Event studies and high-frequency data

A. FOMC announcement effects (Kuttner)
B. Application: daily monetary policy shocks and the effect on new home sales (Hamilton)
C. FOMC meeting decisions (Romer-Romer)
D. Identifying DSGE from daily data (Nakamura and Steinsson)

1

Motivating theme: why do we really believe monetary policy has effects?

- Fed has meetings where they make decisions.
- Market seems to respond to outcome of those meetings.

2

A. FOMC announcement effects

- The Federal Open Market Committee currently meets 8 times a year.
- Will meet again Nov 1 and Dec 13
- At each meeting since mid-1980s, decides on a target for the fed funds rate
  - Overnight interest rate on loans between depository institutions (currently: GSEs lend to U.S. branches of foreign banks)
  - Current target is 1 to 1.25% (funds rate averaged 1.12% during October).

3

- The Nov 2017 fed funds futures contract is a number $f_{t,Nov}$ agreed upon by the buyer and seller at some day t (for example, t = Oct 23, 2017).
- If the average fed funds rate in Nov comes in above the value $f_{t,Nov}$ the buyer pays the seller $41.67 for each basis point below.
- If it comes in below, the seller pays the buyer.

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- For near-term contracts (less than 2 months ahead), there is little role for risk premium.
- Can treat futures price as market's expectation of average fed funds rate for that month.

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- $f_{t,Nov}$ is currently trading at 1.12% (annual rate).
- Average fed funds rate in October has been 1.12%.
  - Traders are betting on relatively little chance of rate hike at next meeting
- $f_{t,Jan}$ is currently 1.36%
  - Traders are betting that rate hike at following meeting is almost a sure thing

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- Research question: what do we see happen when the Fed's announcement surprises the market?

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f_t^0 = price of current-month contract (e.g., price of April contract some day t in April)

f_t^s = price of s-month-ahead contract (e.g., $s = 3$ is price of July contract some day t in April)

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r_t = overnight fed funds rate on day t

m_t = number of calendar days in current month

d_t = calendar days so far in current month as of t

f_t^0 is average of d_t days so far and expectation of $m_t - d_t$ days yet to come

$$f_t^0 = \frac{1}{m_t} E_t \sum_{j=-d_t+1}^{m_t-d_t} r_{t+j}$$

$$f_t^0 - f_{t-1}^0 = \frac{1}{m_t}(E_t - E_{t-1}) \sum_{j=0}^{m_t-d_t} r_{t+j}$$

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Suppose that an FOMC announcement on day t caused me to revise up my expectation of each remaining day of month by δ_t

$$(E_t - E_{t-1})(r_{t+j}) = \delta_t \quad j = 1, \ldots, m_t - d_t$$

E.g., if I was expecting the Fed to raise target by 10 bp and they raised it by 25, $\delta_t = 0.15$

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$$f_t^0 - f_{t-1}^0 = \frac{1}{m_t}(E_t - E_{t-1}) \sum_{j=0}^{m_t-d_t} r_{t+j}$$

$$= \frac{1}{m_t}(m_t - d_t)\delta_t$$

$$\delta_t = \frac{m_t}{m_t - d_t}(f_t^0 - f_{t-1}^0)$$

= Kuttner's measure of a surprise change in the Fed's target

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i_t^n = yield on n-month Treasury bond on day t

$$i_t^n - i_{t-1}^n = \alpha_n + \beta_n \delta_t + \varepsilon_t^n$$

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The 1-day response of interest rates to the Fed funds surprises[a]

Maturity	Intercept	Response to target change: Anticipated	Unanticipated	R^2	SE	DW
3 month	−0.7	4.4	79.1	0.70	7.1	1.82
	(0.5)	(0.8)	(8.4)			
6 month	−2.5	0.6	71.6	0.69	6.3	2.06
	(2.2)	(0.1)	(8.5)			
12 month	−2.2	−2.3	71.6	0.64	6.9	2.10
	(1.8)	(0.5)	(7.8)			
2 year	−2.8	−0.4	61.4	0.52	7.8	2.25
	(2.0)	(0.1)	(6.0)			
5 year	−2.4	−5.8	48.1	0.33	8.6	2.37
	(1.6)	(0.9)	(4.3)			
10 year	−2.4	−7.4	31.5	0.19	7.8	2.37
	(1.8)	(1.3)	(3.1)			
30 year	−2.5	−8.2	19.4	0.13	6.5	2.46
	(2.2)	(1.7)	(2.3)			

[a] *Note*: Anticipated and unanticipated changes in the Fed funds target are computed from the Fed funds futures rates, as described in the text. Parentheses contain *t*-statistics. See also notes to Table 1.

