECTS OF POLICY NEWS SHOCK

TABLE 1
Response of Interest Rates and Inflation to the Policy News Shock

	Nominal	Real	Inflation
2Y Treasury Yield	1.10	1.06	0.04
	(0.33)	(0.24)	(0.18)
5Y Treasury Yield	0.73	0.64	0.09
	(0.20)	(0.15)	(0.11)
10Y Treasury Yield	0.38	0.44	-0.06
	(0.17)	(0.13)	(0.08)
2Y Treasury Inst. Forward Rate	1.14	0.99	0.15
	(0.46)	(0.29)	(0.23)
3Y Treasury Inst. Forward Rate	0.82	0.88	-0.06
	(0.43)	(0.32)	(0.15)
5Y Treasury Inst. Forward Rate	0.26	0.47	-0.21
	(0.19)	(0.17)	(0.08)
10Y Treasury Inst. Forward Rate	-0.08	0.12	-0.20
	(0.18)	(0.12)	(0.09)

Two Empirical Issues

1. "Background noise"
2. Risk premia vs. Expected future short rates

Background Noise

TABLE 2
Allowing For Background Noise in Interest Rates

	10-Year Forward	
	Nominal	Real
Policy News Shock, 30-Minute Window:		
OLS	-0.08 [-0.43, 0.28]	0.12 [-0.12, 0.36]
Rigobon	-0.12 [-0.46, 0.24]	0.11 [-0.13, 0.35]
Policy News Shock, 1-Day Window:		
OLS	0.05 [-0.20, 0.29]	0.15 [-0.10, 0.39]
Rigobon	-0.51 [-1.93, -0.08]	-0.04 [-0.51, 0.45]
2-Year Nominal Yield, 1-Day Window		
OLS	0.18 [0.01, 0.35]	0.20 [0.02, 0.38]
Rigobon (90% CI)	-0.51 [-10.00, -0.21]	-0.04 [-4.57, 0.38]

Rigobon

Risk Premia vs. Expected Real Rates

- Simple view: Effect of policy news shock on long-rates reflects change in future expected interest rates (“forward guidance”)
- Could these instead be “risk premium” effects?
  - We argue not (see also Piazzesi-Swanson 08)

Future Short Rates or Risk Premia?

Three modes of attack:

1. Look directly at survey expectations (Blue Chip)
   - Not affected by risk premia since direct measure of expectations
2. Affine term structure model (Abrahams et al. 15)
   - Provides a decomposition into changes in expected future short rates and risk premia
3. Mean reversion
   - Do effects on long-term yields appear to mean revert over longer windows

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Survey Evidence on Risk Premia

TABLE D.1
Effects of Monetary Shocks on Survey Expectations

	Nominal	Real	Inflation
1 quarter	1.05	1.17	-0.12
	(0.73)	(0.78)	(0.24)
2 quarters	1.18	1.63	-0.44
	(0.75)	(0.60)	(0.31)
3 quarters	0.99	1.29	-0.30
	(0.72)	(0.78)	(0.24)
4 quarters	0.86	1.17	-0.32
	(0.71)	(0.77)	(0.23)
5 quarters	0.73	0.59	0.14
	(0.89)	(0.94)	(0.21)
6 quarters	1.84	1.60	0.23
	(0.89)	(0.88)	(0.24)
7 quarters	4.45	4.29	0.17
	(1.91)	(1.99)	(0.27)

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AFFINE TERM STRUCTURE MODEL

TABLE D.2
Response of Expected Future Short Rates and Risk Premia

	Expected Future Short Rates		Risk Premia	
	Nominal	Real	Nominal	Real
2Y Treasury Yield	1.01	0.86	0.09	0.20
	(0.27)	(0.17)	(0.10)	(0.18)
5Y Treasury Yield	0.76	0.60	-0.04	0.04
	(0.16)	(0.12)	(0.11)	(0.14)
10Y Treasury Yield	0.50	0.40	-0.12	0.04
	(0.11)	(0.08)	(0.14)	(0.14)
2Y Treasury Forward Rate	0.79	0.73	0.35	0.26
	(0.24)	(0.22)	(0.26)	(0.21)
3Y Treasury Forward Rate	0.61	0.56	0.21	0.32
	(0.19)	(0.17)	(0.29)	(0.25)
5Y Treasury Forward Rate	0.36	0.33	-0.11	0.14
	(0.08)	(0.08)	(0.17)	(0.17)
10Y Treasury Forward Rate	0.10	0.09	-0.18	0.04
	(0.02)	(0.02)	(0.18)	(0.12)

