Depression Econometrics:
A FAVAR Approach to Monetary Policy in the Great Depression

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Previous research, I: monetary and financial

- Friedman/Schwartz hypothesis:
  Bordo/Erceg/Evans (2000), Christiano/Motto/Rostagno (2004)
- Financial frictions/debt deflation hypothesis:
  Bernanke (1983, 1985), many others
- Nominal wage rigidity:
  Bernanke/Carey (1996)
- Gold Standard restrictions:
  Eichengreen (1992), Bernanke/James (1991)
- Int'l financial transmission channels:
  James (2001), Ritschl/Sarferaz (2010)

Previous research, II: nonmonetary alternatives

- Monopolies and collective wage bargaining
  - Cole/Ohanian (2005) (during upswing of 1930s)
  - Ebell/Ritschl (2007) (on and off since 1918)

- Investors' expectations/animal spirits
  - [Keynes 1936, 1937, Hansen 1938, Temin 1976]
  - Harrison/Weder (2005), Ritschl/Woitek (2004)

- Productivity shocks vs. int'l monetary transmission
  - Cole/Ohanian/Leung (2005)

Tests of monetary hypothesis: Previous research

- Sims (1998), long run VAR evidence
  finds < 20% of US output variation explained by monetary policy shocks

- Eichengreen et al. (2010), int'l VAR evidence on interwar period
  find some effects but considerable problems

Issues

- 1919-39 highly abnormal
  - Two severe recessions 1920/1 and 1930-2
  - One mid-sized recession 1938
- Patchy data (e.g. no NIPA before 1929)
- Standard identification in money VARs produces rubbish (Ritschl/Woitek 2004)
  - Wrong signs of impulse responses
  - Very low explained forecast error variance

The challenge

- Use identification procedure that suppresses wrongly signed IRFs (sign restriction approach, Uhlig, 2005)
- Use approach that deals with poor data
- Use method that has previously been applied to postwar data

This paper

- Monetary policy in data-rich environment
  - as in Bernanke/Boivin/Eliasz (BBE, 2005)
- Augment VAR by dynamic factor model
  - Include large (N=164) no. of time series, monthly frequency 1919-39
  - Extract common component into factors
  - Run VAR on these factors and policy instrument
- Augment BBE with SR identification approach
  - as in Amir Ahmadi and Uhlig (2009)

What we do: outline of approach

1. Surprise component of monetary policy
   Obtain impulse responses to policy shocks and variance decompositions

2. Policy reaction function
   Back out policy responses to AS / AD shock

3. Systematic component of monetary policy
   Evaluate iImpact of predictable policy component on conditional forecasts of output

What we find: preview of results

- Price puzzles (absent in BBE) reappears

→ Sign restriction identification (Uhlig, 2005)
  - Real effects of MP shocks still change signs
  - Explanatory power <20%, like postwar levels

- Some evidence of systematic effects
  - M0 has a lot of info on turning points
  - Overall effects limited: largely passive stance of systematic MP
  - Policy failures after 1931 financial crisis ?

Variables

- X_t^c Informational variables (163 series)
- f_t^y Central bank policy instrument
- f_t^c (k=4) unobserved factors representing common components of the informational variables

The model: non-structural FAVAR

- Observation equation:

$$X_t^c = \lambda_t^c f_t^c + \lambda_t^y f_t^y + e_t^c$$

- State equation (p=12):

$$\begin{bmatrix} f_t^c \\ f_t^y \end{bmatrix} = b(L) \begin{bmatrix} f_{t-1}^c \\ f_{t-1}^y \end{bmatrix} + u_t^f$$

with

$$u_t^f = A v_t^f$$

Identification and estimation

- Factor identification (as in BBE 2005)

- Shock identification
  - [Cholesky as in BBE → sign puzzles bigtime, not shown]
  - Impulse vectors under sign restrictions

- Choice of priors (as in BBE 2005):
  - Diffuse conjugate Normal-Wishart
  - Augmented by Kadiyala/Karlsson (1997) shrinkage prior
- Estimation by Gibbs sampler

  (iteration over conditional distributions of factors and hyperparameters, n= 50K, burn-in = 10K)

The effects of adverse shocks: sign restrictions

Table 1: **Sign restrictions imposed for identification**

	a_{money}	a_{supply}	a_{demand}
CPI Inflation	≤ 0	$0 \geq$	≤ 0
General Price Index	≤ 0	$0 \geq$	≤ 0
Whole Sale Price Index Metal	≤ 0		
FRB Production Index		≤ 0	≤ 0
Discount Rate	$0 \geq$		
Commercial Paper Rate	$0 \geq$		
Mo	≤ 0		

Restrictions imposed for the contemporaneous period and the specified number of periods following the shock. Each column defines an impulse vector to one orthogonal shock. The shocks are: a_{money} : deflationary monetary policy shock, a_{demand} negative demand shock, a_{supply} positive supply shock.

Analysis of MP shocks

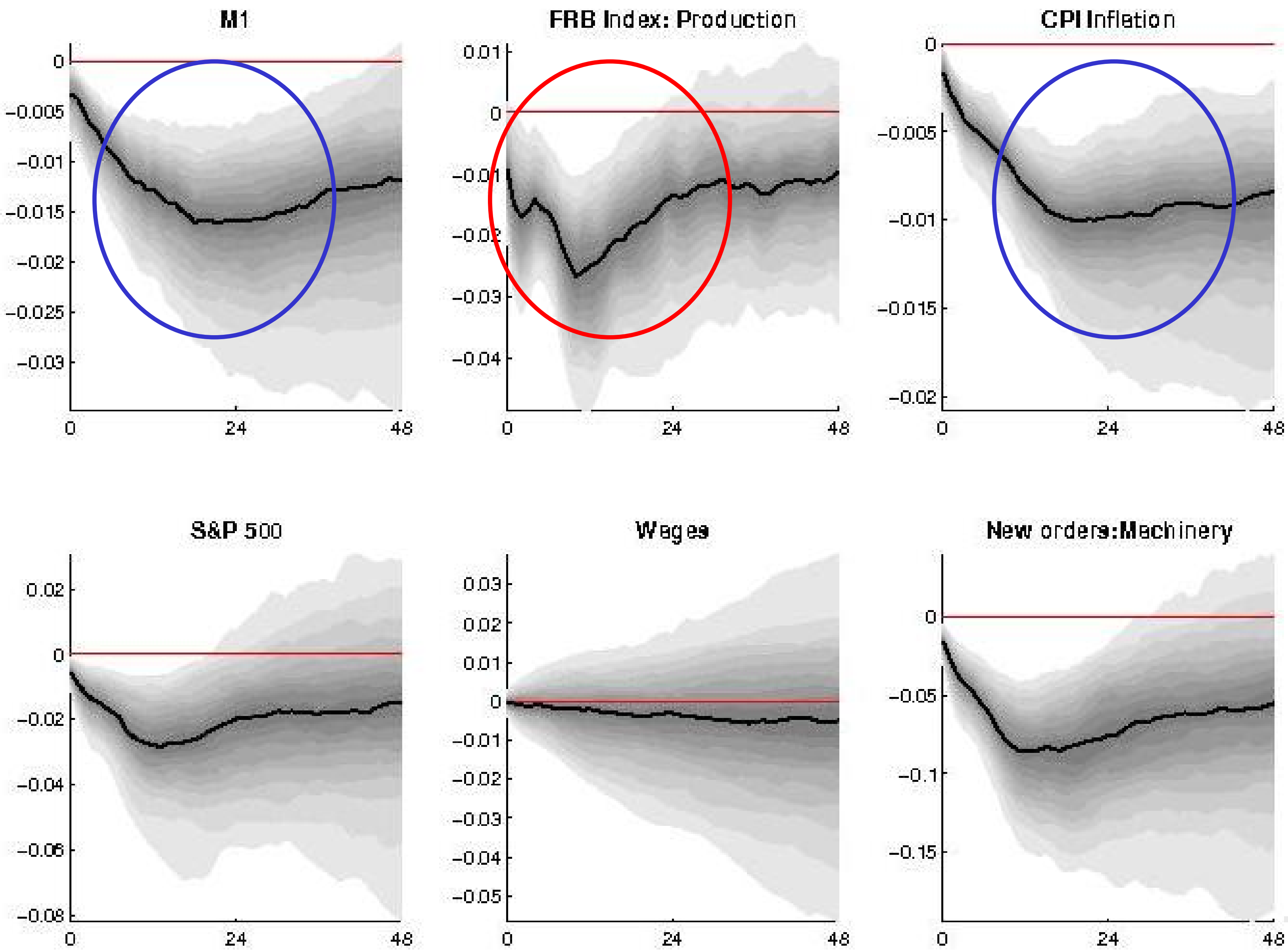
Analyse responses for 5 candidate MP instruments:

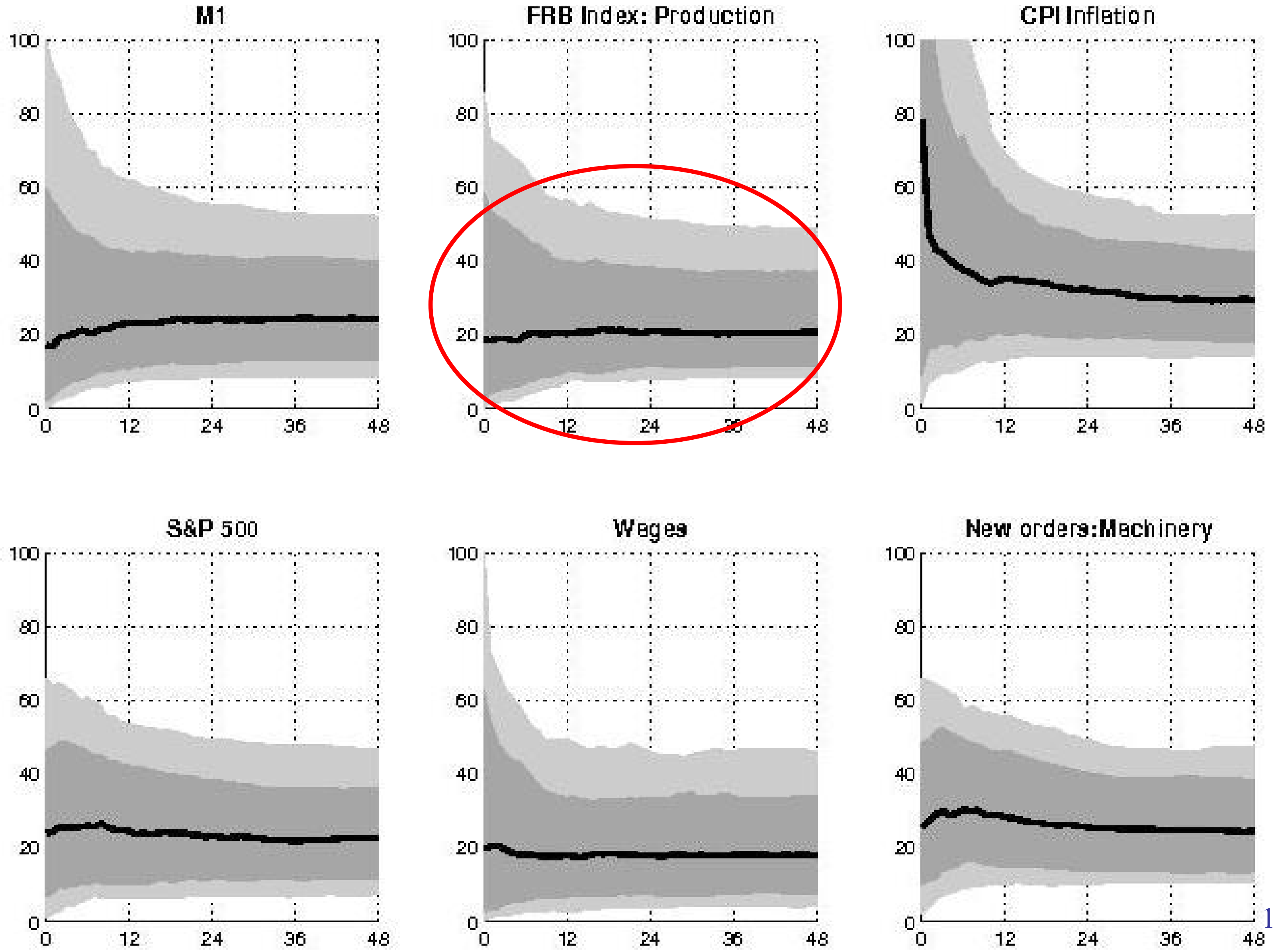
- M1
- M0 Monetary base
- M2 (not shown / see paper)
- Commercial paper rate (not shown / see paper)
- Fed discount rate (not shown / see paper)