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Drawback to Kuttner's measure:
extreme weight to changes near end of month

$\delta_t = \frac{m_t}{m_t - d_t}(f_t^0 - f_{t-1}^0)$

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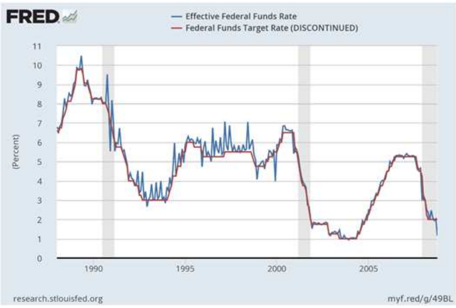
The actual fed funds rate historically not equal to target



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Solutions:

(1) Hamilton (St. Louis Review, 2008) generalizes Kuttner's formlua to recognize difference of actual fed funds rate from target.

(2) Look at change in f_t^1 instead of f_t^0.

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B. Application: daily monetary policy shocks

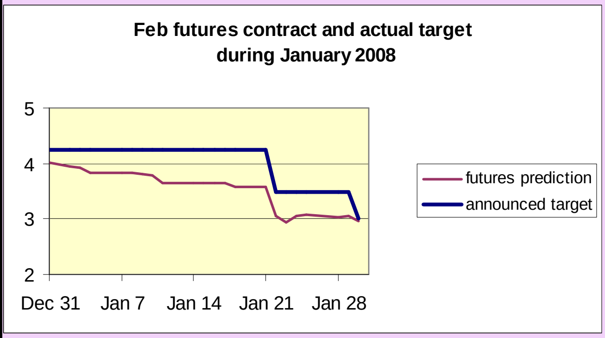
ΔR_w = change in 30-year mortgage rate in week w

ℓ_w^* = change in $f_t^{(1)}$ on day t of week w if t was FOMC day or monetary policy announcement

$\ell_w^* = 0$ otherwise

In regression of ΔR_w on constant, 3 lags, and ℓ_w^*, coefficient on ℓ_w^* is 0.53 with standard error of 0.11 for data Oct 1988 - June 2006.

FOMC was scheduled to meet Jan 30, 2008 but announced 75 bp intermeeting cut on Jan 22



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What if we treated every change in $f_t^{(1)}$ as if it was a monetary policy shock?

ℓ_w = change in $f_1^{(1)}$ between start and end of week w (all days)

In regression of ΔR_w on constant, 3 lags, and ℓ_w, coefficient on ℓ_w is 0.53 with standard error of 0.04 for data Oct 1988 - June 2006.

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h_m = log of new home sales in month m

Regression of h_m on seasonals, lags, lagged GDP, time trend, and 30 lags of weekly changes in mortgage rate.

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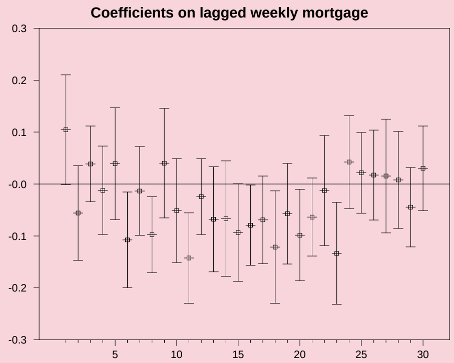

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Separate data source: National Association of Realtors' cross-section survey of time spent searching before buying a house

