HIGH FREQUENCY IDENTIFICATION OF MONETARY NON-NEUTRALITY: THE INFORMATION EFFECT

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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
**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

- **Most common existing approach to identification:**
  - Controlling for confounding variables
    (e.g., Christiano-Eichenbaum-Evans 99, Romer-Romer 04)

- **Worry:** Some endogeneity bias may remain (e.g., 9/11)
Discrete amount of monetary news at time of FOMC announcements

Allows for discontinuity based identification
High Frequency Identification

- Discrete amount of monetary news at time of FOMC announcements
- Allows for discontinuity based identification
- Estimate monetary shock in 30-minute window around FOMC announcements (Gurkaynak-Sack-Swanson 05)
- 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
THE POWER PROBLEM

- HFI arguably the cleanest way to identify monetary shocks
  ... but shocks are small and sample short
- Regressions on future output very imprecise
  (Cochrane-Piazzesi 02)
The Power Problem

- HFI arguably the cleanest way to identify monetary shocks
  ... but shocks are small and sample short
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- Potential solution:
  - Focus on outcome variables that move *contemporaneous*:
    Real yields and forwards (from TIPS)
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Potential solution:
- Focus on outcome variables that move *contemporaneous*:
  Real yields and forwards (from TIPS)
Movements in real rates are *the* key empirical issue in monetary economics:
- Real rates affect output in all models (RBC and NK)
- Persistent movements in real rates is distinguishing feature of New Keynesian models
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:

- Evidence pins down slope of Phillips curve (for given IES)
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:

- Evidence pins down slope of Phillips curve (for given IES)

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
FOMC announcements affect private sector beliefs about future path of **natural rate** of interest

- Optimal policy to track the natural rate
- Natural that Fed announcements affect beliefs about it
Fed Information Model

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- Estimate New Keynesian model with Fed information effect
  - 2/3 of shocks changes in natural rates
  - 1/3 of shocks tightening relative to natural rate
Fed Information Model

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  - Optimal policy to track the natural rate
  - Natural that Fed announcements affect beliefs about it
- Estimate New Keynesian model with Fed information effect
  - 2/3 of shocks changes in natural rates
  - 1/3 of shocks tightening relative to natural rate
- Fed has great deal of power over private sector beliefs
- Fed “fights against itself” by increasing optimism when it tightens policy
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

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)
Forward Guidance

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Implication:
- Measures of monetary shock should incorporate “forward guidance”
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
TABLE 1
Response of Interest Rates and Inflation to the Policy News Shock

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

1. 30-minute windows versus 1-day windows
2. Expected future short rates versus risk premia
# 30-minute vs. 1-Day Windows

<table>
<thead>
<tr>
<th>Table 2: Allowing For Background Noise in Interest Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>10-Year Forward</strong></td>
</tr>
<tr>
<td><strong>Nominal</strong></td>
</tr>
<tr>
<td>Policy News Shock, 30-Minute Window:</td>
</tr>
<tr>
<td>OLS</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rigobon</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Policy News Shock, 1-Day Window:</td>
</tr>
<tr>
<td>OLS</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rigobon</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2-Year Nominal Yield, 1-Day Window</td>
</tr>
<tr>
<td>OLS</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rigobon (90% CI)</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
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)
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
## Survey Evidence on Risk Premia

