

# 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)

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.

# 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).

- 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.

- 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.

- $f_{t,Nov}$  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

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

$f_t^0$  = 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)



$r_t$  = 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

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

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

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

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

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

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

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

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

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

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

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

The 1-day response of interest rates to the Fed funds surprises<sup>a</sup>

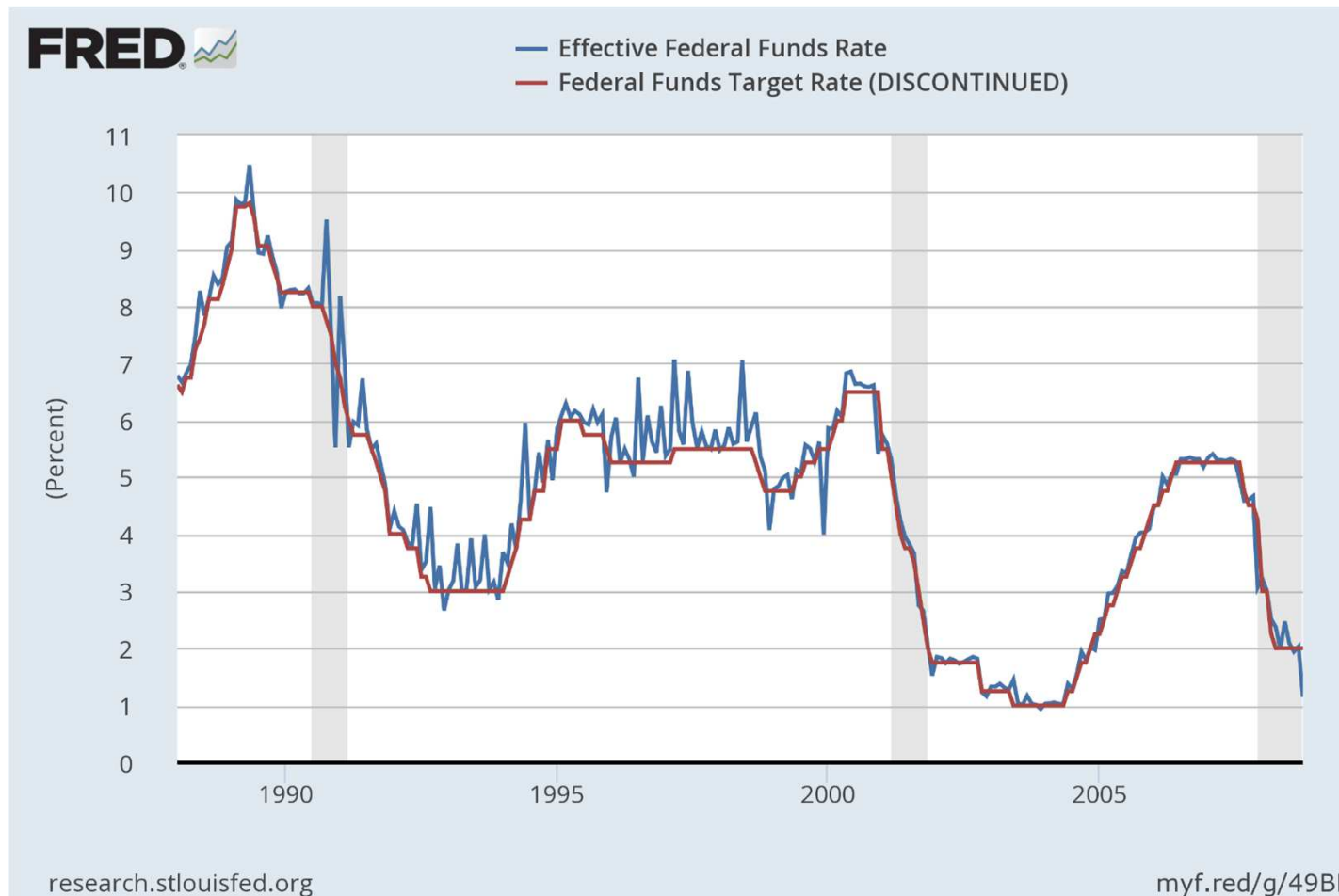
Maturity	Intercept	Response to target change		$R^2$	SE	DW
		Anticipated	Unanticipated			
3 month	- 0.7 (0.5)	4.4 (0.8)	79.1 (8.4)	0.70	7.1	1.82
6 month	- 2.5 (2.2)	0.6 (0.1)	71.6 (8.5)	0.69	6.3	2.06
12 month	- 2.2 (1.8)	- 2.3 (0.5)	71.6 (7.8)	0.64	6.9	2.10
2 year	- 2.8 (2.0)	- 0.4 (0.1)	61.4 (6.0)	0.52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

<sup>a</sup> *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.

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

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

# The actual fed funds rate historically not equal to target



## Solutions:

- (1) Hamilton (St. Louis Review, 2008) generalizes Kuttner's formula to recognize difference of actual fed funds rate from target.
- (2) Look at change in  $f_t^1$  instead of  $f_t^0$ .