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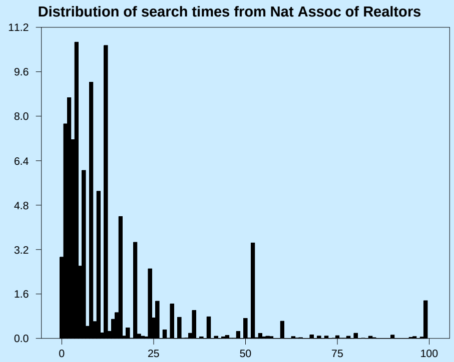

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Households differ in search times

Weibull distribution:

$$f(j;k,\lambda) = \frac{k}{\lambda}\left(\frac{j}{\lambda}\right)^{k-1} \exp[-(j/\lambda)^k]$$

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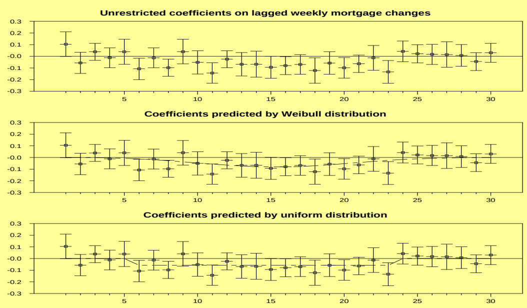

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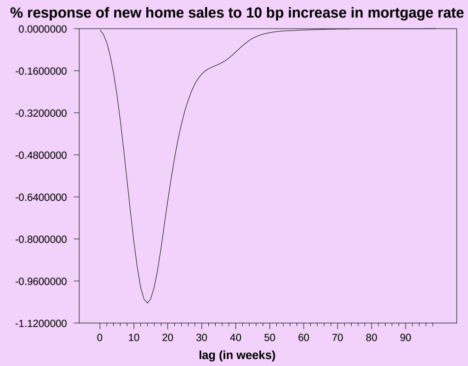
Same as effect of 20 bp increase in fed funds futures



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C. FOMC meeting decisions (Romer and Romer, 2004)

- Step 1: Studied minutes and announcements for each FOMC meeting to calculate the change in target that Fed decided to implement
- For data since 1994, this is straightforward (Fed announced its decision publicly)
- For earlier periods, it can be much less clear (Fed often viewed policy in terms of monetary aggregates, not funds rate)

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Romer-Romer				Thornton (DFEDTAR on FRED)		
MTGDATE	DTARG	OLDTARG		1995-07-05	6.0000	
70695	-0.2500	6.0000		1995-07-06	5.7500	
82295	0.0000	5.7500		1995-07-07	5.7500	
92695	0.0000	5.7500				
111595	0.0000	5.7500		1995-12-18	5.7500	
121995	-0.2500	5.7500		1995-12-19	5.5000	
13196	-0.2500	5.5000		1995-12-20	5.5000	
32696	0.0000	5.2500				

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Romer-Romer				Thornton (DFEDTAR on FRED)		
MTGDATE	DTARG	OLDTARG		1982-10-05	10.0000	
82482	-0.7500	10.2500		1982-10-06	10.0000	
100582	-0.7500	10.2500		1982-10-07	9.5000	
111682	-0.5000	9.5000				
122182	0.0000	8.5000		1982-11-16	9.5000	
				1982-11-17	9.5000	
				1982-11-18	9.5000	
				1982-11-19	9.0000	

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- Step 2: Regressed Fed's intended change in target on Fed's own forecasts of inflation and output at time of meeting.
- Fitted value interpreted as Fed response to economic conditions.
- Residual interpreted as shock s_t to monetary policy in month *t*.
- s_t = 0 if no meeting in month *t*

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- Step 3:

Our baseline regression is therefore:

$$(2)\quad \Delta y_t = a_0 + \sum_{k=1}^{11} a_k D_{kt} + \sum_{i=1}^{24} b_i \Delta y_{t-i} + \sum_{j=1}^{36} c_j S_{t-j} + e_t,$$

where y is the log of industrial production, S is our new measure of monetary policy shocks, and the D_k's are monthly dummies. Our sample period is 1970:1–1996:12, with the values of S_t before 1969:3 set to zero. The end date is the

Can think of this as first equation in a 2-variable VAR for $\mathbf{y}_t = (\Delta y_t, S_t)'$.