Decomposition of real and nominal term structure from Abrahams et al. (2015)

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3. Mean reversion
   - Do effects on long-term yields appear to mean revert over longer windows

MEAN REVERSION

TABLE D.3
Mean Reversion

Horizon (Trading Days)	Real Yields 2-Year	3-Year	5-Year
1	1.06	1.02	0.64
	(0.28)	(0.31)	(0.19)
5	1.01	0.93	0.52
	(0.64)	(0.68)	(0.38)
10	1.35	1.20	0.28
	(0.55)	(0.57)	(0.53)
20	0.88	0.43	0.04
	(0.95)	(0.94)	(0.79)
60	1.96	1.72	-0.10
	(2.13)	(1.92)	(1.13)
125	6.16	5.22	2.47
	(2.86)	(2.50)	(1.44)
250	9.58	8.22	4.13
	(2.92)	(2.97)	(1.84)

SUMMING UP

Policy news shock has:

- Large and persistent effects on real rates

    ...that do not appear to arise from risk premia

- Small effects on expected inflation

Interpretation

What Can Real Interest Rates Tell Us?

Fed affects nominal rates

$\rightarrow$ change in nominal rates affects real rates

$\rightarrow$ change in real rates affects output and inflation

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- 2nd step (real rates $\rightarrow$ output) common to RBC and NK models
- 1st step (nominal rates $\rightarrow$ real rates) more controversial

- Our results provide direct evidence on 1st step

Textbook Interpretation of Monetary Shocks

- Euler equation:

$$\begin{aligned} \hat{y}_t &= E_t\hat{y}_{t+1} - \sigma(\hat{\imath}_t - E_t\hat{\pi}_{t+1}) \\ \rightarrow \hat{x}_t &= E_t\hat{x}_{t+1} - \sigma(\hat{\imath}_t - E_t\hat{\pi}_{t+1} - \hat{r}_t^n) \end{aligned}$$

  where $\hat{x}_t = y_t - y_t^n$

- Phillips curve:

$$\hat{\pi}_t = \beta E_t\hat{\pi}_{t+1} + \kappa\zeta\hat{x}_t$$

SOLVING FORWARD

Solve forward Euler equation (assuming r_t^n unchanged) to get

$$\hat{x}_t = -\sigma \sum_{j=0}^{\infty} E_t \hat{\imath}_{t+j} - E_{t+j} \hat{\pi}_{t+j+1} = -\sigma \hat{r}_t^{\ell}$$

Solve forward the Phillips curve:

$$\hat{\pi}_t = \kappa \zeta \sum_{j=0}^{\infty} \beta^j E_t \hat{x}_{t+j}$$

Combine these two:

$$\hat{\pi}_t = -\kappa \zeta \sigma \sum_{j=0}^{\infty} \beta^j E_t \hat{r}_{t+j}^{\ell}$$

What Real Rates Tell Us

$$\hat{\pi}_t = -\kappa\zeta\sigma \sum_{j=0}^{\infty} \beta^j E_t \hat{r}^{\ell}_{t+j}$$

1. Small response of inflation relative to response of real rates implies:
   - Large amounts of nominal and real rigidities (small $\kappa\zeta$)
   - Small value of intertemporal elasticity of substitution (small σ)

   (or both)

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   - Small value of intertemporal elasticity of substitution (small σ)

   (or both)
2. Output should fall!

Output Expectations Actually Rise!