- Several subsamples (not shown / see paper / see Appendix E on the web)

Monetary Policy Shock

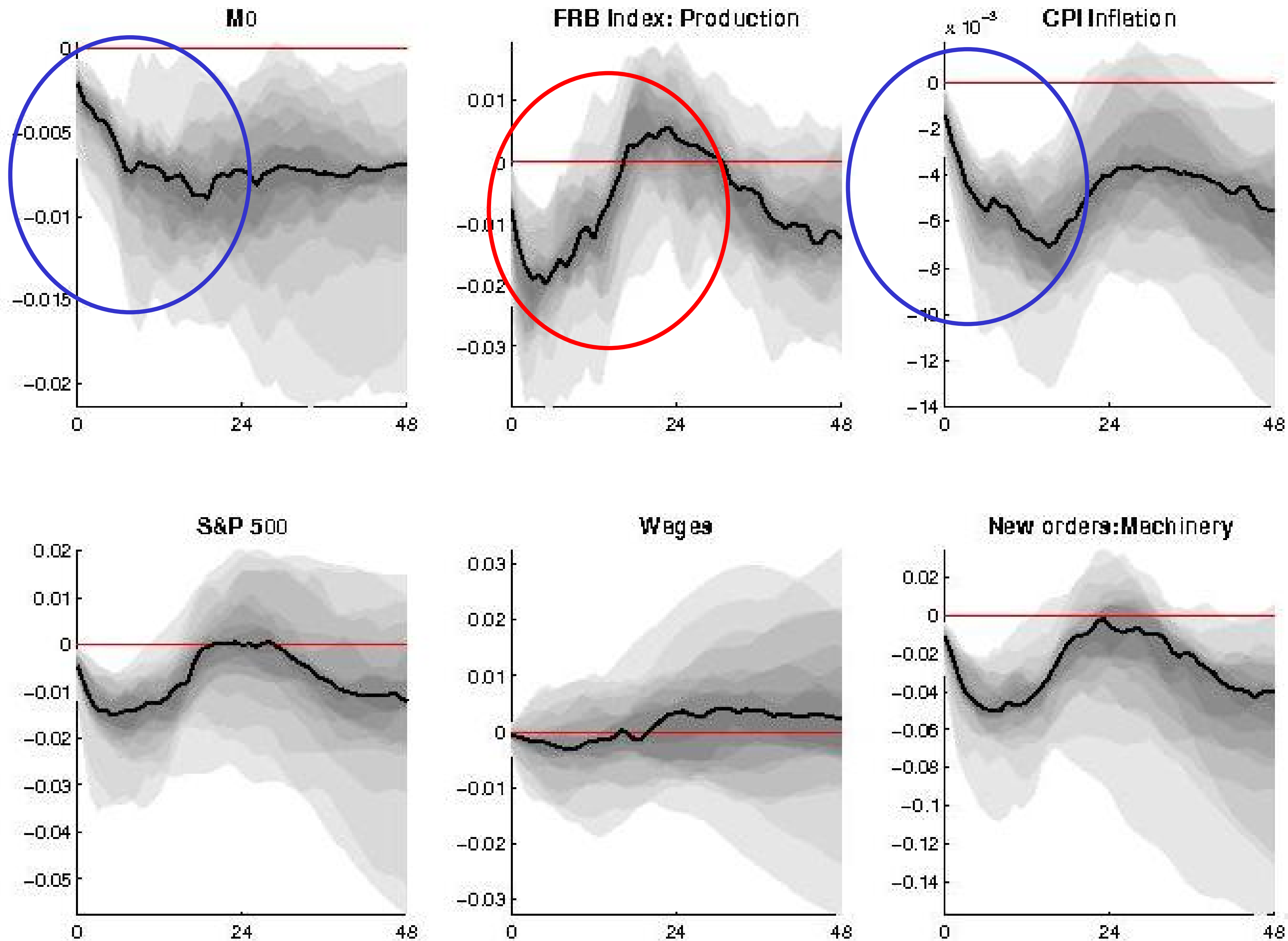
- Assume M1 is the policy instrument
- Trace propagation of adverse shock to M1

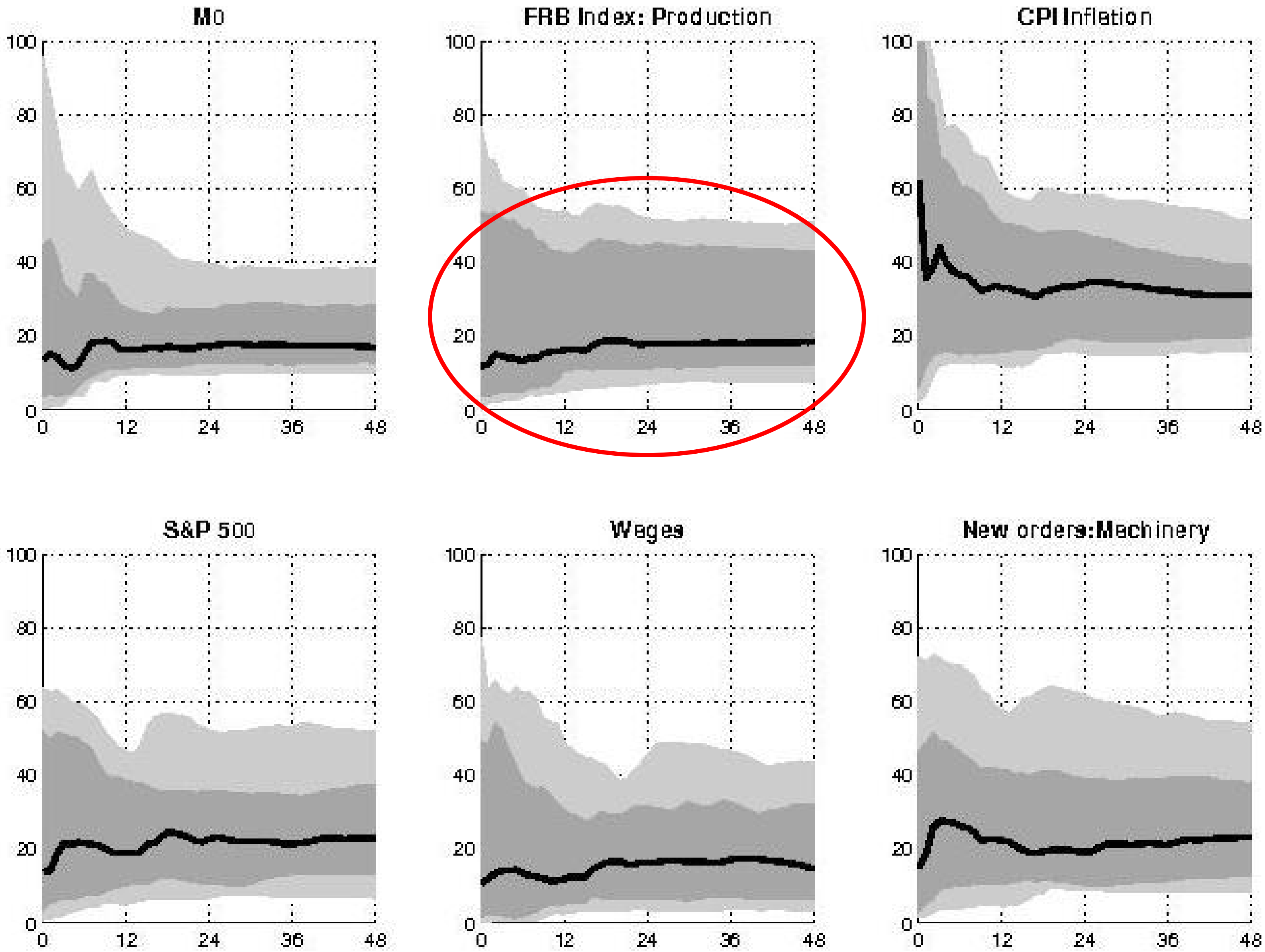

M1
0
−0.005
−0.01
−0.015
−0.02
−0.025
−0.03
0
24
48
FRB Index: Production
0.01
0
−0.01
−0.02
−0.03
−0.04
0
24
48
CPI Inflation
0
−0.005
−0.01
−0.015
−0.02
0
24
48
S&P 500
0.02
0
−0.02
−0.04
−0.06
−0.08
0
24
48
Wages
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
−0.04
−0.05
0
24
48
New orders:Machinery
0
−0.05
−0.1
−0.15
0
24
48