Second equation:

$$S_t = \varepsilon_t^S$$

S_t is already a shock (not forecastable)

$$\begin{bmatrix} \Delta y_t \\ S_t \end{bmatrix} = \begin{bmatrix} c_t \\ 0 \end{bmatrix} + \mathbf{\Phi}_1 \mathbf{y}_{t-1} + \cdots + \mathbf{\Phi}_{36} \mathbf{y}_{t-36} + \boldsymbol{\varepsilon}_t$$

Second row of $\mathbf{\Phi}_j = \mathbf{0}$

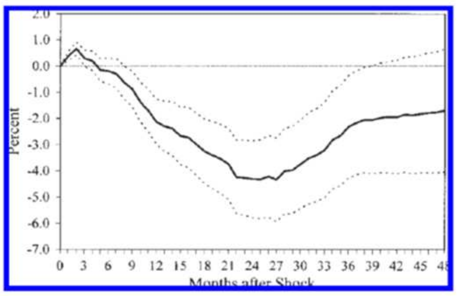
$(1,1)$ element of $\mathbf{\Phi}_{25}, \ldots, \mathbf{\Phi}_{36} = 0$

$$\mathbf{\Psi}_0 = \mathbf{I}_n$$
$$\mathbf{\Psi}_1 = \mathbf{\Phi}_1$$
$$\mathbf{\Psi}_2 = \mathbf{\Phi}_1^2 + \mathbf{\Phi}_2$$
$$\mathbf{\Psi}_s = \mathbf{\Phi}_1 \mathbf{\Psi}_{s-1} + \mathbf{\Phi}_2 \mathbf{\Psi}_{s-2} + \cdots + \mathbf{\Phi}_p \mathbf{\Psi}_{s-p}$$

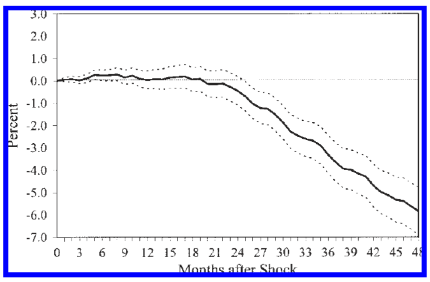
Interested in cumulative effect of S_t on level of industrial production

$= (1,2)$ element of $\mathbf{\Psi}_0 + \mathbf{\Psi}_1 + \cdots + \mathbf{\Psi}_s$

Effect on output of unanticipated 100 bp increase in intended target



Effect on price level of unanticipated 100 bp increase in intended target



Romer and Romer alternatively report a VAR based on accumulation of S_t:

$\tilde{S}_t = \tilde{S}_{t-1} + S_t$

$\tilde{S}_0 = 0$

$\mathbf{y}_t = (\Delta y_t, \tilde{S}_t)'$

$$\begin{bmatrix} \Delta y_t \\ \tilde{S}_t \end{bmatrix} = \begin{bmatrix} c_t \\ \tilde{c} \end{bmatrix} + \mathbf{\Phi}_1 \mathbf{y}_{t-1} + \cdots + \mathbf{\Phi}_{36} \mathbf{y}_{t-36} + \boldsymbol{\varepsilon}_t$$

$\mathbf{\Phi}_j$ unrestricted

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This procedure deliberately and knowingly introduces a unit root into $\tilde{S}_t$.

OLS will minimize

$$T^{-1} \sum_{t=1}^{T} (\tilde{S}_t - \tilde{c} - \boldsymbol{\phi}_{1S}' \mathbf{y}_{t-1} - \cdots - \boldsymbol{\phi}_{36,S}' \mathbf{y}_{t-36})^2$$

Diverges to infinity unless second element of

$$\boldsymbol{\phi}_{1S} + \cdots + \boldsymbol{\phi}_{36,S} \to 1$$

Forcing OLS to estimate a parameter that the researcher knows with certainty pointlessly introduces an additional source of measurement error.