### TABLE 3
Effects of Monetary Shocks on Survey Expectations

<table>
<thead>
<tr>
<th>Time Periods</th>
<th>Nominal</th>
<th>Real</th>
<th>Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 quarter</td>
<td>1.04</td>
<td>1.21</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>(0.48)</td>
<td>(0.52)</td>
<td>(0.23)</td>
</tr>
<tr>
<td>2 quarters</td>
<td>1.15</td>
<td>1.59</td>
<td>-0.44</td>
</tr>
<tr>
<td></td>
<td>(0.48)</td>
<td>(0.49)</td>
<td>(0.23)</td>
</tr>
<tr>
<td>3 quarters</td>
<td>0.90</td>
<td>1.20</td>
<td>-0.30</td>
</tr>
<tr>
<td></td>
<td>(0.52)</td>
<td>(0.49)</td>
<td>(0.21)</td>
</tr>
<tr>
<td>4 quarters</td>
<td>0.84</td>
<td>1.17</td>
<td>-0.33</td>
</tr>
<tr>
<td></td>
<td>(0.47)</td>
<td>(0.53)</td>
<td>(0.20)</td>
</tr>
<tr>
<td>5 quarters</td>
<td>0.70</td>
<td>0.59</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>(0.60)</td>
<td>(0.62)</td>
<td>(0.23)</td>
</tr>
<tr>
<td>6 quarters</td>
<td>1.84</td>
<td>1.60</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>(0.59)</td>
<td>(0.60)</td>
<td>(0.27)</td>
</tr>
<tr>
<td>7 quarters</td>
<td>4.45</td>
<td>4.29</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>(1.33)</td>
<td>(1.36)</td>
<td>(0.41)</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th></th>
<th>Expected Future Short Rates</th>
<th>Risk Premia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nominal</td>
<td>Real</td>
</tr>
<tr>
<td>2Y Treasury Yield</td>
<td>1.01</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>(0.27)</td>
<td>(0.17)</td>
</tr>
<tr>
<td>5Y Treasury Yield</td>
<td>0.76</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>10Y Treasury Yield</td>
<td>0.50</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td>(0.08)</td>
</tr>
<tr>
<td>2Y Treasury Forward Rate</td>
<td>0.79</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>(0.24)</td>
<td>(0.22)</td>
</tr>
<tr>
<td>3Y Treasury Forward Rate</td>
<td>0.61</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>(0.19)</td>
<td>(0.17)</td>
</tr>
<tr>
<td>5Y Treasury Forward Rate</td>
<td>0.36</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.08)</td>
</tr>
<tr>
<td>10Y Treasury Forward Rate</td>
<td>0.10</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.02)</td>
</tr>
</tbody>
</table>

Decomposition of real and nominal term structure from Abrahams et al. (2013)
Three modes of attack:

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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
## Mean Reversion

**TABLE 5**

<table>
<thead>
<tr>
<th>Horizon (Trading Days)</th>
<th>Real Yields</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2-Year</td>
<td>3-Year</td>
</tr>
<tr>
<td>1</td>
<td>1.06</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>(0.28)</td>
<td>(0.31)</td>
</tr>
<tr>
<td>5</td>
<td>1.01</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>(0.64)</td>
<td>(0.68)</td>
</tr>
<tr>
<td>10</td>
<td>1.35</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>(0.55)</td>
<td>(0.57)</td>
</tr>
<tr>
<td>20</td>
<td>0.88</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>(0.95)</td>
<td>(0.94)</td>
</tr>
<tr>
<td>60</td>
<td>1.96</td>
<td>1.72</td>
</tr>
<tr>
<td></td>
<td>(2.13)</td>
<td>(1.92)</td>
</tr>
<tr>
<td>125</td>
<td>6.16</td>
<td>5.22</td>
</tr>
<tr>
<td></td>
<td>(2.86)</td>
<td>(2.50)</td>
</tr>
<tr>
<td>250</td>
<td>9.58</td>
<td>8.22</td>
</tr>
<tr>
<td></td>
<td>(2.92)</td>
<td>(2.97)</td>
</tr>
</tbody>
</table>
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
Fed affects nominal rates

→ change in nominal rates affects real rates

→ change in real rates affects output and inflation
Fed affects nominal rates

→ change in nominal rates affects real rates

→ change in real rates affects output and inflation

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

- Our results provide direct evidence on 1st step
Euler equation:

\[ \hat{y}_t = E_t \hat{y}_{t+1} - \sigma (\hat{\imath}_t - E_t \hat{\pi}_{t+1}) \]

\[ \rightarrow \hat{x}_t = E_t \hat{x}_{t+1} - \sigma (\hat{\imath}_t - E_t \hat{\pi}_{t+1} - \hat{r}_t) \]

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 to get

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

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:

\[ \hat{\pi}_t = -\kappa \zeta \sigma \sum_{j=0}^{\infty} \beta^j E_t \hat{r}^{\ell}_{t+j} \]
What Real Rates Tell Us

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

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 \( \sigma \))
   (or both)

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   (or both)

2. Output should fall!
TABLE 6
Response of Expected Output Growth

<table>
<thead>
<tr>
<th>Output Growth</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Growth in Current Qr</td>
<td>1.42</td>
<td>(1.18)</td>
</tr>
<tr>
<td>Output Growth 1 Qr Ahead</td>
<td>1.59</td>
<td>(0.61)</td>
</tr>
<tr>
<td>Output Growth 2 Qr Ahead</td>
<td>0.66</td>
<td>(0.34)</td>
</tr>
<tr>
<td>Output Growth 3 Qr Ahead</td>
<td>0.82</td>
<td>(0.27)</td>
</tr>
<tr>
<td>Output Growth 4 Qr Ahead</td>
<td>0.50</td>
<td>(0.30)</td>
</tr>
<tr>
<td>Output Growth 5 Qr Ahead</td>
<td>0.55</td>
<td>(0.27)</td>
</tr>
<tr>
<td>Output Growth 6 Qr Ahead</td>
<td>0.48</td>
<td>(0.29)</td>
</tr>
<tr>
<td>Output Growth 7 Qr Ahead</td>
<td>0.87</td>
<td>(0.70)</td>
</tr>
</tbody>
</table>
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