## B. Application: daily monetary policy shocks

$\Delta R_w$  = change in 30-year mortgage rate in week  $w$

$\ell_w^*$  = 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  $\Delta R_w$  on constant,

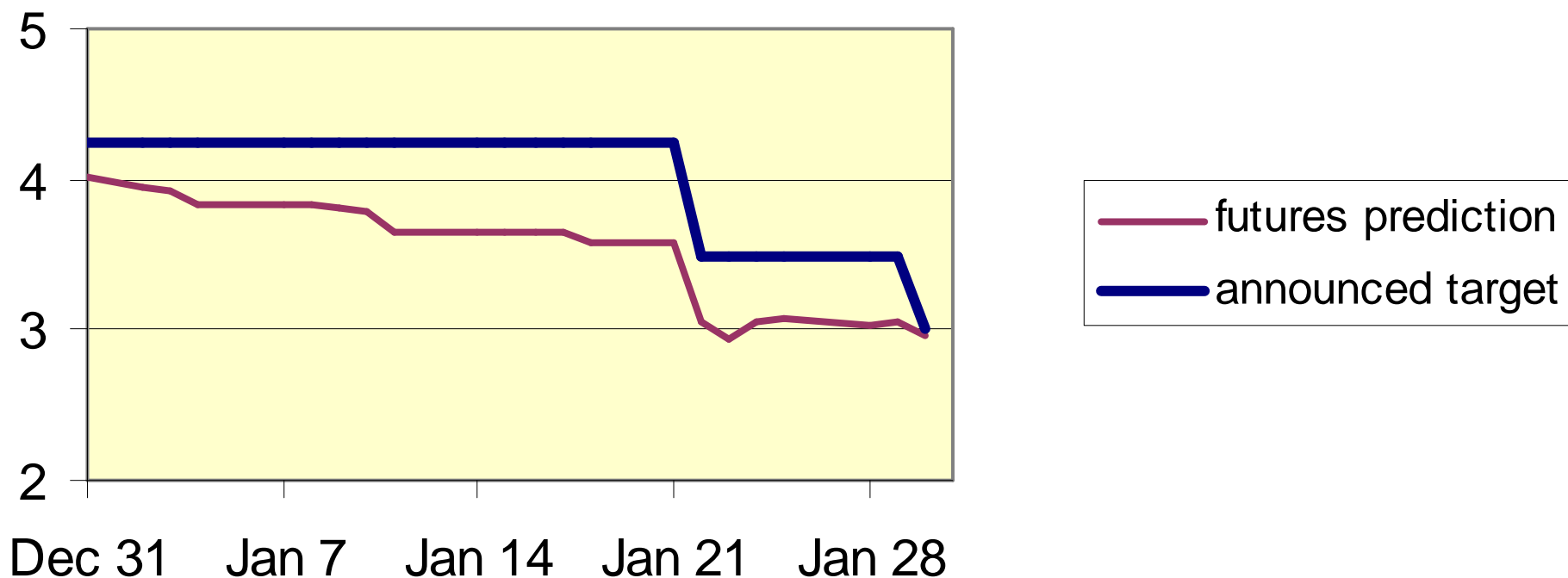
3 lags, and  $\ell_w^*$ , coefficient on  $\ell_w^*$  is 0.53

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

**Feb futures contract and actual target during January 2008**



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

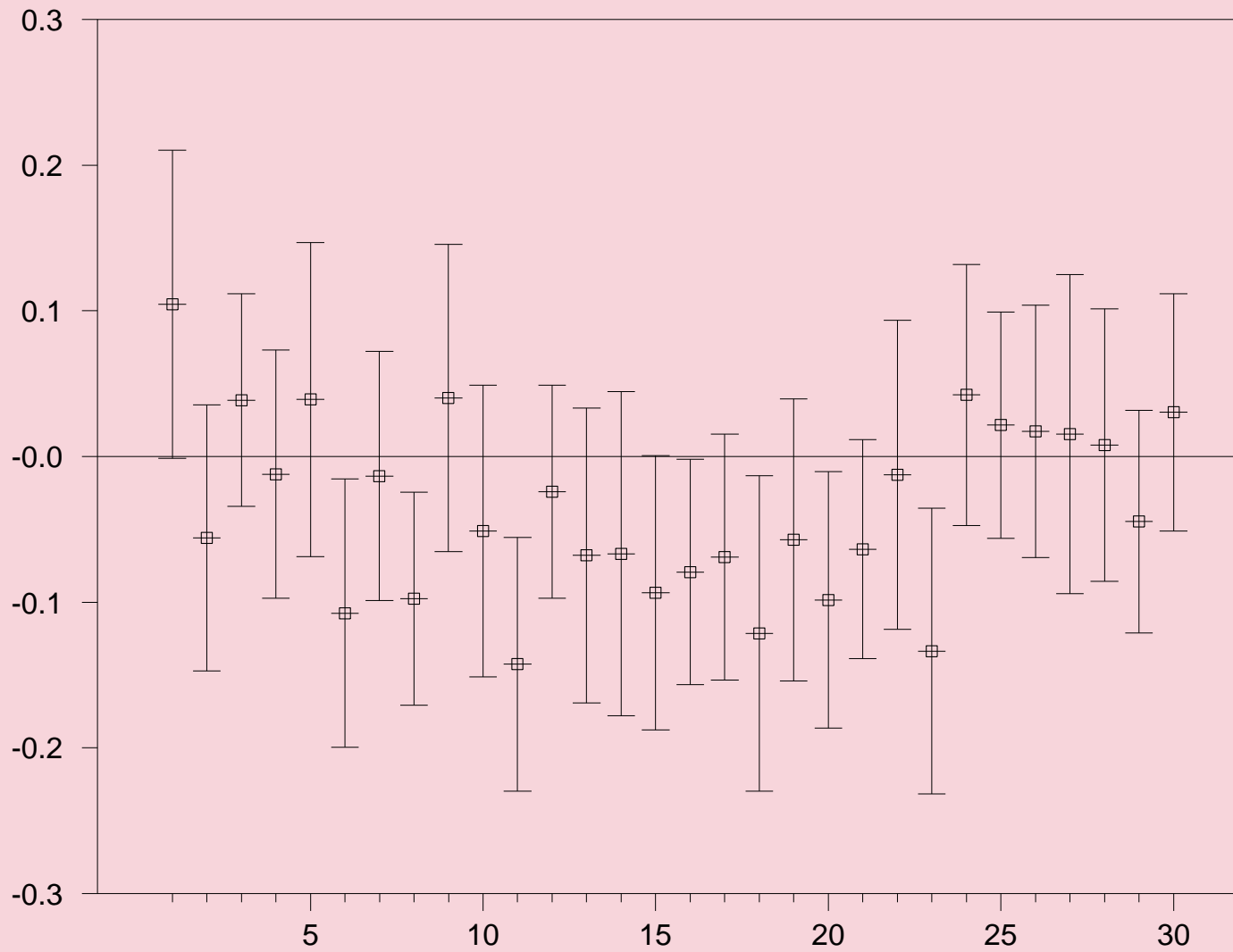
$\ell_w$  = change in  $f_1^{(1)}$  between start and end of week  $w$  (all days)