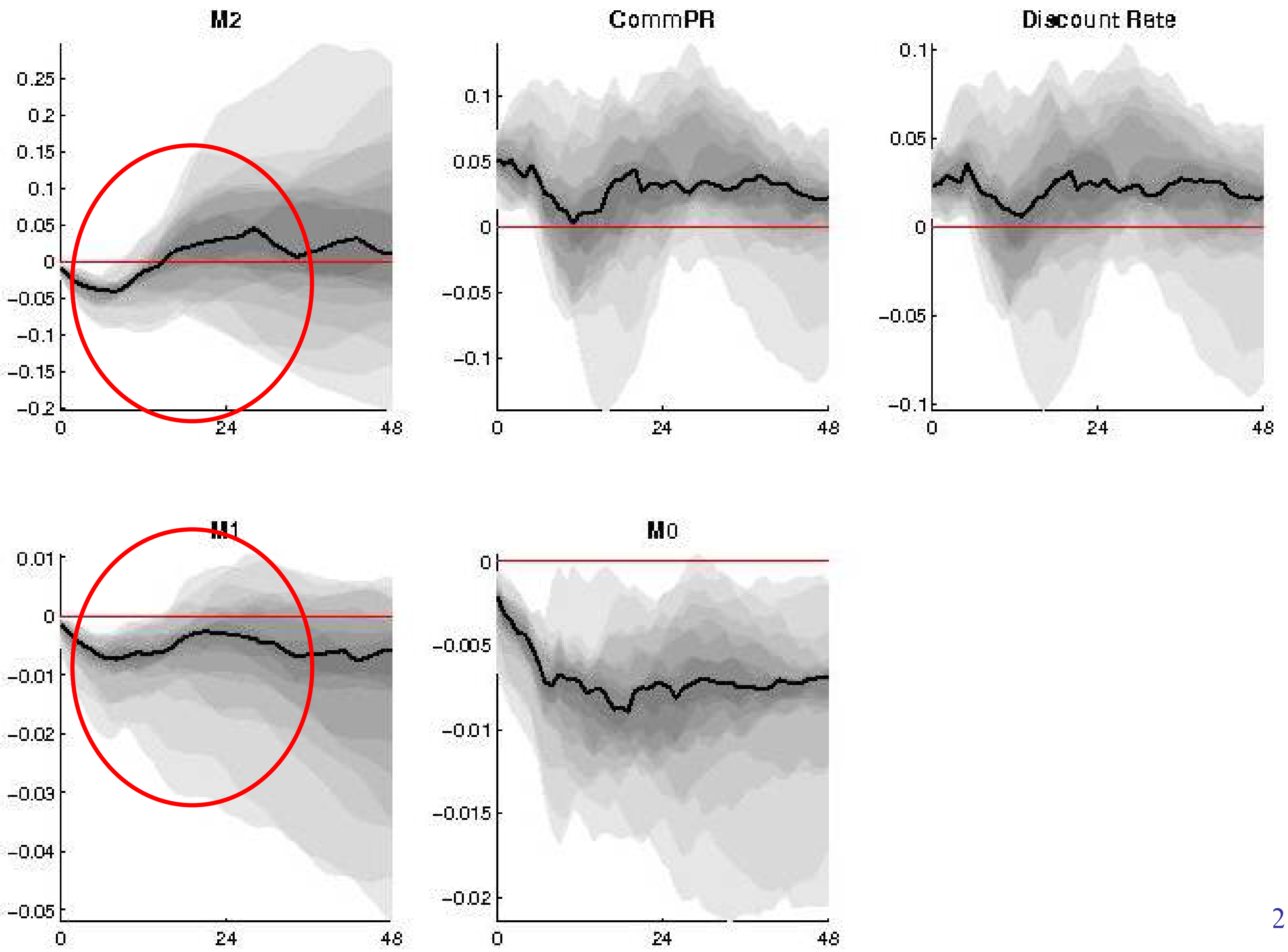

M1
FRB Index: Production
CPI Inflation
S&P 500
Wages
New orders:Machinery
0
20
40
60
80
100
0
12
24
36
48

Monetary Policy Shock

- Assume (with F/S) that monetary base (M0) is the instrument
- Again, trace propagation of adverse shock to policy instrument


M0
0
-0.005
-0.01
-0.015
-0.02
0
24
48
FRB Index: Production
0.01
0
-0.01
-0.02
-0.03
CPI Inflation
x 10^-3
0
-2
-4
-6
-8
-10
-12
-14
S&P 500
0.02
0.01
-0.03
-0.04
-0.05
Wages
0.03
0.02
New orders:Machinery
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14


M0
FRB Index: Production
CPI Inflation
S&P 500
Wages
New orders:Machinery
100
80
60
40
20
0
0
12
24
36
48


M2
CommPR
Discount Rate
M1
M0
0
24
48

What was the policy instrument? Find CB reaction function

- Model Aggregate Supply/Aggregate Demand Shocks
- Obtain response of candidate policy instruments
- See if this results in plausible MP transmission

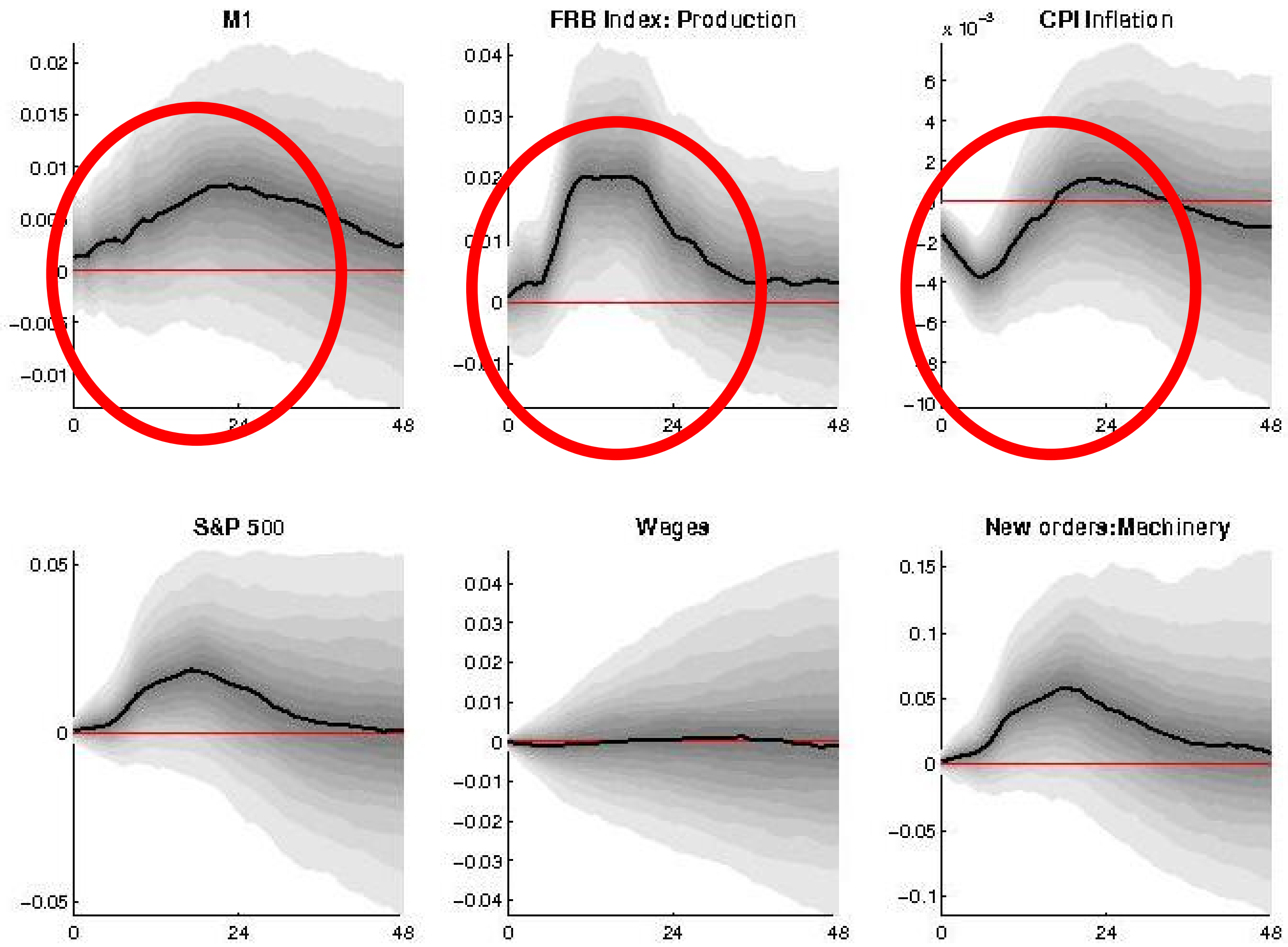
Aggregate Supply Shock

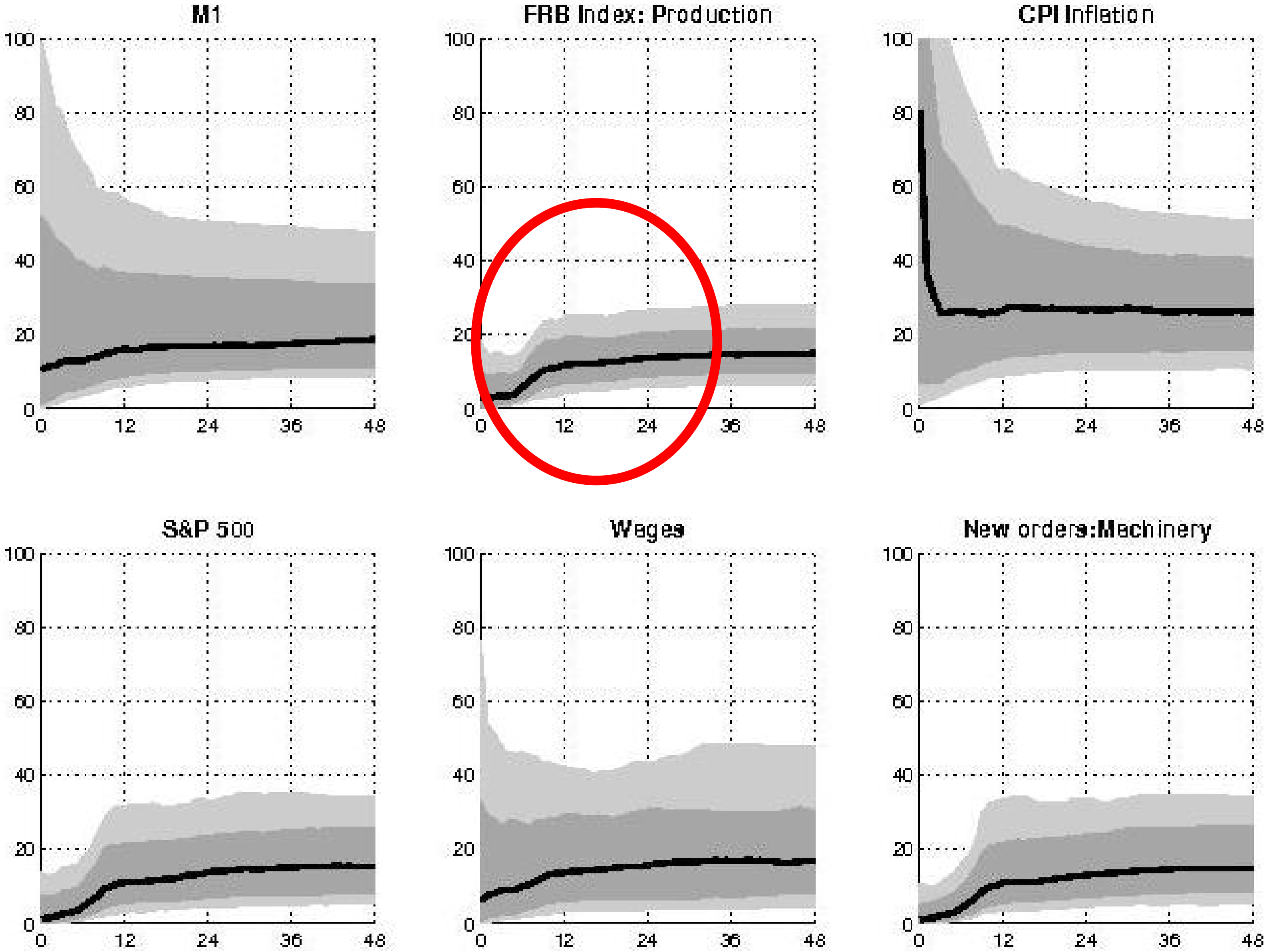
- Positive shock identified as:
  - FRB output up
  - CPI inflation down