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The Role of Fed Information

Conventional interpretation of monetary shocks:

- Fed conveying information only about its own future policy
  - Public learning about policy maker’s preferences
  - Public learning about how policy maker thinks the world works
    (but not updating own beliefs about how world works)
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
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    (but not updating own beliefs about how world works)

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?
  - Could be anything at any horizon
  - Very high dimensional!

- Crucial to find a parsimonious specification
How to Model Fed Information?

- Which fundamentals should Fed be modeled as affecting beliefs about?
  - Could be anything at any horizon
  - Very high dimensional!

- Crucial to find a parsimonious specification

- We assume Fed affects beliefs about path of natural rate of interest
**Fed Information Effect**

Conventional view of monetary policy shocks:

- Fed conveying information about future monetary policy

\[
\hat{x}_t = -\sigma \sum_{j=0}^{\infty} E_t (\hat{i}_{t+j} - \hat{\pi}_{t+j+1} - \hat{r}_t^n)
\]
Fed Information Effect

Conventional view of monetary policy shocks:

- Fed conveying information about future monetary policy
  \[
  \hat{x}_t = -\sigma \sum_{j=0}^{\infty} E_t(\hat{\pi}_{t+j} - \hat{\pi}_{t+j+1} - \hat{r}_{t+j})
  \]

Fed Information Case:

- Fed conveys information about future monetary policy but also about current and future natural rates of interest
  \[
  \hat{x}_t = -\sigma \sum_{j=0}^{\infty} E_t(\hat{\pi}_{t+j} - \hat{\pi}_{t+j+1} - \hat{r}_{t+j})
  \]
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  \]

Fed Information Case:

- Fed conveys information about future monetary policy but also about current and future natural rates of interest
  \[
  \hat{x}_t = -\sigma \sum_{j=0}^{\infty} E_t(\hat{i}_{t+j} - \hat{\pi}_{t+j+1} - \hat{r}_{t+j}^n)
  \]

In simple model: \( r_{t+j}^n = \sigma^{-1}(E_t y_{t+j+1}^n - y_{t+j}^n) \)
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
Non-Neutrality with Fed Information

Inflation response determined by interest rate gap:

\[ \hat{\pi}_t = -\kappa \zeta \sigma \sum_{j=0}^{\infty} \beta^j E_t(\hat{r}_{t+j}^e - \hat{r}_t^{nl}) \]

If Fed information large:

- Interest rate gap small
- Traditional power of Fed small
Non-Neutrality with Fed Information

Inflation response determined by interest rate gap:

\[ \hat{\pi}_t = -\kappa \zeta \sigma \sum_{j=0}^{\infty} \beta^j E_t (\hat{r}^{\ell}_{t+j} - \hat{r}^{nl}_t) \]

If Fed information large:

- Interest rate gap small
- Traditional power of Fed small
- But Fed not powerless
- Fed has enormous power over beliefs about fundamentals which may in turn affect economic activity
Estimation
Fed Information Model: Empirics

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

\[ \hat{i}_t - E_t \hat{\pi}_{t+1} = \bar{r}_t + \phi_\pi \hat{\pi}_t \]

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

\[ E_t \hat{r}^n_{t+j} = \psi E_t \bar{r}_{t+j} \]

here \( \psi \) governs strength of Fed information
Intuition for Identification

- Conventional view:
  - Nominal/real rigidity pinned down by response of inflation ($\pi_t$) relative to response of real rates ($r_t$)

\[
\hat{\pi}_{t+i} = -\kappa \zeta \sigma \sum_{j=0}^{\infty} \beta^j E_t \hat{r}_{t+i+j}^\ell
\]
**Intuition for Identification**

- **Conventional view:**
  - Nominal/real rigidity pinned down by response of inflation ($\pi_t$) relative to response of real rates ($r_t$)
  
  \[
  \hat{\pi}_{t+i} = -\kappa \zeta \sigma \sum_{j=0}^{\infty} \beta^j E_{t+i} \hat{r}_{t+i+j}^\ell
  \]