TABLE 3

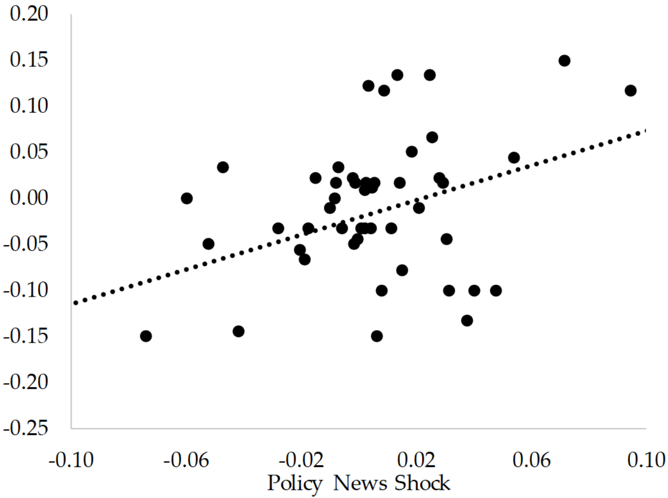
Response of Expected Growth over Next Year for Different Sample Periods

	1995-2014	2000-2014	2000-2007	1995-2000
Policy News Shock	1.01	1.04	0.95	0.79
	(0.32)	(0.35)	(0.32)	(0.63)
Observations	120	90	52	30

Greenbook

Scatter Plot: Expected Growth

Figure 2: Binned Scatter Plot for Expected Output Growth Regression



IS THIS CRAZY?

- Maybe not
- When Fed raises rates, people may conclude that economy is stronger than they thought

Is this Crazy?

- Maybe not
- When Fed raises rates, people may conclude that economy is stronger than they thought
- Fed has little private data, but hundreds of PhD economists
- Following Romer-Romer 00, we call this the **Fed Information Effect**

THE ROLE OF FED INFORMATION

Conventional interpretation of monetary shocks:

- Fed conveying information **only** about its own future policy

The Role of Fed Information

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Fed information view:

- Fed conveys information about its own future policy but also about current and future exogenous shocks
  - Suppose Fed tightens policy ...
  - Public infers that Fed is more optimistic about economic outlook ...
  - Public updates its own assessment of economic outlook in response

How to Model Fed Information?

- Which fundamentals should Fed be modeled as affecting beliefs about?
- Prior literature assumes Fed signals through actions
  - Very limited signal space
  - Literature about limits to Feds ability to signal

How to Model Fed Information?

- Which fundamentals should Fed be modeled as affecting beliefs about?
- Prior literature assumes Fed signals through actions
  - Very limited signal space
  - Literature about limits to Feds ability to signal
- Recent empirical evidence makes clear that Fed can signal with statements (forward guidance)
  - Could signal about anything at any horizon
  - Very high dimensional!
- Crucial to find a parsimonious specification

How we Model Fed Information

Conventional view of monetary policy shocks:

- Fed conveying information about future monetary policy

$$\hat{x}_t = -\sigma \sum_{j=0}^{\infty} E_t(\hat{\imath}_{t+j} - \hat{\pi}_{t+j+1} - \hat{r}^n_{t+j})$$

Fed Information Case:

- Fed conveys information about future monetary policy
  but also about current and future natural rates of interest

$$\hat{x}_t = -\sigma \sum_{j=0}^{\infty} E_t(\hat{\imath}_{t+j} - \hat{\pi}_{t+j+1} - \hat{r}^n_{t+j})$$

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In simple model: $r^n_{t+j} = \sigma^{-1}(E_t y^n_{t+j+1} - y^n_{t+j})$

Fed Information Effect

Why model Fed info this way?

- Tractable with forward guidance shocks
- Optimal monetary policy for Fed to track natural rate of interest
- Natural to think of monetary policy as revealing information about natural rate of interest

Estimation

Fed Information Model

- Augmented New Keynesian model:
  - Internal habit
  - Lagged term in Phillips curve
- Monetary policy with Fed information:

$$\hat{\imath}_t - E_t \hat{\pi}_{t+1} = \bar{r}_t + \phi_\pi \hat{\pi}_t$$

where $\bar{r}_t$ follows AR(2)

- Strength of Fed Information:

$$E_t \hat{r}^n_{t+j} = \psi E_t \bar{r}_{t+j}.$$

Here ψ governs strength of Fed information

Estimation Approach

- Simulated method of moments
- High frequency moments:
  - Real yields and forwards (2, 3, 5, and 10-year)
  - Break-even inflation (2, 3, 5, and 10-year)
  - Output growth expectations from Blue Chip
    (monthly responses of 0 qtr to 7 qtr ahead output growth)
- Weighting matrix:
  - Diagonal: Inverse of standard deviations of moments
  - Off-Diagonal: Zero
- Bootstrap standard errors