  during 6 months after the shock

AS Shock

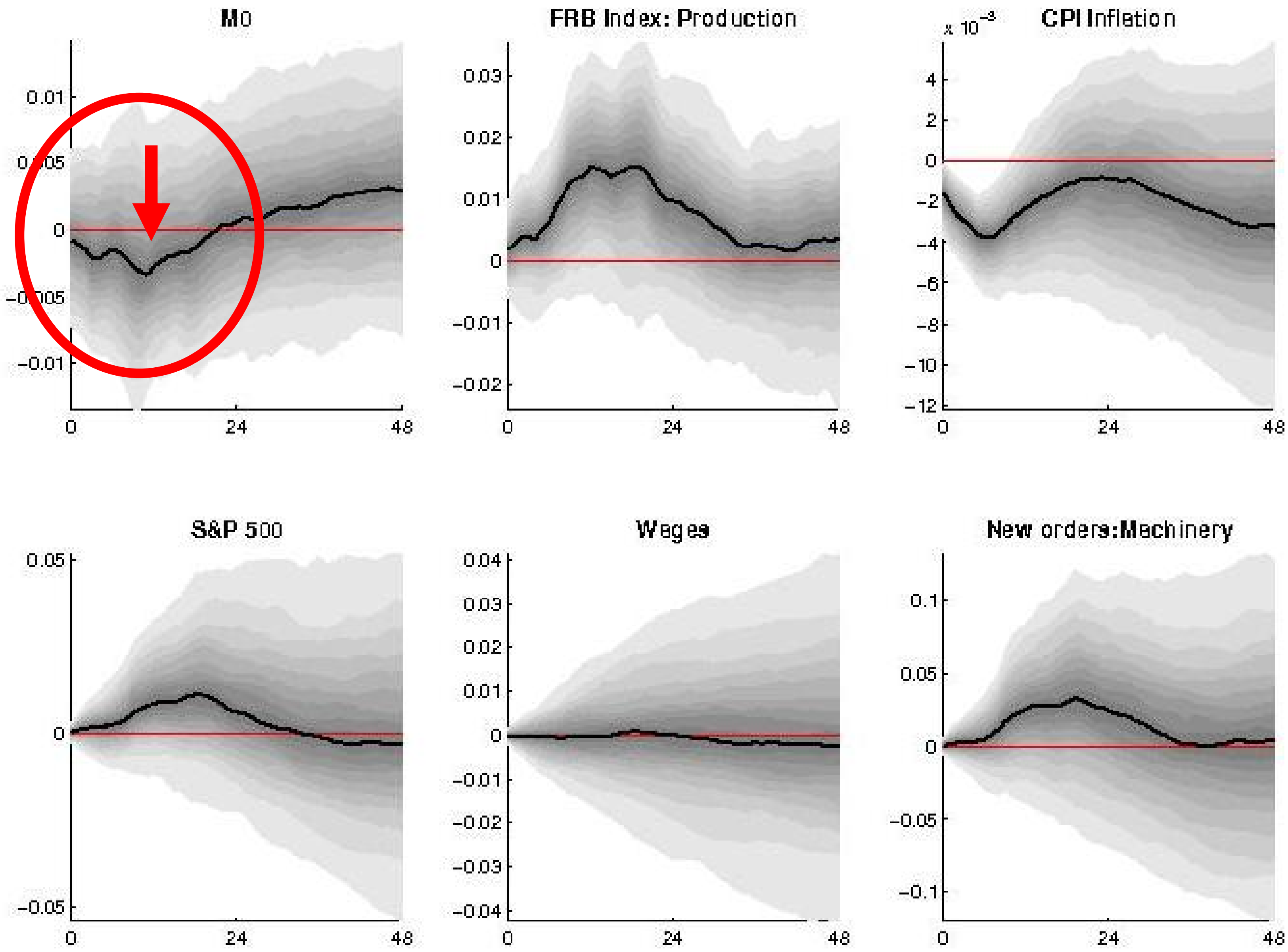
1. Assume M1 is the policy instrument

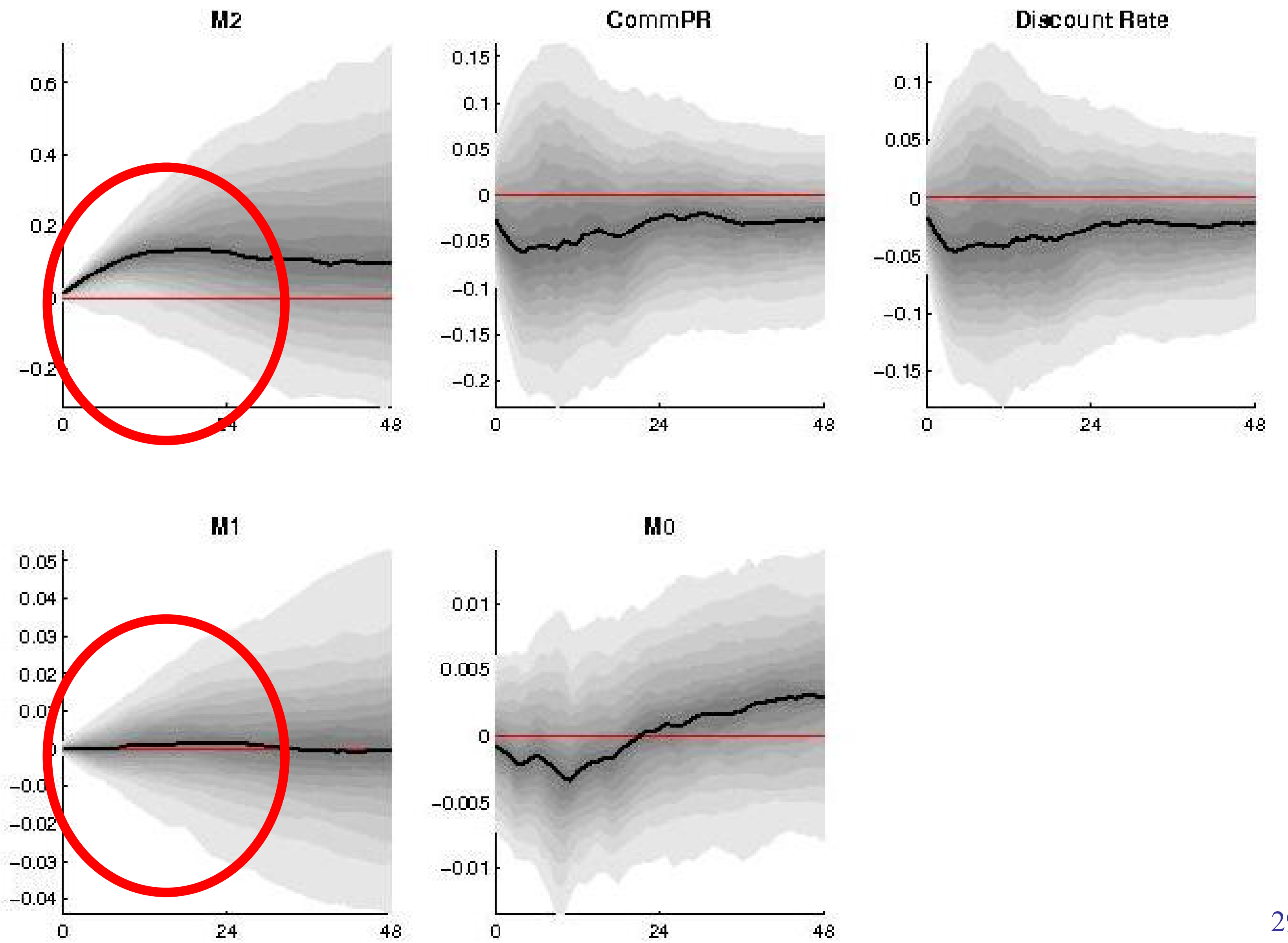

M1
0.02
0.015
0.01
−0.01
0
24
48
FRB Index: Production
0.04
0.03
0
CPI Inflation
x 10^-3
6
4
2
−10
S&P 500
0.05
−0.05
Wages
0.04
0.03
0.02
0.01
−0.01
−0.02
−0.03
−0.04
New orders:Machinery
0.15
0.1
0.05
−0.05
−0.1

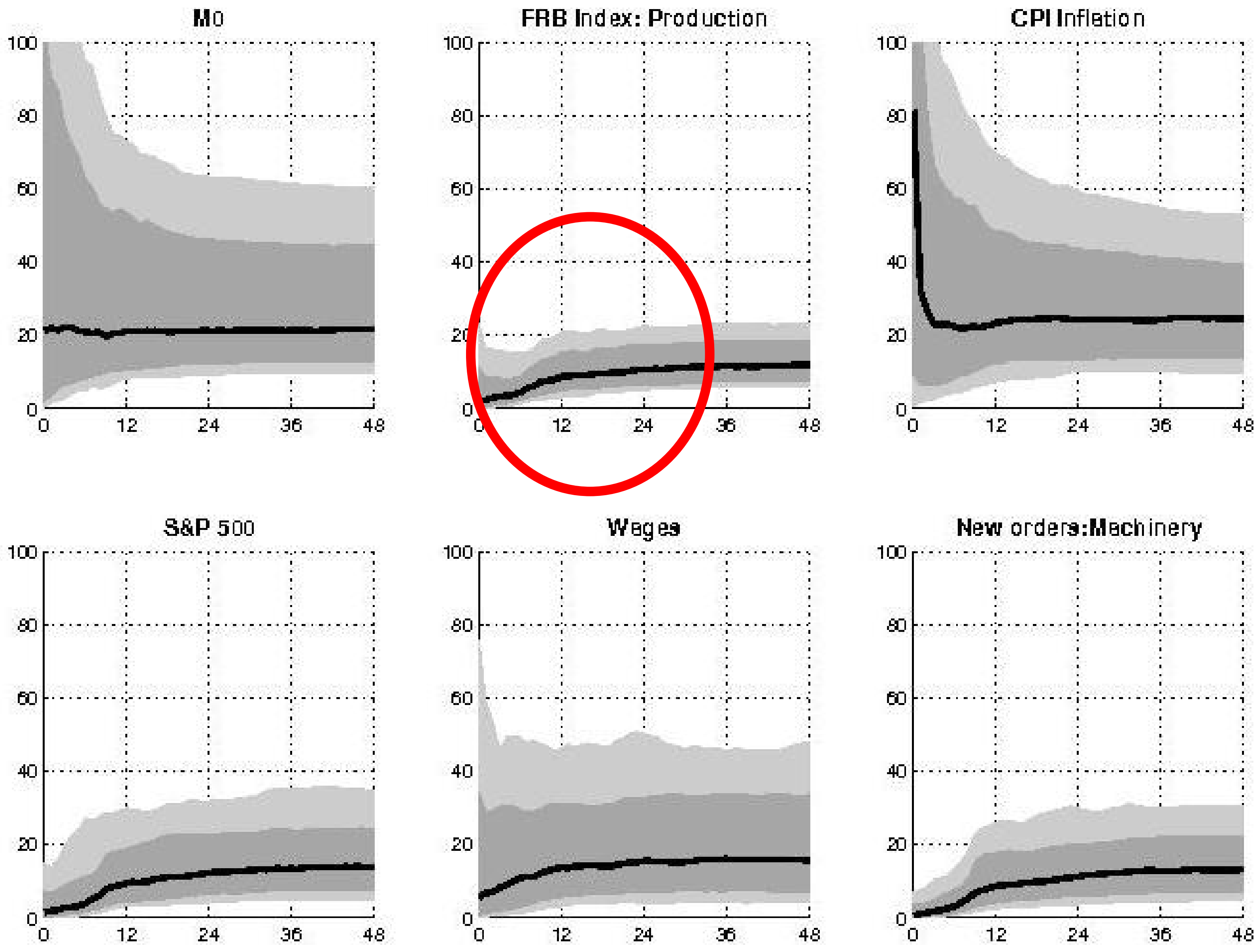

M1
FRB Index: Production
CPI Inflation
S&P 500
Wages
New orders:Machinery
0
20
40
60
80
100
0
12
24
36
48