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D. Identifying DSGE from daily data (Nakamura and Steinsson)

- Nakamura and Steinsson argue that changes on day of FOMC meeting could reflect more news than just the meeting.
- They look at changes in 5 measures in a 30-minute window 10 minutes before to 20 minutes after the FOMC announcement.

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(1) Kuttner measure of unanticipated change in current-month's fed funds rate from fed funds futures

(2) Kuttner measure of unanticipated change in fed funds futures expected outcome of next FOMC meeting

(3)-(5) Change in 3-month Eurodollar futures 2-, 3-, and 4-quarters ahead

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- Calculate first principal component of these 5 variables on set of FOMC announcements 1995-2012.
- Regress change in interest rate for this day on a constant and this component (normalize 1-year coefficient = 1.0)

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	Nominal	Real	Inflation
3M Treasury Yield	0.67		
	(0.14)		
6M Treasury Yield	0.85		
	(0.11)		
1Y Treasury Yield	1.00		
	(0.14)		
2Y Treasury Yield	1.10	1.06	0.04
	(0.33)	(0.24)	(0.18)
3Y Treasury Yield	1.06	1.02	0.04
	(0.36)	(0.25)	(0.17)
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)

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New Keynesian Phillips Curve:

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

$\hat{\pi}_t$ = % deviation inflation from steady state

$\hat{x}_t$ = % deviation real output from s.s.

β = discount rate

$\kappa\zeta$ = summary of nominal and real rigidities

$\kappa\zeta \to \infty$ for perfectly flexible prices

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$$\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \kappa\zeta \hat{x}_t$$
$$\hat{\pi}_t = \kappa\zeta \sum_{s=0}^{\infty} \beta^s E_t \hat{x}_{t+s}$$
$$\frac{\partial \hat{\pi}_t}{\partial u_t^m} = \kappa\zeta \sum_{s=0}^{\infty} \beta^s \frac{\partial E_t \hat{x}_{t+s}}{u_t^m}$$

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Consumption Euler equation:

$\hat{x}_t = E_t \hat{x}_{t+1} - \sigma(\hat{r}_t - \hat{r}_t^n)$

σ = intertemporal elasticity of substitution

$\hat{r}_t = \hat{\imath}_t - E_t \hat{\pi}_{t+1}$ = real interest rate

$\hat{r}_t^n$ = natural rate of interest

$\frac{\partial \hat{x}_t}{\partial u_t^m} = \frac{\partial E_t \hat{x}_{t+1}}{\partial u_t^m} - \sigma \frac{\partial \hat{r}_t}{\partial u_t^m}$

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$$\frac{\partial \hat{x}_t}{\partial u_t^m} = \frac{\partial E_t \hat{x}_{t+1}}{\partial u_t^m} - \sigma \frac{\partial \hat{r}_t}{\partial u_t^m}$$

If $\lim_{s\to\infty} \frac{\partial E_t \hat{x}_{t+s}}{\partial u_t^m} = 0$, then

$$\frac{\partial \hat{x}_t}{\partial u_t^m} = -\sigma \sum_{s=0}^{\infty} \frac{\partial E_t \hat{r}_{t+s}}{\partial u_t^m} = -\sigma \frac{\partial \hat{r}_t^\ell}{\partial u_t^m}$$

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$$\frac{\partial \hat{x}_t}{\partial u_t^m} = -\sigma \sum_{s=0}^{\infty} \frac{\partial E_t \hat{r}_{t+s}}{\partial u_t^m} = -\sigma \frac{\partial \hat{r}_t^\ell}{\partial u_t^m}$$
$$\frac{\partial \hat{\pi}_t}{\partial u_t^m} = \kappa\zeta \sum_{s=0}^{\infty} \beta^s \frac{\partial E_t \hat{x}_{t+s}}{u_t^m}$$
$$\frac{\partial \hat{\pi}_t}{\partial u_t^m} = -\sigma\kappa\zeta \sum_{s=0}^{\infty} \beta^s \frac{\partial E_t \hat{r}_{t+s}^\ell}{u_t^m}$$

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$\frac{\partial \hat{\pi}_t}{\partial u_t^m} = -\sigma\kappa\zeta \sum_{s=0}^{\infty} \beta^s \frac{\partial E_t \hat{r}_{t+s}^\ell}{u_t^m}$

Response of real rates large relative to inflation means high nominal or real rigidities ($\kappa\zeta$ small) or low intertemporal substitution (σ small).