- **Fed Information Case:**
  - Path of $r_t^n$ pinned down survey data on $E_t y_t$
  - Nominal/real rigidity pinned down by response of inflation ($\pi_t$) relative to ($r_t - r_t^n$)
  
  \[
  \hat{\pi}_{t+i} = -\kappa \zeta \sigma \sum_{j=0}^{\infty} \beta^j E_{t+i} (\hat{r}_{t+i+j}^\ell - \hat{r}_{t+i+j}^{n\ell})
  \]
Fed Information Model: Empirics

- Estimate key parameters:
  - Slope of Phillips curve ($\kappa \zeta$)
  - Information content of shocks ($\psi$)
  - 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)
  - $\phi_\pi = 0.01$
    - Implies determinacy
    - Limits endogenous feedback from policy rule
    - Helps guarantee that real rate dies out within 10 years
Simulated method of moments estimation

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
Results
LARGE INFORMATION EFFECT

![Graph showing the Natural Interest Rate and Real Interest Rate over quarters. The graph indicates that the Natural Interest Rate peaks and then declines, while the Real Interest Rate follows a similar trend but with a higher peak.](image-url)
Model Matches Interest Rates and Inflation

Nakamura and Steinsson (Columbia)  Monetary Shocks  October 2016
EXPECTED GROWTH RISES

![Graph showing expected growth rises over quarters](attachment:image.png)

- Output Growth
- Output Gap

Quarters:

-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
0 5 10 15 20 25 30 35 40

Output Growth
Output Gap

Nakamura and Steinsson (Columbia) Monetary Shocks October 2016
Monetary Non-Neutrality: Fed Information

- Informational effect very large: roughly 2/3 of shock
- Model matches empirical response of interest rates, expected inflation, and expected output
- Lots of rigidity: Phillips curve very flat (in line with recent estimates...)
- Shutting down information effect leads to underestimate of slope of the Phillips curve

\[ \hat{\pi}_{t+i} = -\kappa \zeta \sigma \sum_{j=0}^{\infty} \beta^j E_{t+i}(\hat{r}^l_{t+i+j} - \hat{r}^{nl}_{t+i+j}) \]
Massive Effects on Expected Output

- Output
- Natural Output
- Output Gap

Quarters

Output
Natural Output
Output Gap

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Fed action signals high future growth
But this doesn’t mean Fed causes high future growth
Fed action signals high future growth

But this doesn’t mean Fed *causes* high future growth

Changes in non-monetary fundamentals would have occurred anyway!

To assess the *causal effect* of monetary policy on output, we need to think carefully about the counterfactual
Fed action signals high future growth

But this doesn’t mean Fed causes high future growth

Changes in non-monetary fundamentals would have occurred anyway!

To assess the causal effect of monetary policy on output, we need to think carefully about the counterfactual

Proposed counterfactual:

- People learn about productivity changes when they happen
- Expect productivity to follow random walk
Output: Actual and Counterfactual

Most of the increase would have happened anyway

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Causal Effect of Monetary Policy

- **Conventional effect:**
  - Interest rate increase generates negative output gap

- **Fed information effect:**
  - Good news about future boosts demand today
  - Due to internal habit (capital another channel)
  - Fed “fighting against itself”
  - Could imply perverse effects of monetary policy (e.g. at ZLB)
Interest rate change associated with policy rule do not have information effect.

This is a potentially important advantage of systematic policy.
Advantage of Systematic Policy

- Interest rate change associated with **policy rule** do not have information effect.
- This is a potentially important advantage of systematic policy.
- Let’s compare output response to interest rate change with and without information effect.
ADVANTAGE OF SYSTEMATIC POLICY

Nakamura and Steinsson (Columbia)  Monetary Shocks  October 2016
**TABLE 8**  
Response of Stock Prices

<table>
<thead>
<tr>
<th>Description</th>
<th>Stock Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response in the Data</td>
<td>-6.5</td>
</tr>
<tr>
<td></td>
<td>(3.3)</td>
</tr>
<tr>
<td>Response in the Model</td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>-6.8</td>
</tr>
<tr>
<td></td>
<td>[-11.3, -1.5]</td>
</tr>
<tr>
<td>No Fed Information Effect</td>
<td>-11.1</td>
</tr>
<tr>
<td></td>
<td>[-19.5, -2.6]</td>
</tr>
</tbody>
</table>

**IMPROVED FIT TO STOCK PRICES**
CONCLUSION

Monetary shocks identified using high frequency identification:

- Nominal and real rate move one-for-one several years out into term structure
- Small response of expected inflation
- Tightening of policy raises expected output growth

Interpretation:
Crucial to account for Fed Information Effect
Fed fighting against itself:
Conventional channel lowers output
Information channel raises output
Helps explain flat Phillips curve
CONCLUSION