In regression of  $\Delta R_w$  on constant, 3 lags, and  $\ell_w$ , coefficient on  $\ell_w$  is 0.53 with standard error of 0.04 for data Oct 1988 - June 2006.

$h_m$  = log of new home sales in month  $m$

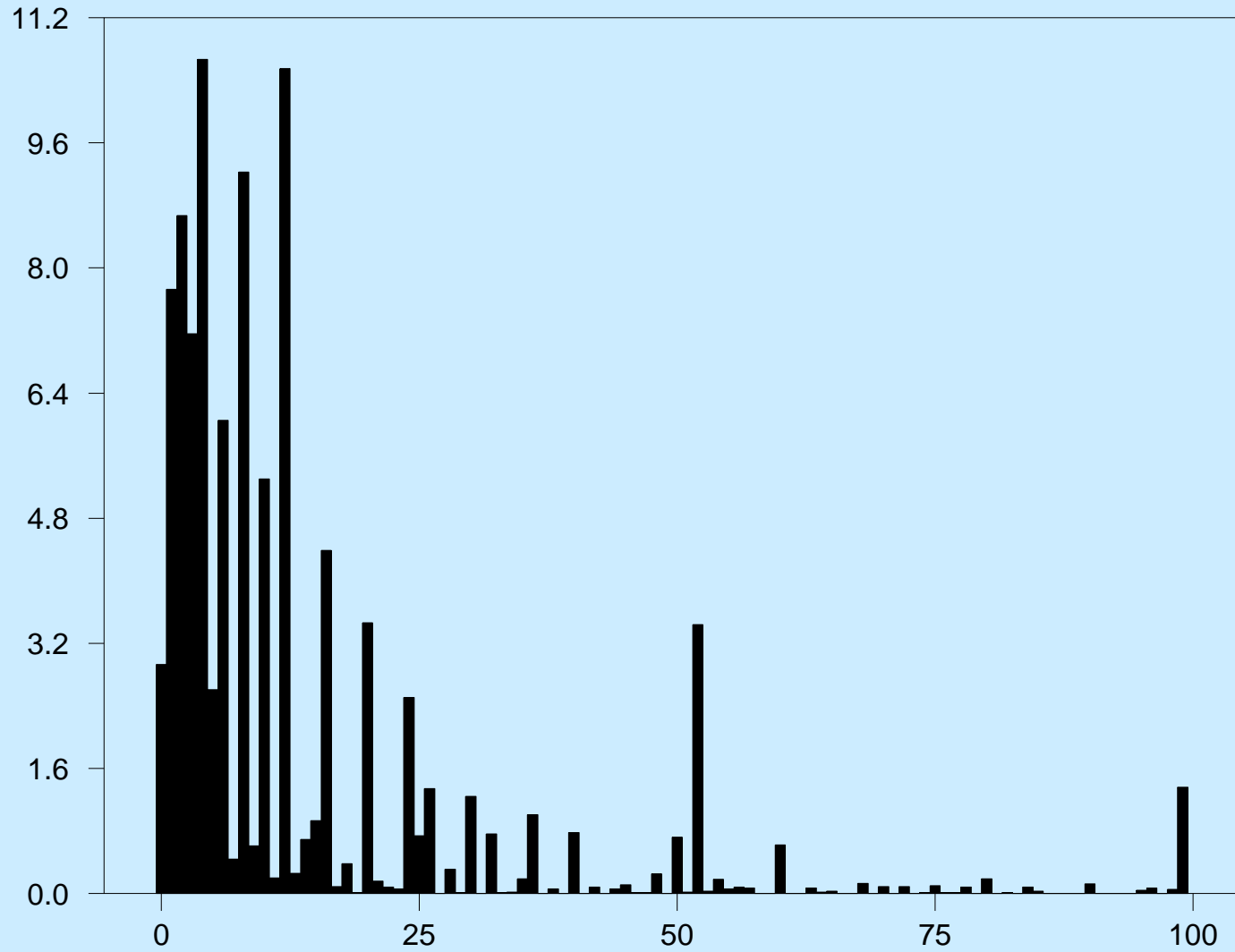
Regression of  $h_m$  on seasonals, lags, lagged GDP, time trend, and 30 lags of weekly changes in mortgage rate.