Estimation Approach

- Estimate key parameters:
  - Slope of Phillips curve ($\kappa\zeta$)
  - Information content of shocks (ψ)
  - Dynamics of shock ($\bar{r}_t$ assumed to be AR(2))
- Fix other parameters:
  - $\beta = 0.99$, $\sigma = 0.5$, $b = 0.9$, $\omega = 2$ (standard values)
  - $\phi_\pi = 0.01$ (guarantees determinacy)

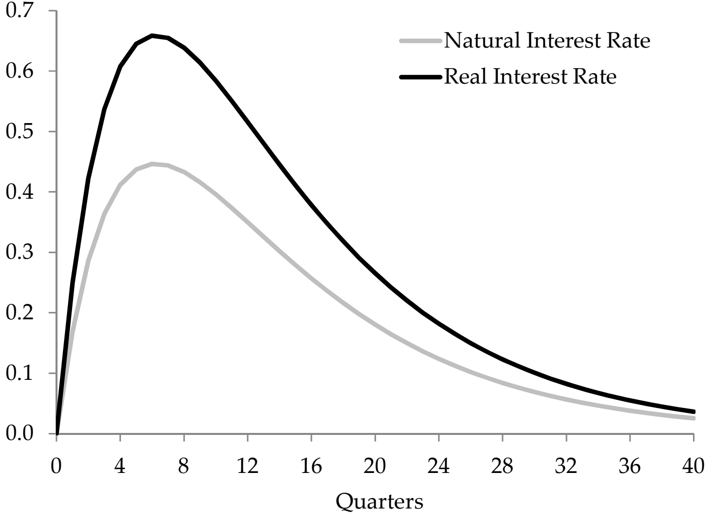
INTUITION

- What identifies parameters?
  - Path of $\hat{r}^n_{t+j}$ (and thereby strength of Fed information effects) pinned down by survey data on $E_t y_{t+j}$
  - Nominal/real rigidity pinned down by response of inflation (π_t) relative to ($r_t - r^n_t$)

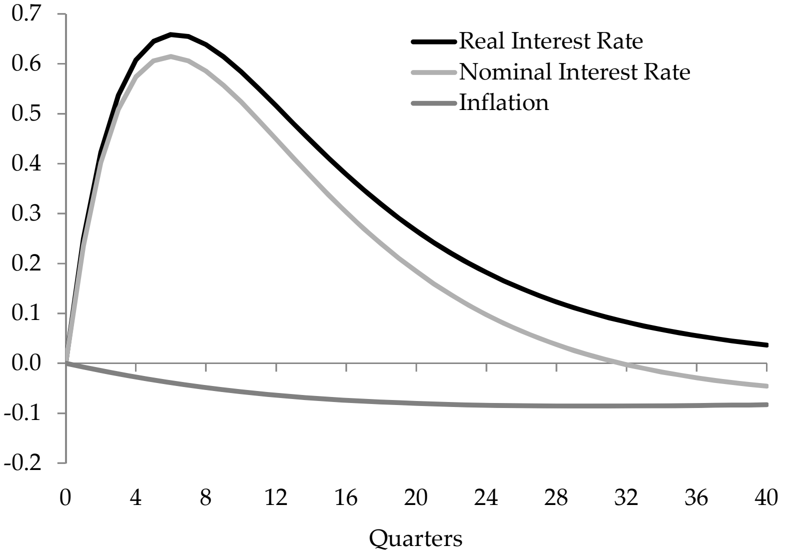
$$\hat{\pi}_{t+i} = -\kappa\zeta\sigma \sum_{j=0}^{\infty} \beta^j E_{t+i}(\hat{r}^{\ell}_{t+i+j} - \hat{r}^{n\ell}_{t+i+j})$$