AS Shock

1. Assume M1 is the policy instrument
2. Assume M0 is the policy instrument


M0
0.01
0.005
0
-0.005
-0.01
0
24
48
FRB Index: Production
0.03
0.02
0.01
0
-0.01
-0.02
0
24
48
x 10^-3
CPI Inflation
4
2
0
-2
-4
-6
-8
-10
-12
0
24
48
S&P 500
0.05
0
-0.05
0
24
48
Wages
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
0
24
48
New orders:Machinery
0.1
0.05
0
-0.05
-0.1
0
24
48


M2
CommPR
Discount Rate
M1
M0
0
24
48


M0
FRB Index: Production
CPI Inflation
S&P 500
Wages
New orders:Machinery
100
80
60
40
20
0
0
12
24
36
48

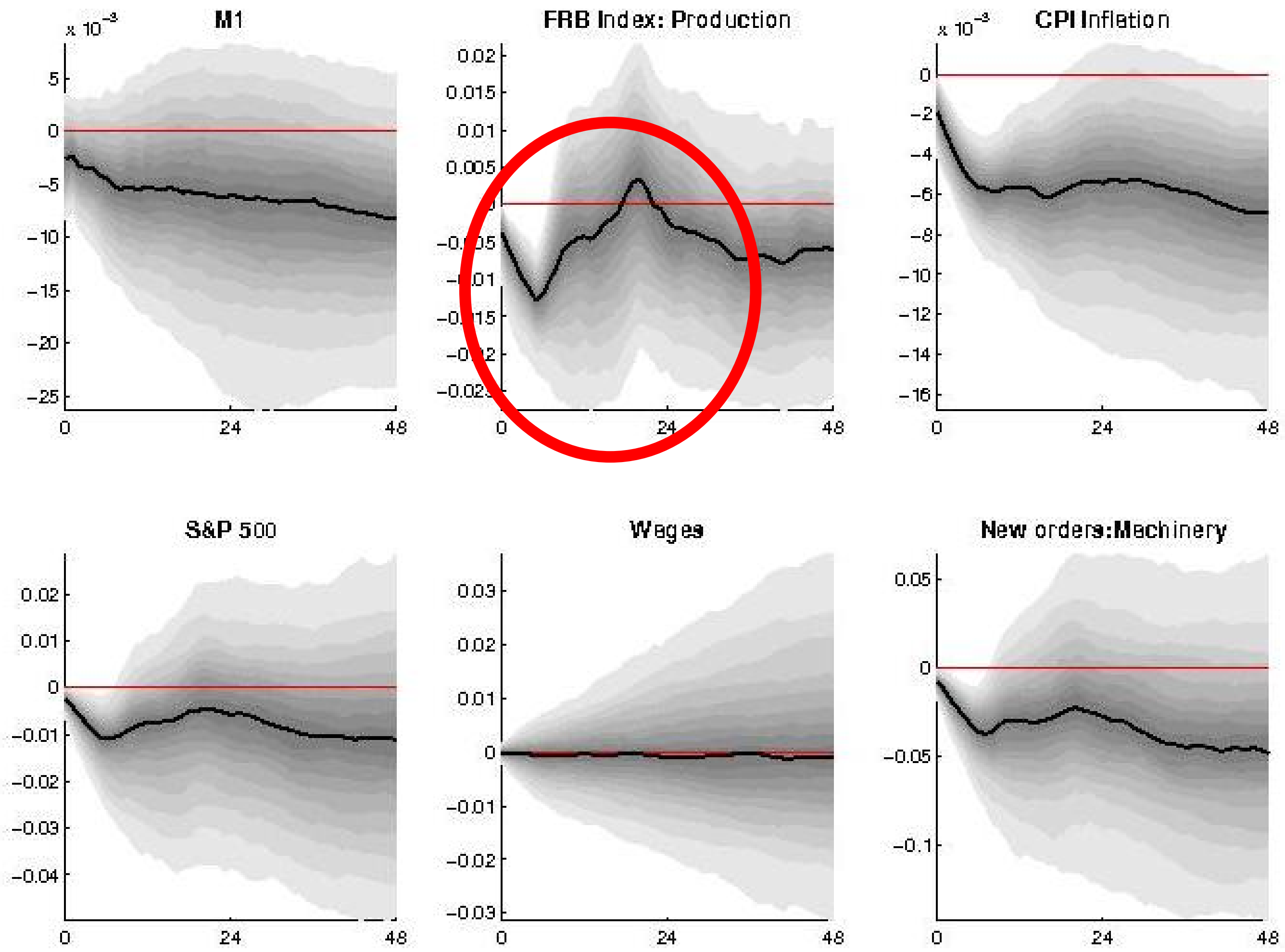
Aggegate Demand Shock

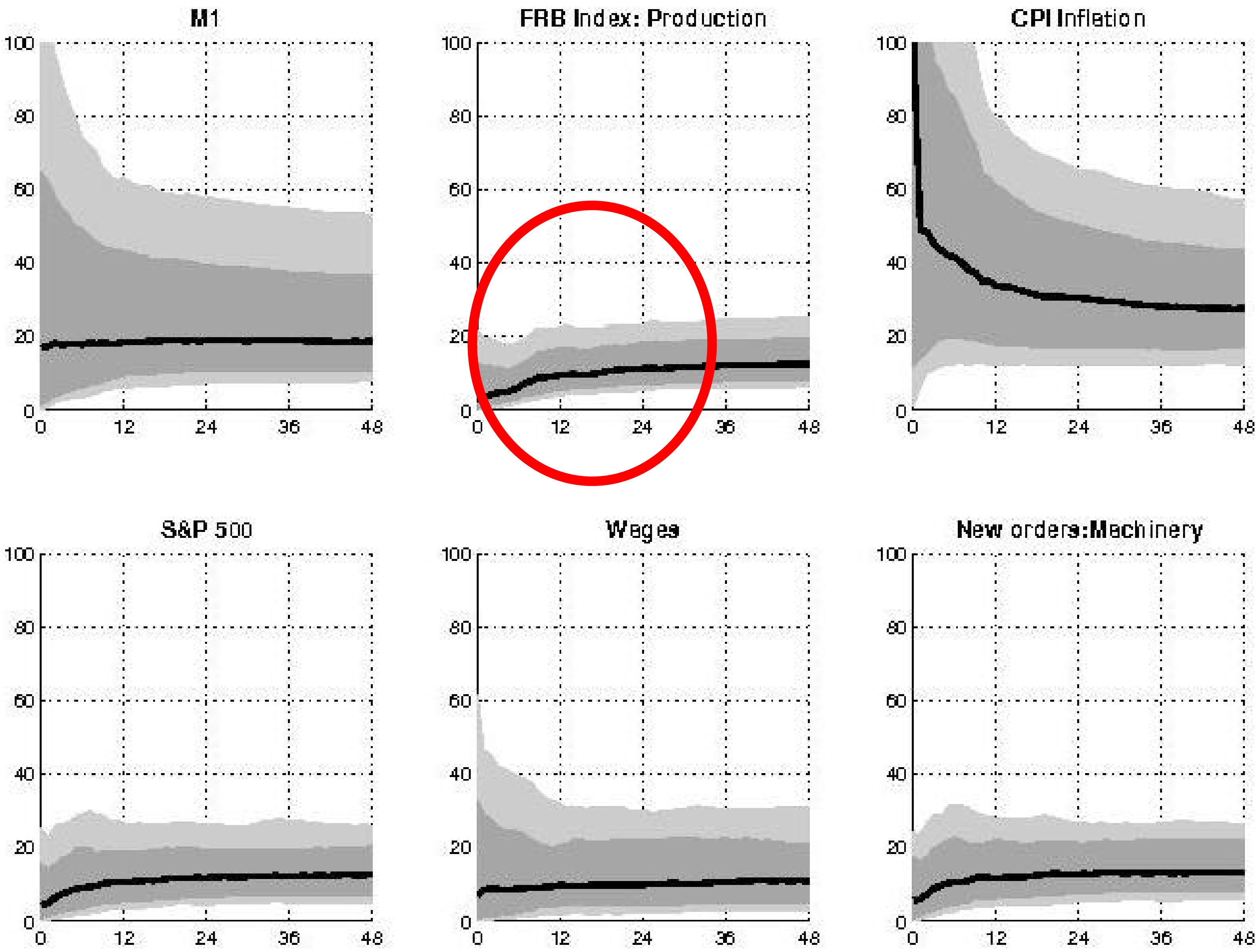
- Adverse demand shock:
  - FRB output down
  - CPI inflation down