## Coefficients on lagged weekly mortgage



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

## Distribution of search times from Nat Assoc of Realtors



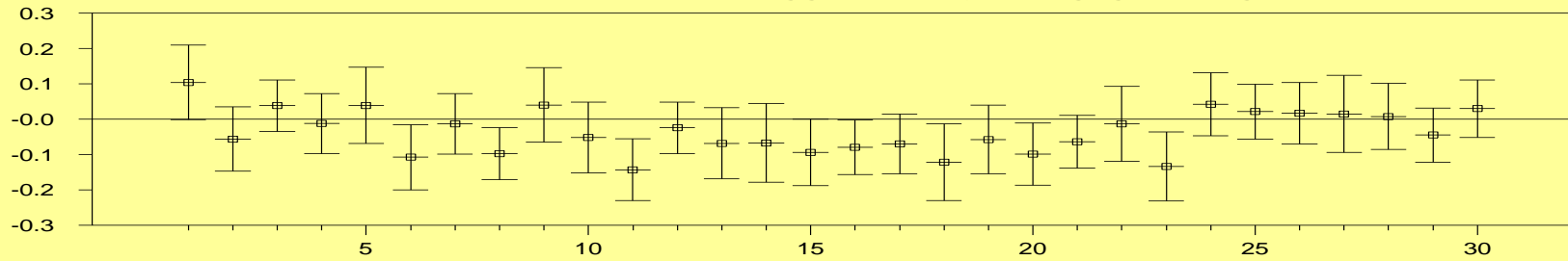
Households differ in search times

Weibull distribution:

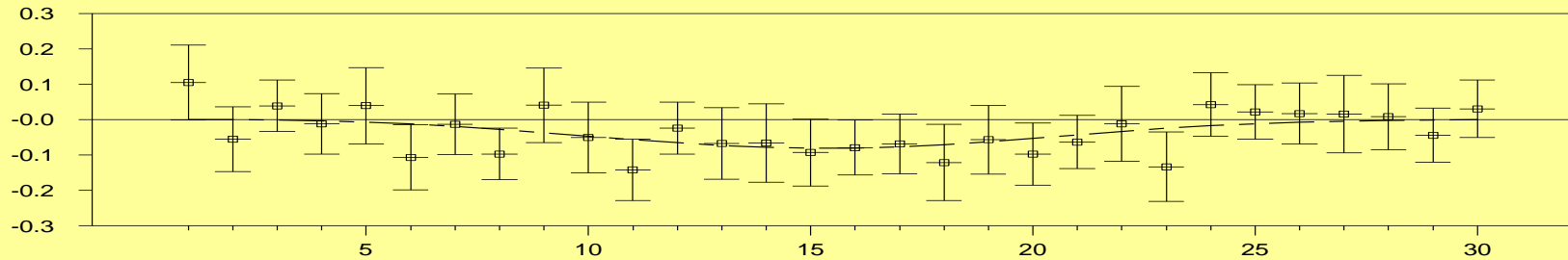
$$f(j; k, \lambda) = \frac{k}{\lambda} \left( \frac{j}{\lambda} \right)^{k-1} \exp[-(j/\lambda)^k]$$



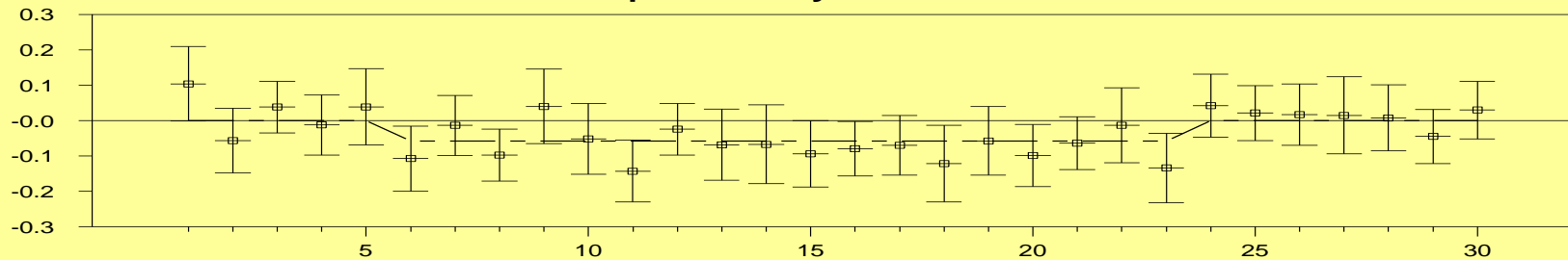
**Unrestricted coefficients on lagged weekly mortgage changes**