Results

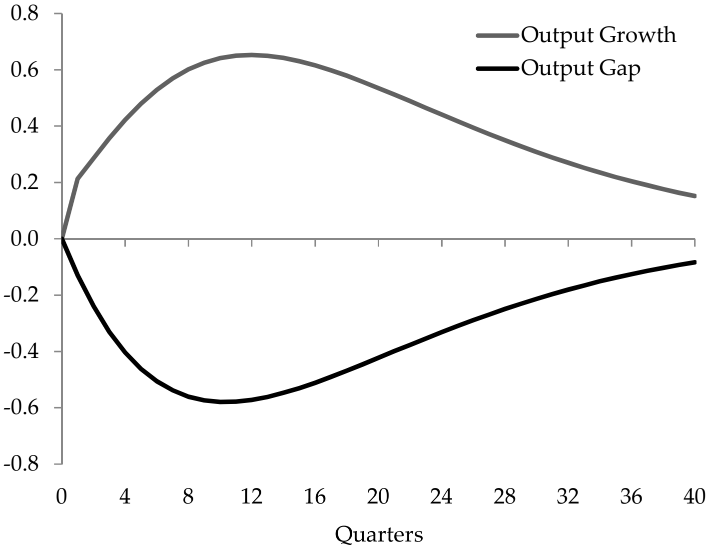
Large Information Effect



Model Matches Interest Rates and Inflation



Expected Growth Rises



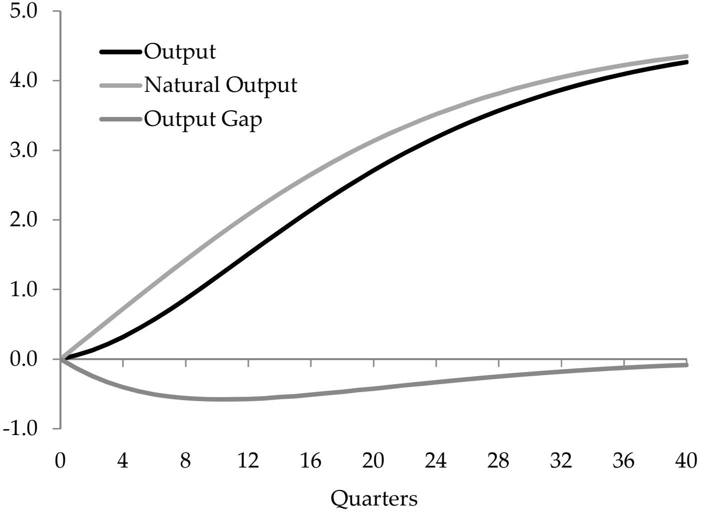
PHILLIPS CURVE

- Lots of rigidity: Phillips curve very flat
  (in line with recent estimates...)
  - $\kappa\zeta \approx 10^{-4}$
- Shutting down information effect leads to underestimate of slope of the Phillips curve

$$\hat{\pi}_{t+i} = -\kappa\zeta\sigma \sum_{j=0}^{\infty} \beta^j E_{t+i}(\hat{r}^{\ell}_{t+i+j} - \hat{r}^{n\ell}_{t+i+j})$$

Table

Massive Effects on Expected Output



IS THIS CAUSAL EFFECT?

- Fed action signals high future growth
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- Changes in non-monetary fundamentals would have occurred anyway!
- To assess the **causal effect** of monetary policy on output,
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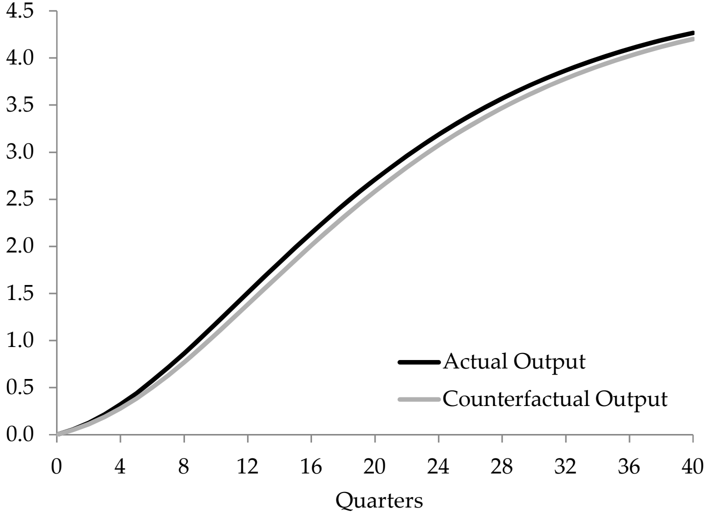
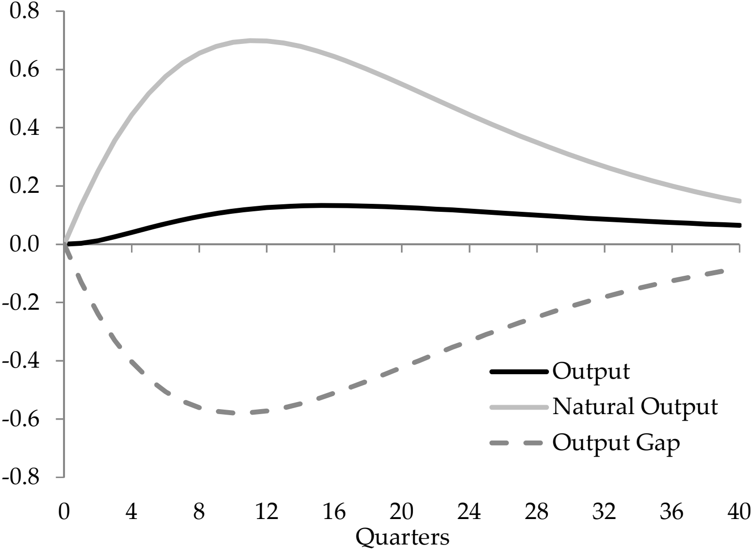
- Proposed counterfactual:
  - People learn about productivity changes when they happen
  - Expect productivity to follow random walk