  for six months after the shock

AD Shock

1. Assume M1 is the policy instrument

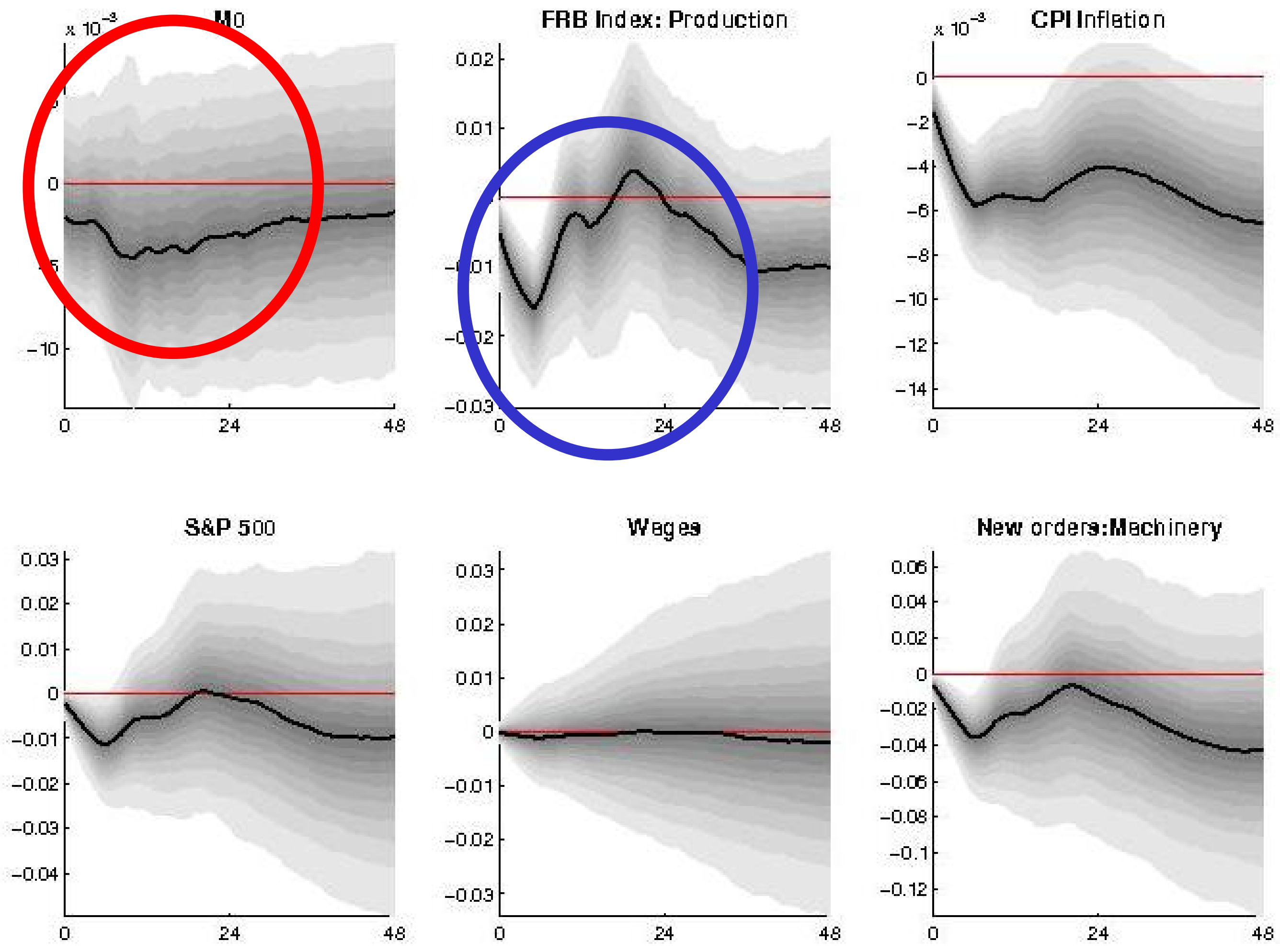

M1
x 10^-3
5
0
−5
−10
−15
−20
−25
0
24
48
FRB Index: Production
0.02
0.015
0.01
0.005
CPI Inflation
x 10^-3
0
−2
−4
−6
−8
−10
−12
−14
−16
S&P 500
0.02
0.01
0
−0.01
−0.02
−0.03
−0.04
Wages
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
New orders:Machinery
0.05
0
−0.05
−0.1

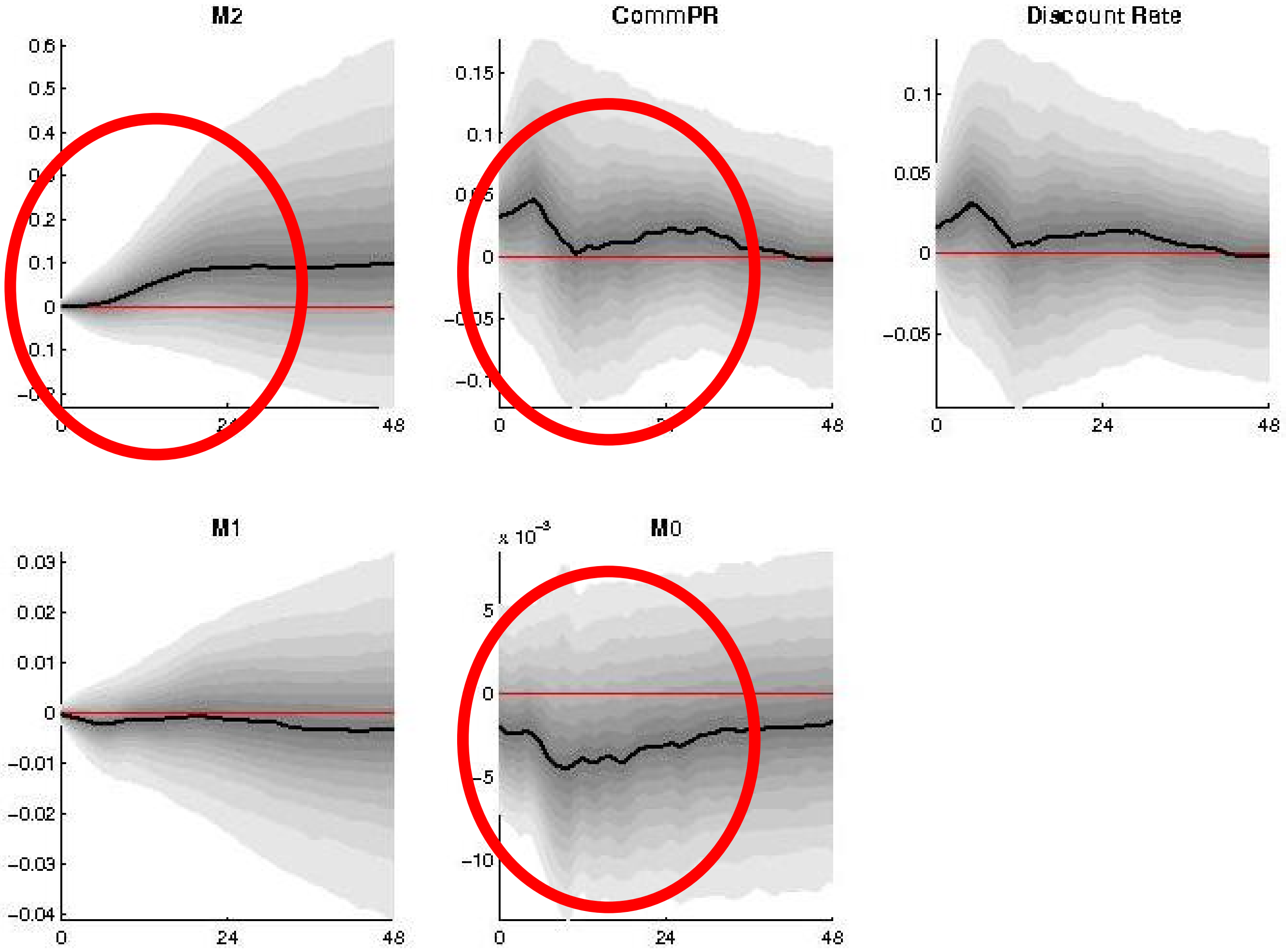

M1
FRB Index: Production
CPI Inflation
S&P 500
Wages
New orders:Machinery
0
12
24
36
48
100
80
60
40
20
0

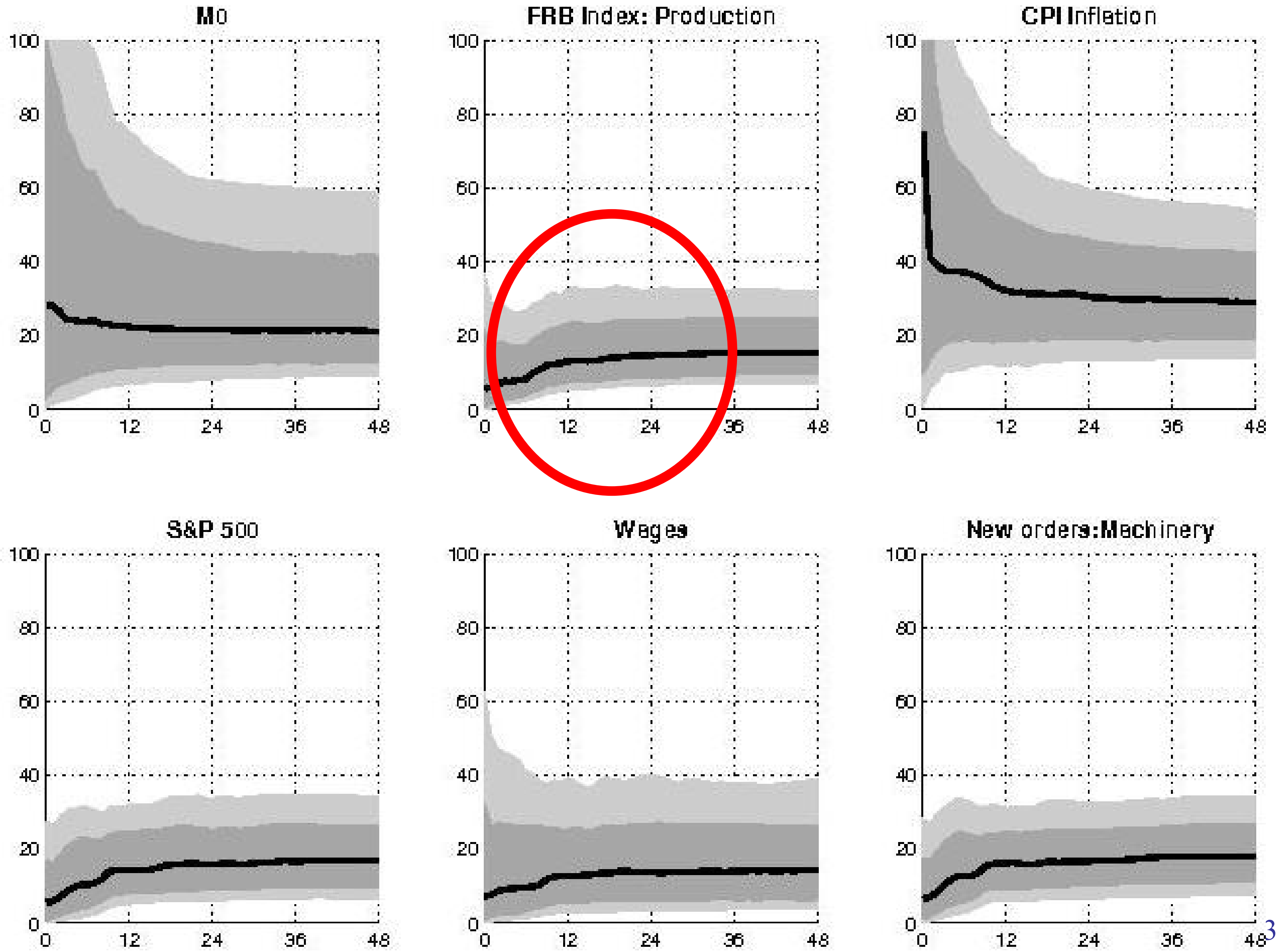
AD Shock

1. Assume M1 is the policy instrument

2. Assume M0 is the policy instrument


M0
x 10^-3
0
−10
0
24
48
FRB Index: Production
0.02
0.01
−0.03
CPI Inflation
x 10^-3
0
−2
−4
−6
−8
−10
−12
−14
S&P 500
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
−0.04
Wages
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
New orders:Machinery
0.06
0.04
0.02
0
−0.02
−0.04
−0.06
−0.08
−0.1
−0.12


M2
CommPR
Discount Rate
M1
M0
x 10^-3


M0
FRB Index: Production
CPI Inflation
S&P 500
Wages
New orders:Machinery
100
80
60
40
20
0
0
12
24
36
48

Policy reaction function

- Policy (kind of) accommodates AS shocks
- Policy does not lean against AD shocks

- But M0, M1, M2 responses often contradictory

- Responses of output and prices change sign after 6-month sign restriction

- Overall low explanatory power of AS/AD shocks

Systematic monetary policy effects?

- This is the original claim by F/S 1963
- Should not occur in RE equilibria with moderate rigidities
- Need measuring approach that does not violate Lucas critique

→ Obtain counterfactuals out of sample

Assessing systematic policy by conditional forecasts

- Estimated (hyper)parameters $\hat{\theta}_t \big| h_t^y$ at time t are conditional on history h_t^y of policy instrument f^y.