**Coefficients predicted by Weibull distribution**

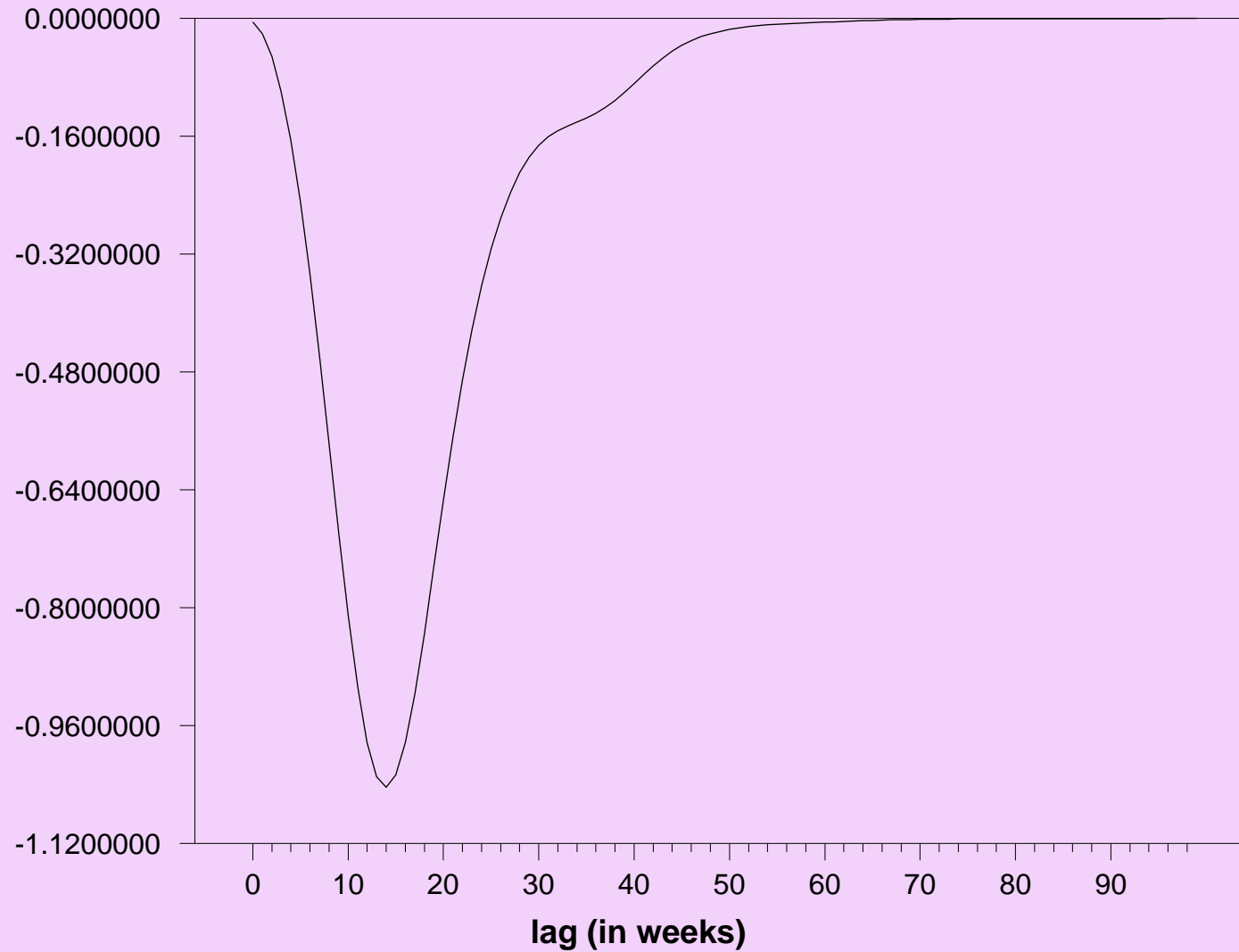


**Coefficients predicted by uniform distribution**



# Same as effect of 20 bp increase in fed funds futures

**% response of new home sales to 10 bp increase in mortgage rate**



## 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)

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			

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	

- **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  $t$

- 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)



$$\begin{bmatrix} \Delta y_t \\ S_t \end{bmatrix} = \begin{bmatrix} c_t \\ 0 \end{bmatrix} + \Phi_1 \mathbf{y}_{t-1} + \dots + \Phi_{36} \mathbf{y}_{t-36} + \boldsymbol{\varepsilon}_t$$