Output: Actual and Counterfactual



Causal Effect with Fed Information



Causal Effect of Monetary Policy

- Fed information can have a *causal* effect on output
- But it differs from effect on expected output
  (most of which would have occurred anyway)

Causal effect of information:

- Good news about future boosts demand today
- Due to internal habit (capital another channel)
- Leads natural rate of output to *rise*

SUMMING UP

- We estimate strong support for two channels of monetary policy:
  - Conventional channel: high interest rate gap lowers output
  - Information channel: Positive news about the future *raises* output
- Information effect outweighs conventional channel for our shocks
- Unexpected monetary contraction can *raise* output
  - Fed fighting against itself

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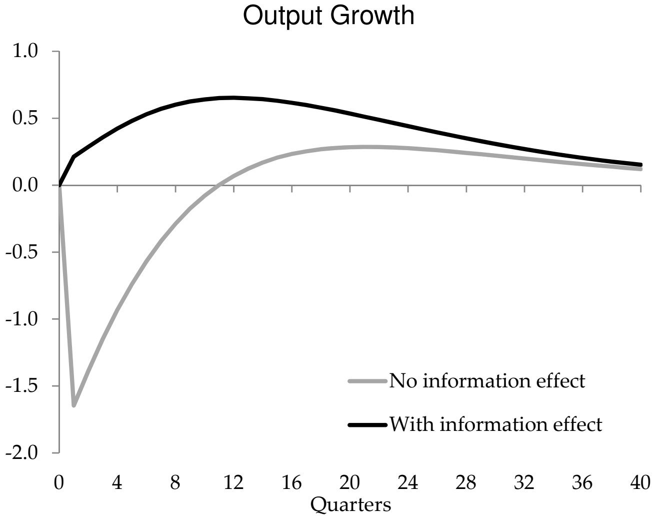
- If monetary contractions are expansionary and vice versa then is monetary economics turned on its head?

IS MONETARY ECONOMICS BACKWARDS?

- If monetary contractions are expansionary and vice versa then is monetary economics turned on its head?
  - No!
- Most monetary policy is systematic
  - Rules based on public information
  - No information effect

"CONTRACTIONARY" SHOCK: INFO VS. NO INFO



Improved Fit to Stock Prices

TABLE 5
Response of Stock Prices

	Stock Prices
Response in the Data	-6.5
	(3.9)
Response in the Model	
Baseline	-6.8
	[-11.5, -1.6]
No Fed Information Effect	-11.1
	[-19.4, -2.5]

CONCLUSION

Fed has enormous power over real interest rate

- Nominal and real rates move together several years into term structure
- But output growth expectations rise in response to tightening!