→ no counterfactual simulations in-sample
(unless variations very small)
→ but yes counterfactuals out of sample
(= conditional forecasts)

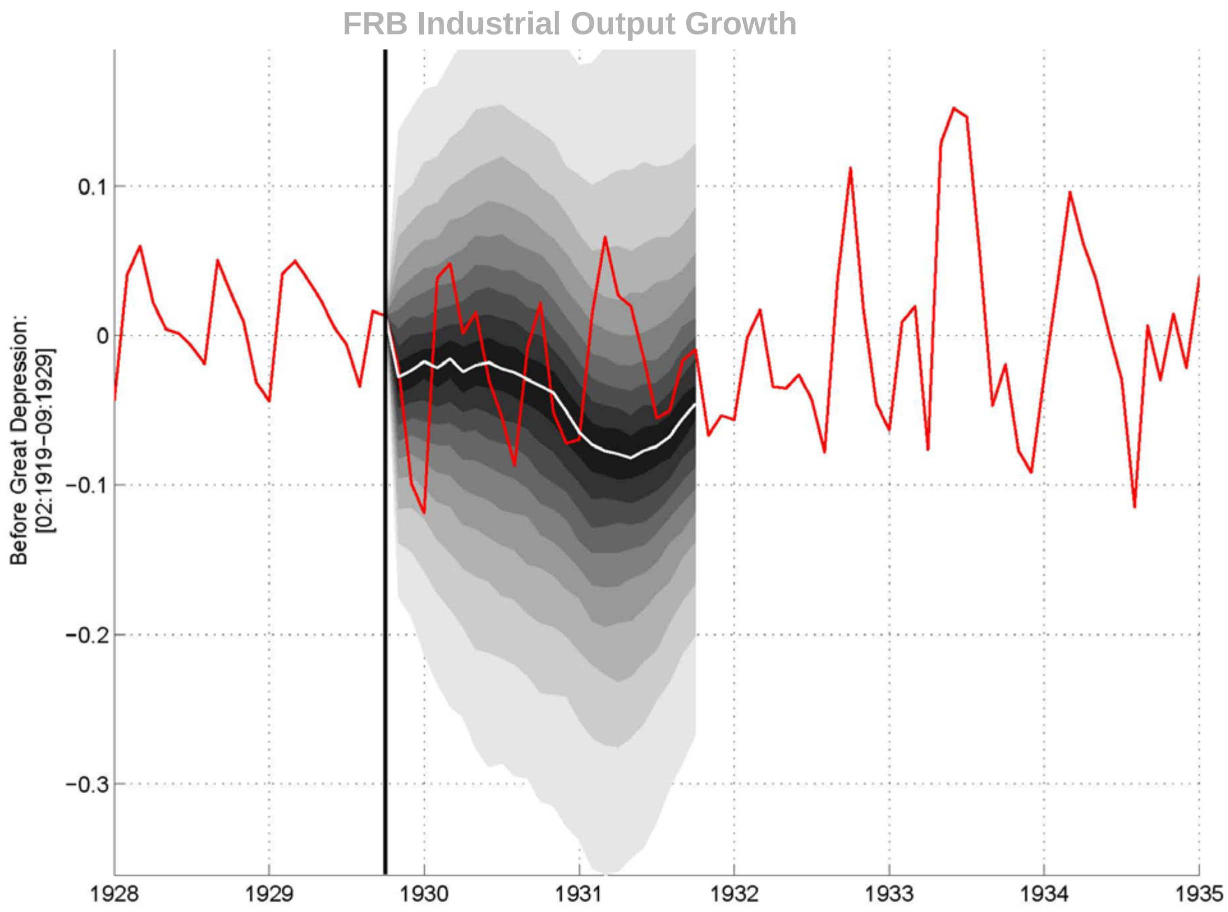
Out-of-sample counterfactuals

- Evaluate gain in predictive power over baseline from including policy history.
- Baseline: $E_t(X^c_{t+s} \mid I_t)$
- Extended: $E_t(X^c_{t+s} \mid I_t, h^y_t)$

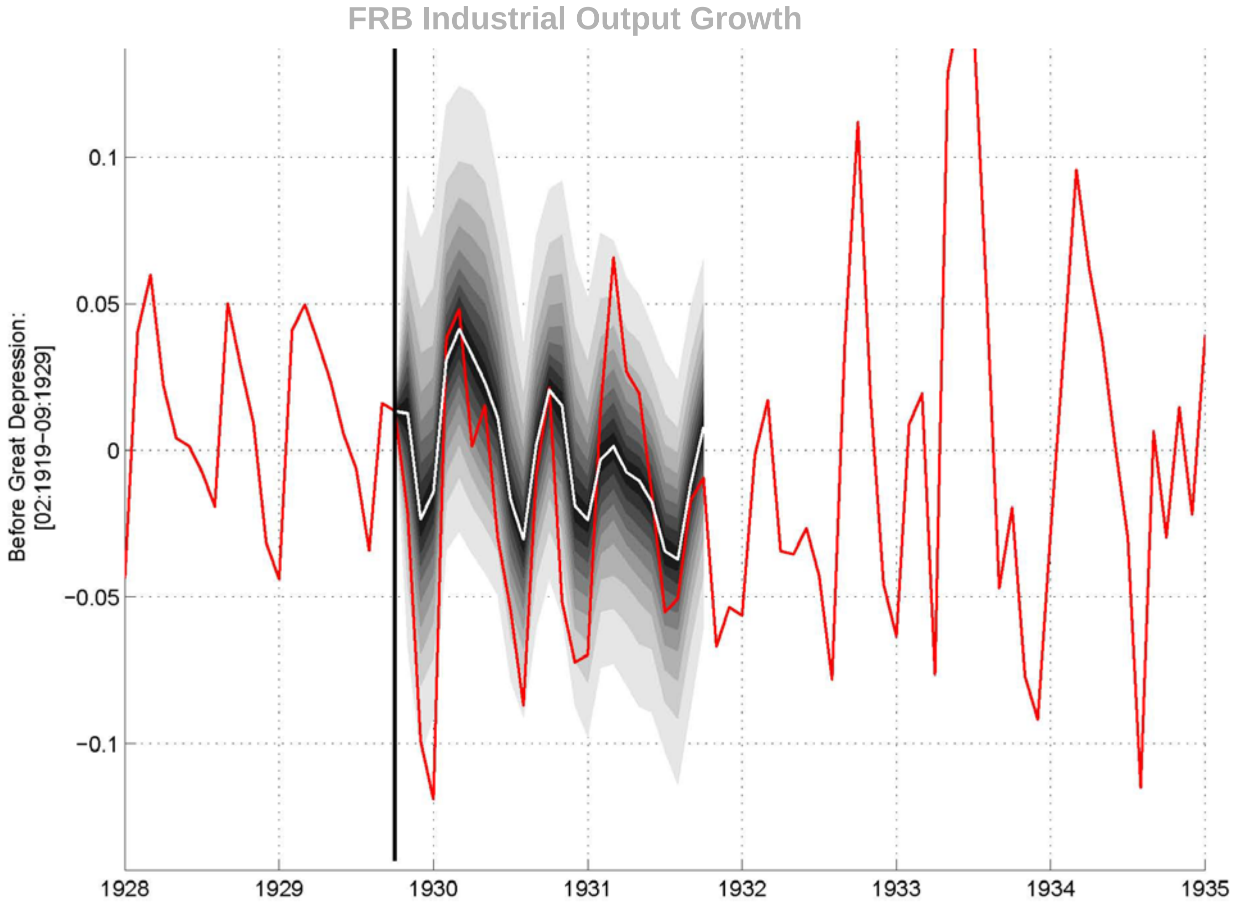
where $h^y_t = \{f^m_t\}^t_o$ summarizes policy history up to time *t* .

"What if monetary policy had followed its predictable component and no other shocks had occurred during forecasting period?"

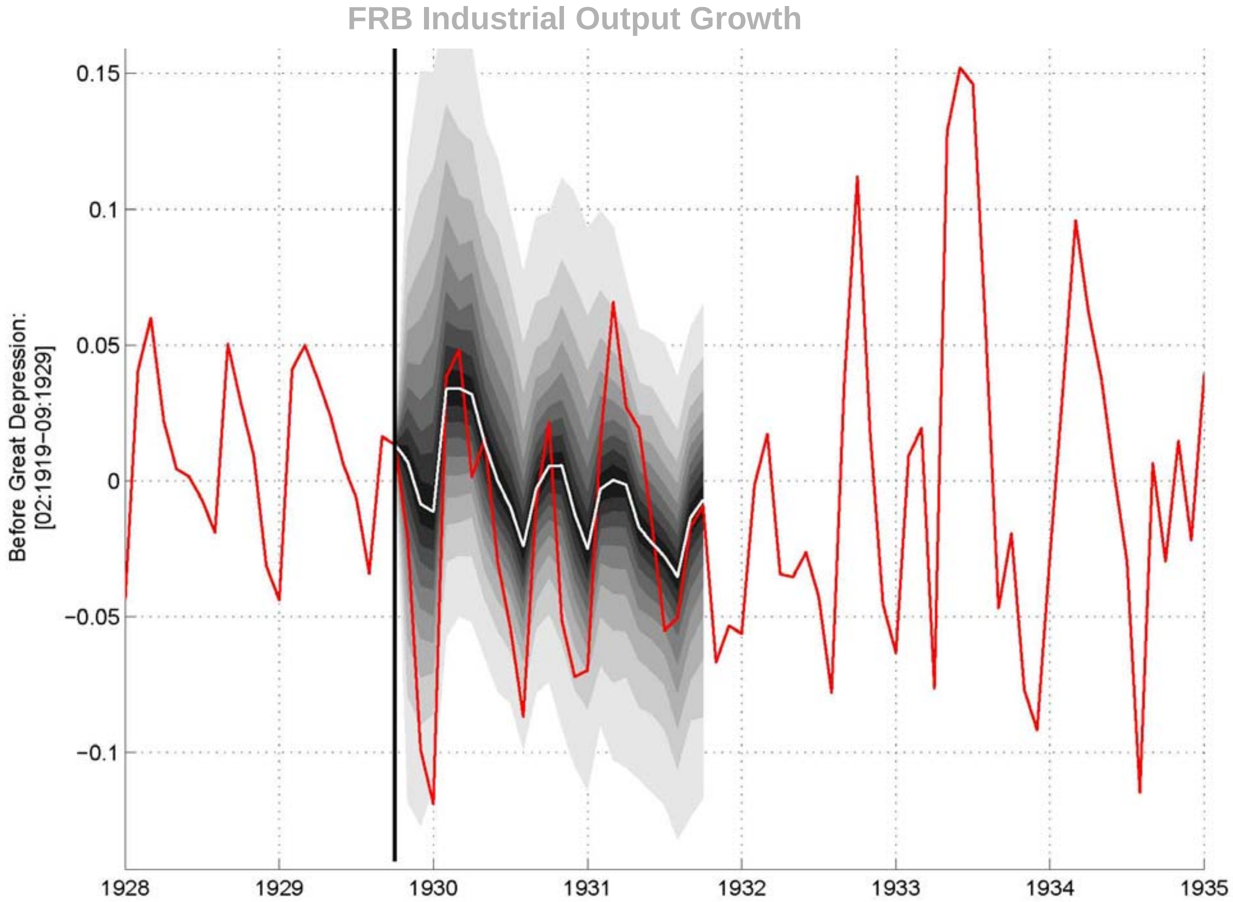
Baseline Forecast from September 1929: No Policy Instrument