Second row of  $\Phi_j = \mathbf{0}$

(1, 1) element of  $\Phi_{25}, \dots, \Phi_{36} = 0$

$$\Psi_0 = \mathbf{I}_n$$

$$\Psi_1 = \Phi_1$$

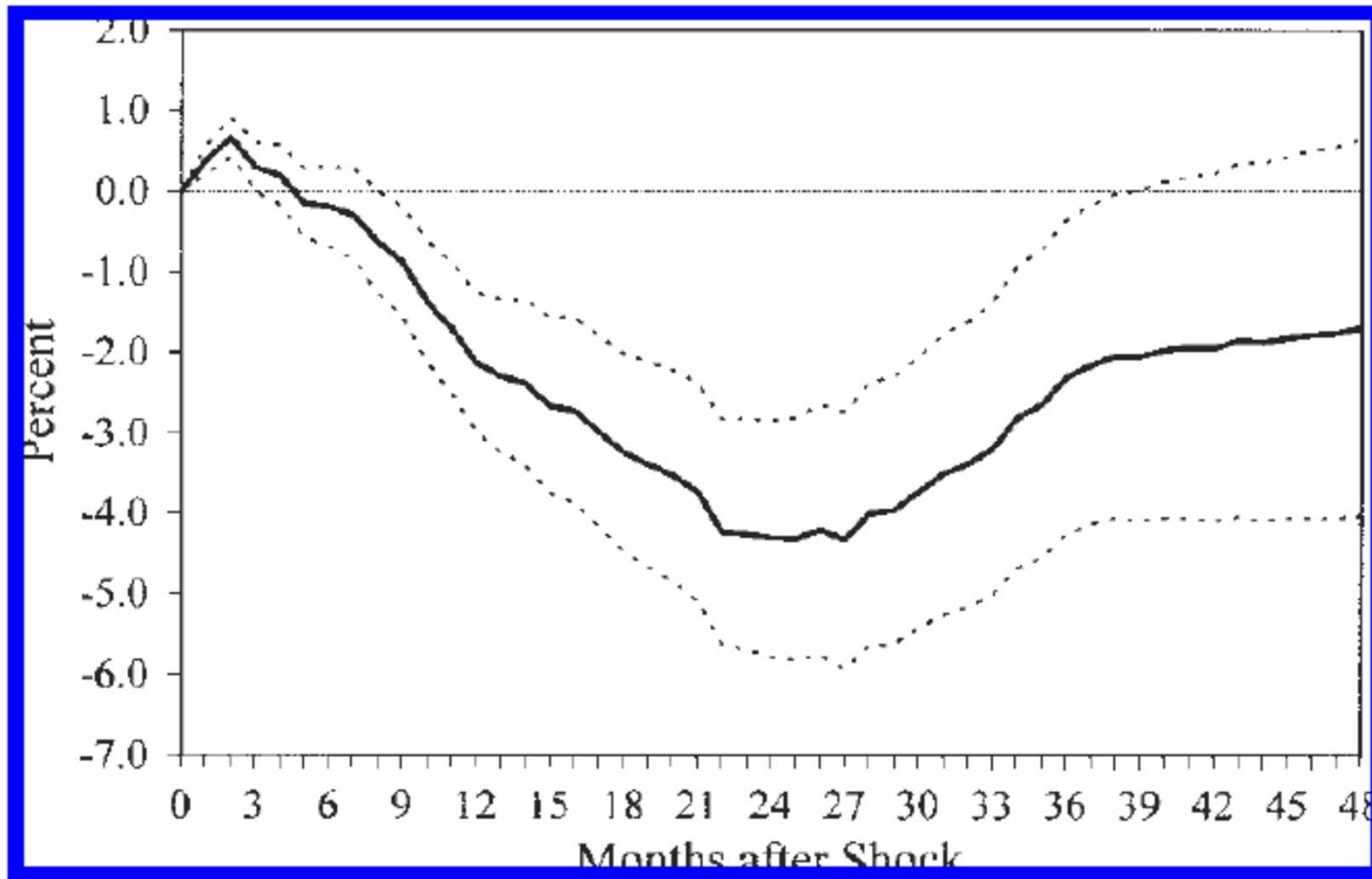
$$\Psi_2 = \Phi_1^2 + \Phi_2$$

$$\Psi_s = \Phi_1 \Psi_{s-1} + \Phi_2 \Psi_{s-2} + \cdots + \Phi_p \Psi_{s-p}$$

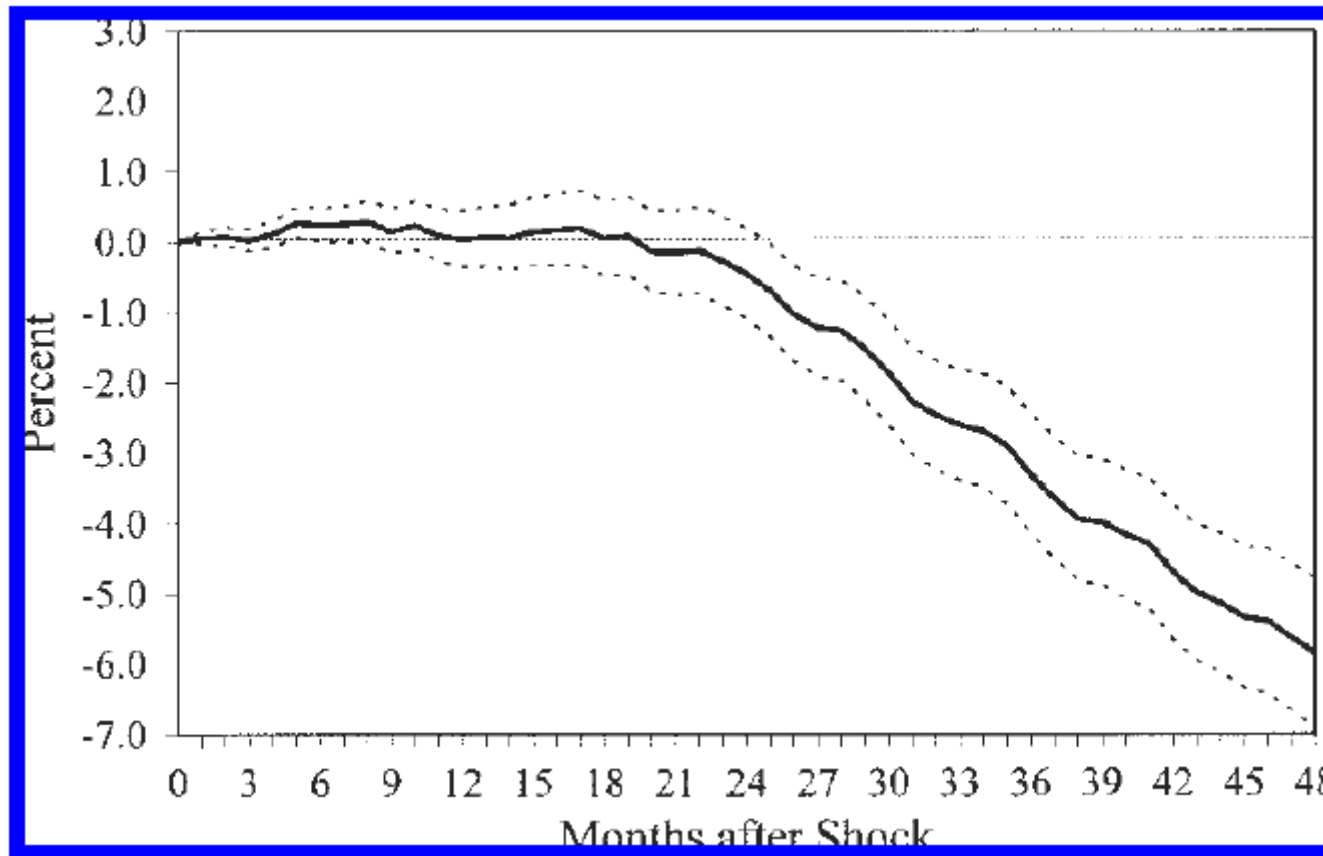
Interested in cumulative effect of  $S_t$   
on level of industrial production