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- Estimate key parameters of Christiano, Eichenbaum Evans (JPE, 2005) quarterly model.
- Observed and predicted responses of 2, 3, 5, 10 year nominal yields, real yields, nominal forwards, and real forwards to monetary policy shock.

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	Nominal	Real	Inflation
3M Treasury Yield	0.67 (0.14)		
6M Treasury Yield	0.85 (0.11)		
1Y Treasury Yield	1.00 (0.14)		
2Y Treasury Yield	1.10 (0.33)	1.06 (0.24)	0.04 (0.18)
3Y Treasury Yield	1.06 (0.36)	1.02 (0.25)	0.04 (0.17)
5Y Treasury Yield	0.73 (0.20)	0.64 (0.15)	0.09 (0.11)
10Y Treasury Yield	0.38 (0.17)	0.44 (0.13)	-0.06 (0.08)
2Y Treasury Inst. Forward Rate	1.14 (0.46)	0.99 (0.29)	0.15 (0.23)
3Y Treasury Inst. Forward Rate	0.82 (0.43)	0.88 (0.32)	-0.06 (0.15)
5Y Treasury Inst. Forward Rate	0.26 (0.19)	0.47 (0.17)	-0.21 (0.08)
10Y Treasury Inst. Forward Rate	-0.08 (0.18)	0.12 (0.12)	-0.20 (0.09)

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param	meaning	estimate	95%
ξ_p	prob no price Δ	0.99	$[0.49, 0.99]$
ξ_w	prob no wage Δ	0.90	$[0.48, 0.99]$
k_I	recip of invest elast	25.0	$[0.69, 25.0]$
ρ	inertia in policy rule	0.96	$[0.91, 0.99]$
ν	inertia in policy shock	0.74	$[0.01, 0.96]$

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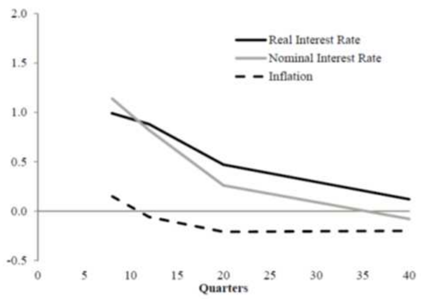

Figure 2: Interest Rates and Inflation in the Data

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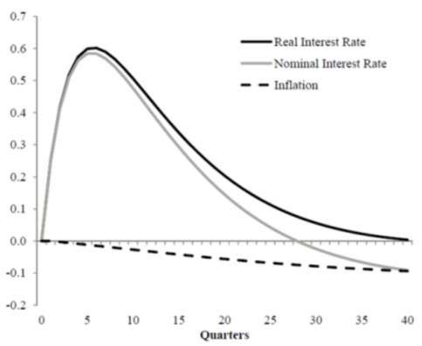

Figure 3: The Response of Inflation and Interest Rates to the Policy News Shock in Our Estimation of CEE/ACEL Model

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But Blue Chip forecast expects higher GDP after contractionary monetary shock

Exp. Output Growth in Current Qr	1.35 (1.59)
Exp. Output Growth 1 Qr Ahead	1.58 (0.61)
Exp. Output Growth 2 Qr Ahead	0.66 (0.34)
Exp. Output Growth 3 Qr Ahead	0.82 (0.26)
Exp. Output Growth 4 Qr Ahead	0.50 (0.30)
Exp. Output Growth 5 Qr Ahead	0.55 (0.27)
Exp. Output Growth 6 Qr Ahead	0.47 (0.30)
Exp. Output Growth 7 Qr Ahead	0.88 (0.66)

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- Interpretation: Fed has information that market did not
- People see Fed contracted, assume it means Fed sees faster growth
- Fed information effect

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