Monetary shocks identified using high frequency identification:

- Nominal and real rate move one-for-one several years out into term structure
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Interpretation:

- Crucial to account for Fed Information Effect
- Fed fighting against itself:
  - Conventional channel lowers output
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Extra Slides
Identification by Heteroskedasticity

Policy news shock ($\Delta i_t$) and other variables of interest ($\Delta s_t$) affected by monetary shock ($\epsilon_t$) and other shocks ($\eta_t$)

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

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

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 \( \Delta s_t \) and \( \Delta i_t \)
If Fed information is important, contractionary monetary policy shocks should occur when Fed is more optimistic than private sector

\[
policy\text{ news shock}_t = \alpha + \beta \left( \Delta y_{t,q}^{GB} - \Delta y_{t,q}^{BC} \right) + \varepsilon_t,
\]
If Fed information is important, contractionary monetary policy shocks should occur when Fed is more optimistic than private sector

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

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

\[ \left[ \left( \Delta y_{t+1,q}^{GB} - \Delta y_{t+1,q}^{BC} \right) - \left( \Delta y_{t,q}^{GB} - \Delta y_{t,q}^{BC} \right) \right] = \alpha + \beta \text{policy news shock}_t + \varepsilon_{t+1} \]
### TABLE E.1
Greenbook versus Blue Chip Forecasts

<table>
<thead>
<tr>
<th>Horizon (q):</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Does Fed Relative Optimism Explain Monetary Shocks?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.90</td>
<td>1.01</td>
<td>1.21</td>
<td>1.00</td>
<td>1.20</td>
<td>1.89</td>
<td>3.10</td>
<td>1.88</td>
</tr>
<tr>
<td></td>
<td>(0.44)</td>
<td>(0.64)</td>
<td>(0.58)</td>
<td>(0.59)</td>
<td>(0.65)</td>
<td>(0.89)</td>
<td>(1.32)</td>
<td>(2.07)</td>
</tr>
<tr>
<td>N</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>66</td>
<td>42</td>
<td>22</td>
</tr>
<tr>
<td><strong>Does Fed Relative Optimism Reverse in Response to Monetary Shocks?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>-14.03</td>
<td>0.40</td>
<td>-0.74</td>
<td>-0.94</td>
<td>-1.40</td>
<td>-2.17</td>
<td>-3.01</td>
<td>-1.45</td>
</tr>
<tr>
<td></td>
<td>(5.29)</td>
<td>(1.89)</td>
<td>(1.78)</td>
<td>(1.58)</td>
<td>(1.11)</td>
<td>(0.98)</td>
<td>(1.16)</td>
<td>(1.48)</td>
</tr>
<tr>
<td>N</td>
<td>53</td>
<td>89</td>
<td>89</td>
<td>89</td>
<td>89</td>
<td>66</td>
<td>42</td>
<td>22</td>
</tr>
</tbody>
</table>
### TABLE 7
Estimates of Structural Parameters

<table>
<thead>
<tr>
<th></th>
<th>$\psi$</th>
<th>$\kappa \zeta \times 10^{-5}$</th>
<th>$\rho_1$</th>
<th>$\rho_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td>0.67</td>
<td>[0.30, 0.85]</td>
<td>0.90</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[0.0, 57.5]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No Information</strong></td>
<td>0.00</td>
<td>[0.0, 19.7]</td>
<td>0.90</td>
<td>0.79</td>
</tr>
<tr>
<td>($\psi = 0$)</td>
<td></td>
<td>[0, 10148]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Full Information</strong></td>
<td>0.99</td>
<td>[0.24, 0.89]</td>
<td>0.90</td>
<td>0.79</td>
</tr>
<tr>
<td>($\psi = 0.99$)</td>
<td></td>
<td>[0.0, 75.8]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lower IES</strong></td>
<td>0.66</td>
<td>[0.37, 0.82]</td>
<td>0.90</td>
<td>0.79</td>
</tr>
<tr>
<td>($\sigma = 0.25$)</td>
<td></td>
<td>[0.0, 41.1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Higher IES</strong></td>
<td>0.68</td>
<td>[0.92, 1.00]</td>
<td>0.90</td>
<td>0.79</td>
</tr>
<tr>
<td>($\sigma = 1$)</td>
<td></td>
<td>[0, 10217]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No Habits</strong></td>
<td>1.00</td>
<td>[0.83, 0.96]</td>
<td>0.90</td>
<td>0.79</td>
</tr>
<tr>
<td>($b = 0$)</td>
<td></td>
<td>[-0.70, 0.88]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>