$$= (1, 2) \text{ element of } \Psi_0 + \Psi_1 + \cdots + \Psi_s$$

# 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  $S_t$ :

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

$$\tilde{S}_0 = 0$$

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

$$\begin{bmatrix} \Delta y_t \\ \tilde{S}_t \end{bmatrix} = \begin{bmatrix} c_t \\ \tilde{c} \end{bmatrix} + \Phi_1 \mathbf{y}_{t-1} + \dots + \Phi_{36} \mathbf{y}_{t-36} + \boldsymbol{\varepsilon}_t$$

$\Phi_j$  unrestricted

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

OLS will minimize

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

Diverges to infinity unless second element of

$$\phi_{1S} + \cdots + \phi_{36,S} \rightarrow 1$$

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

## 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.

- (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



- 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)

	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)

## 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.

$\beta$  = discount rate

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

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

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

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

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

Consumption Euler equation:

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

$\sigma$  = intertemporal elasticity of substitution

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

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

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

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

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

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

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

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

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

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

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



- 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.

	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)
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10Y Treasury Inst. Forward Rate	-0.08 (0.18)	0.12 (0.12)	-0.20 (0.09)

param	meaning	estimate	95%
$\xi_p$	prob no price $\Delta$	0.99	[0.49, 0.99]
$\xi_w$	prob no wage $\Delta$	0.90	[0.48, 0.99]
$k_I$	recip of invest elast	25.0	[0.69, 25.0]
$\rho$	inertia in policy rule	0.96	[0.91, 0.99]
$\nu$	inertia in policy shock	0.74	[0.01, 0.96]