Evidence for two channels:

- Conventional sticky price channel
- Information effect

Extra Slides

Identification by Heteroskedasticity

Policy news shock (Δi_t) and other variables of interest (Δs_t) affected by monetary shock (ϵ_t) and other shocks (η_t)

$$\Delta i_t = \alpha_i + \epsilon_t + \beta_i \eta_t$$

$$\Delta s_t = \alpha_s + \gamma \epsilon_t + \beta_s \eta_t$$

Two regimes:

- “Treatment” sample: FOMC announcements (R1)
- “Control” sample: Other 30-minute/1-day windows (R2)

Identification assumption:

$$\sigma_{\epsilon,R1} > \sigma_{\epsilon,R2} \quad \text{while} \quad \sigma_{\eta,R1} = \sigma_{\eta,R2}$$

Identification by Heteroskedasticity

$$\Delta i_t = \alpha_i + \epsilon_t + \beta_i \eta_t$$

$$\Delta s_t = \alpha_s + \gamma \epsilon_t + \beta_s \eta_t$$

Given this identification assumption, we have:

$$\gamma = \frac{\text{cov}_{R1}(\Delta i_t, \Delta s_t) - \text{cov}_{R2}(\Delta i_t, \Delta s_t)}{\text{var}_{R1}(\Delta i_t) - \text{var}_{R2}(\Delta i_t)}$$

- If no background noise, you could just run a regression
- Intuitively, OLS adjusted for "normal" covariance between Δs_t and Δi_t

Back

Greenbook Evidence

- If Fed information is important, contractionary monetary policy shocks should occur when Fed is more optimistic than private sector

$$\text{policy news shock}_t = \alpha + \beta \left(\Delta y_{t,q}^{GB} - \Delta y_{t,q}^{BC} \right) + \varepsilon_t,$$

Greenbook Evidence

- If Fed information is important, contractionary monetary policy shocks should occur when Fed is more optimistic than private sector

$$\text{policy news shock}_t = \alpha + \beta \left(\Delta y^{GB}_{t,q} - \Delta y^{BC}_{t,q} \right) + \varepsilon_t,$$

- If private sector learns from Fed, this difference should narrow after announcement

$$\left[\left(\Delta y^{GB}_{t+1,q} - \Delta y^{BC}_{t+1,q} \right) - \left(\Delta y^{GB}_{t,q} - \Delta y^{BC}_{t,q} \right) \right] = \alpha + \beta \text{policy news shock}_t + \varepsilon_{t+1}$$

GREENBOOK EVIDENCE

TABLE G.1

Greenbook versus Blue Chip Forecasts

Horizon (q):	0	1	2	3	4	5	6	7
Does Fed Relative Optimism Explain Monetary Shocks?								
β	1.19	1.01	1.21	1.00	1.20	1.89	3.10	1.88
	(0.55)	(0.74)	(0.69)	(0.77)	(0.90)	(1.10)	(1.14)	(1.64)
N	90	90	90	90	90	66	42	22
Does Fed Relative Optimism Reverse in Response to Monetary Shocks?								
β	-4.07	-0.45	-0.87	-0.46	-1.66	-3.58	-1.34	-3.04
	(1.80)	(1.53)	(1.30)	(1.08)	(1.11)	(1.31)	(1.30)	(2.44)
N	89	89	89	89	76	55	32	8

Back

TABLE 4
Estimates of Structural Parameters

	ψ	$\kappa\zeta$ x 10^{-5}	ρ_1	ρ_2
Baseline	0.68	11.2	0.90	0.79
	[0.33, 0.84]	[0.0, 60.2]	[0.83, 0.96]	[-0.69, 0.89]
No Information	0.00	3.4	0.90	0.79
($\psi = 0$)	--	[0.0, 24.1]	[0.83, 0.96]	[-0.69, 0.89]
Full Information	0.99	563	0.90	0.79
($\psi = 0.99$)	--	[0, 12538]	[0.82, 0.96]	[-0.67, 0.89]
Lower IES	0.67	13.7	0.90	0.79
($\sigma = 0.25$)	[0.25, 0.89]	[0.0, 94.6]	[0.83, 0.96]	[-0.69, 0.89]
Higher IES	0.68	8.2	0.90	0.79
($\sigma = 1$)	[0.42, 0.81]	[0.0, 44.0]	[0.83, 0.96]	[-0.69, 0.89]
No Habits	1.00	1000	0.90	0.79
($b = 0$)	[0.92, 1.00]	[0, 43236]	[0.83, 0.96]	[-0.69, 0.89]

Back