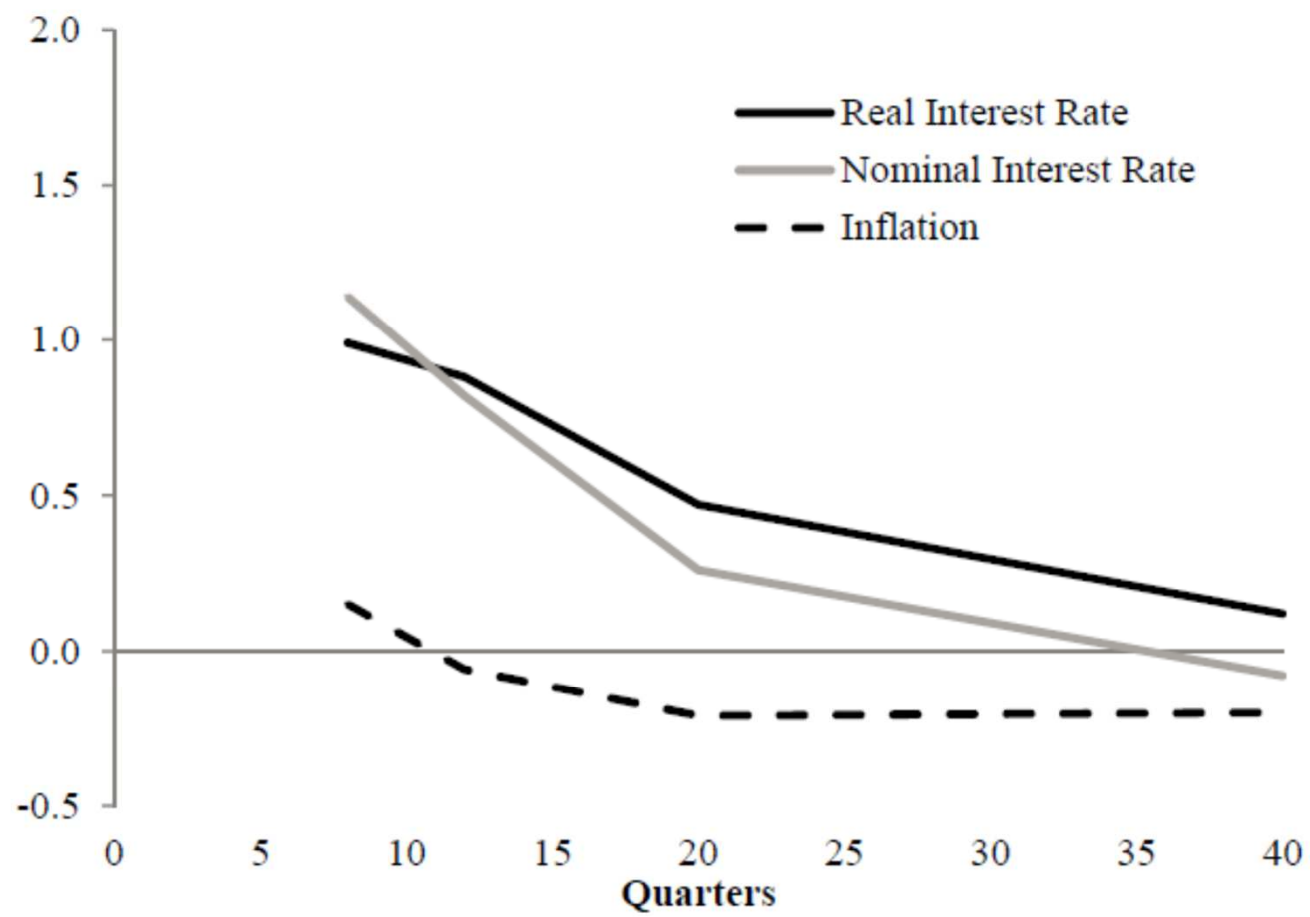


Figure 2: Interest Rates and Inflation in the Data

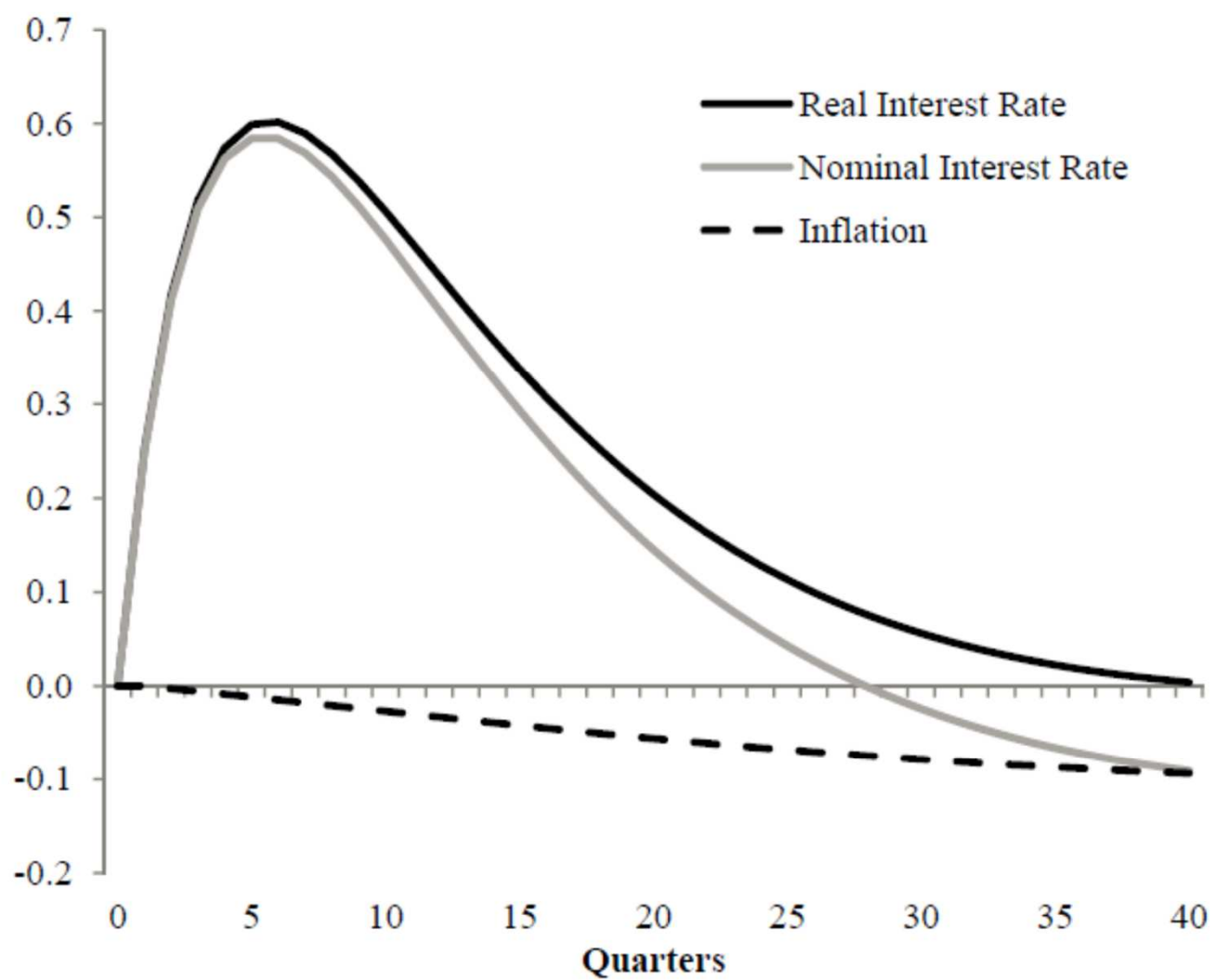


Figure 3: The Response of Inflation and Interest Rates to the Policy News Shock in Our Estimation of CEE/ACEL Model

# 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)

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