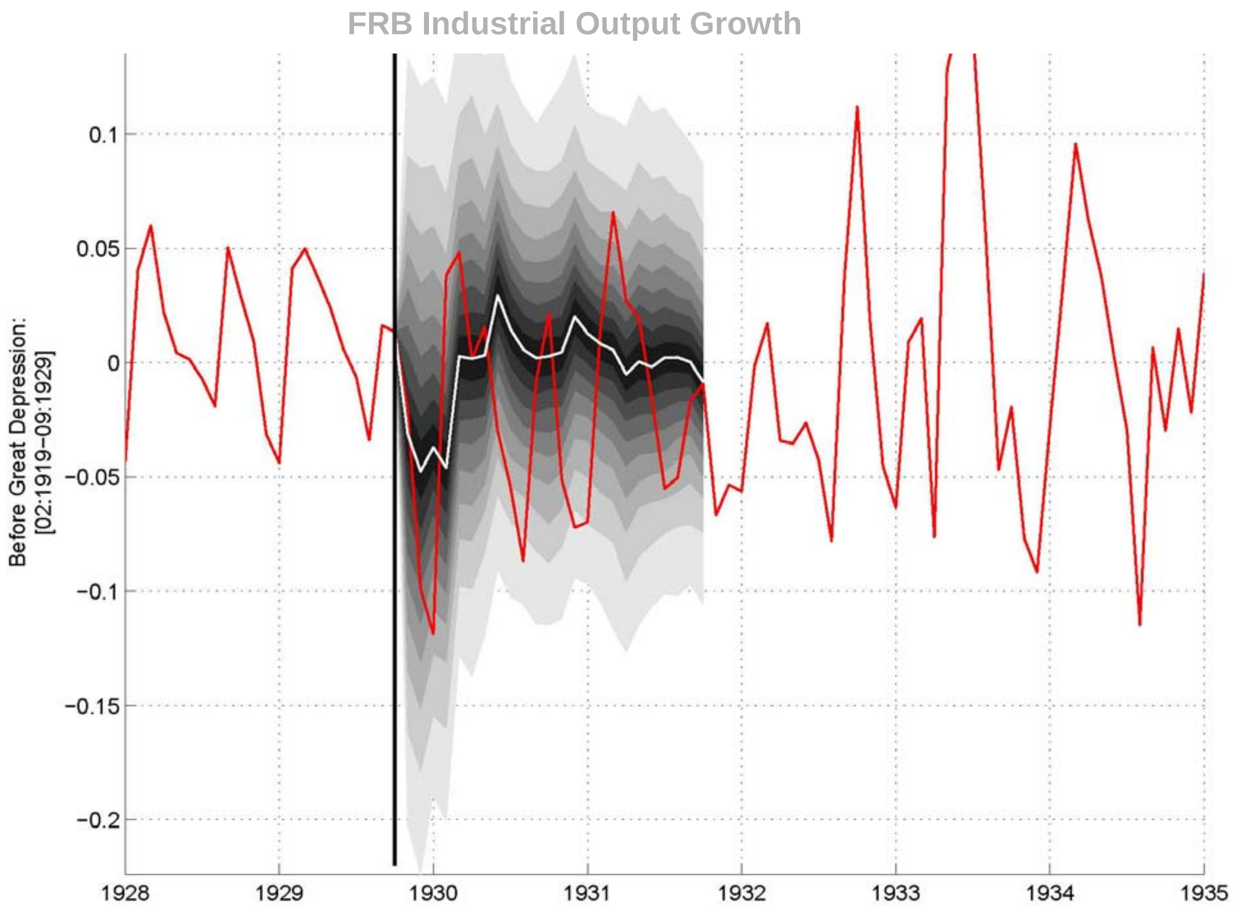
Baseline Forecast from September 1929 & M0 as Policy Instrument



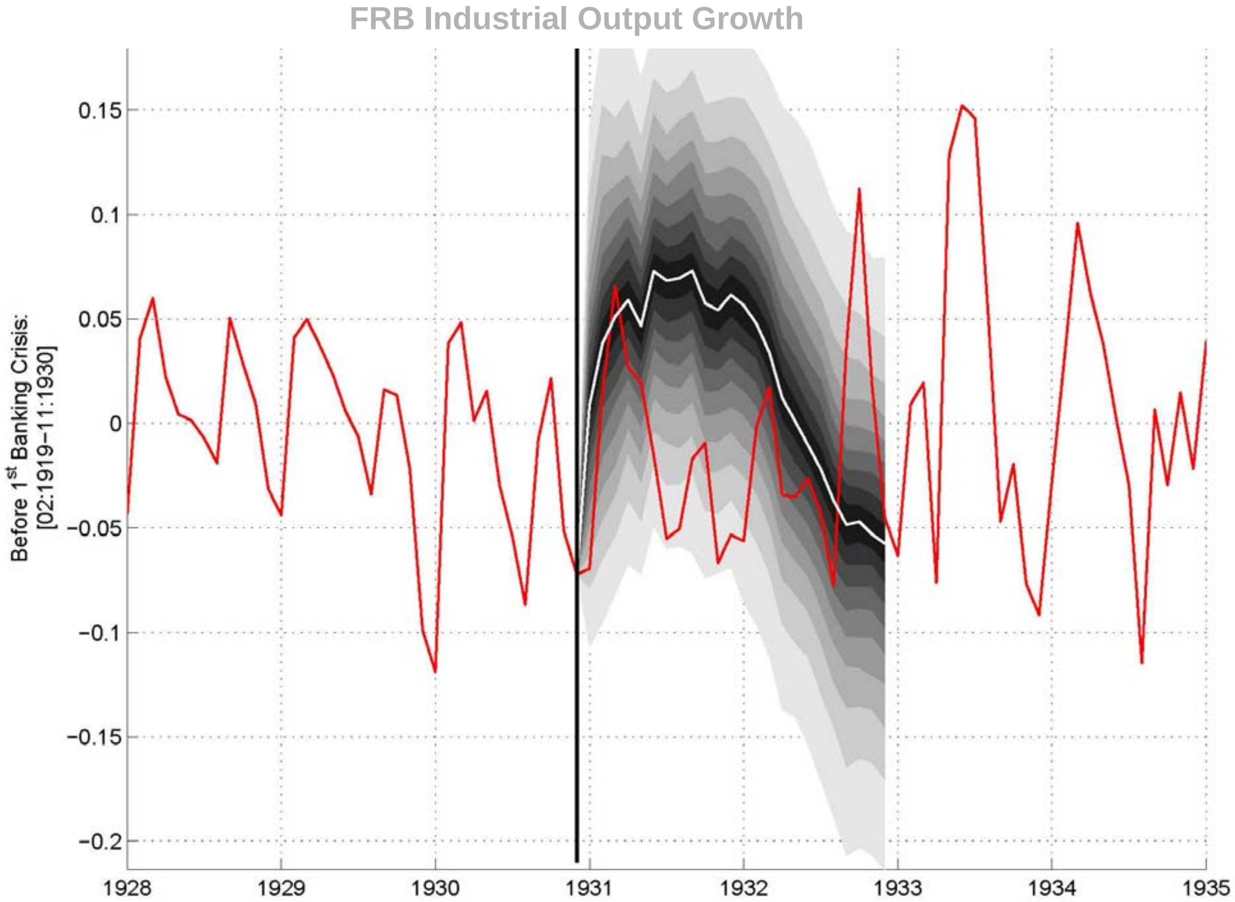
Baseline Forecast from September 1929 & M1 as Policy Instrument



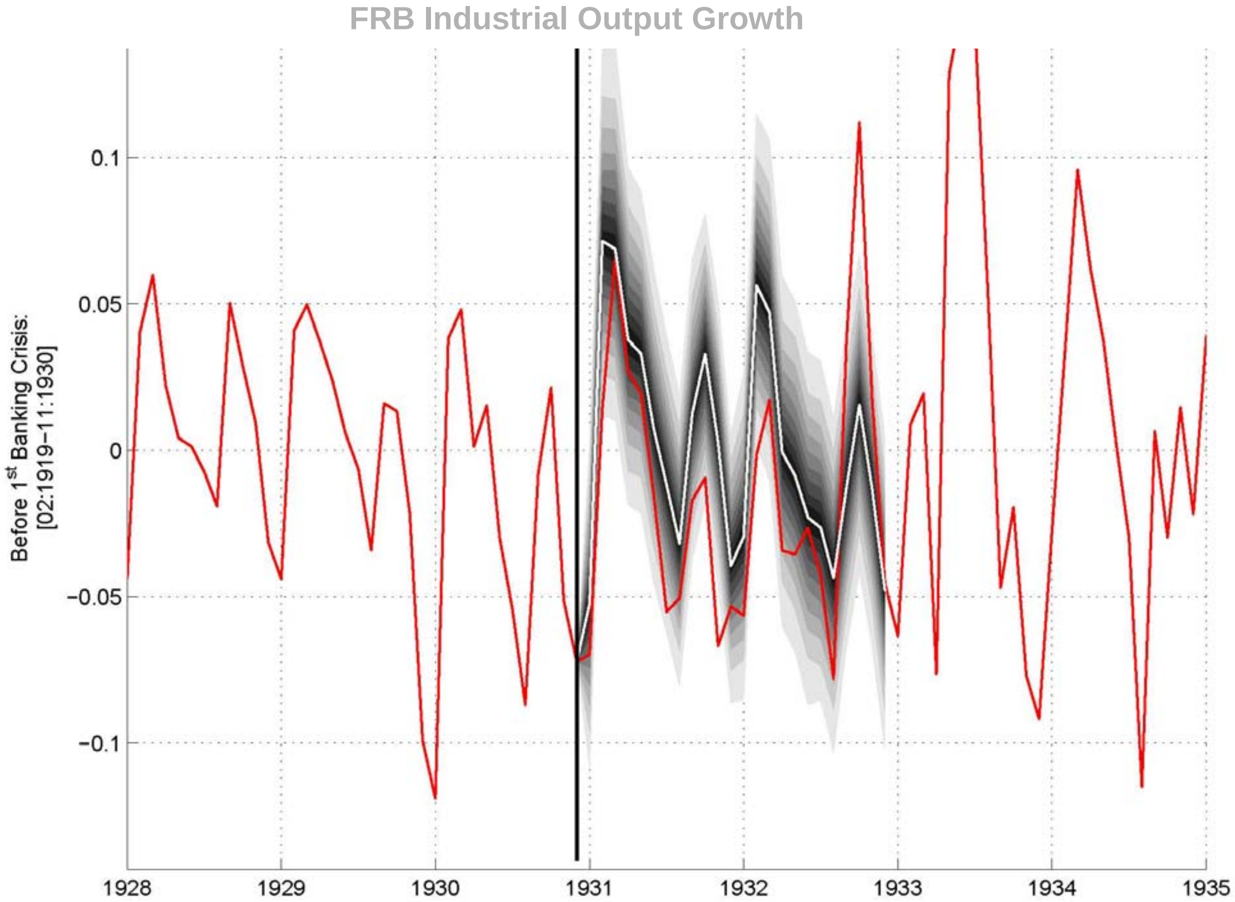
Baseline Forecast from September 1929 & NY Fed Rate as Policy Instrument



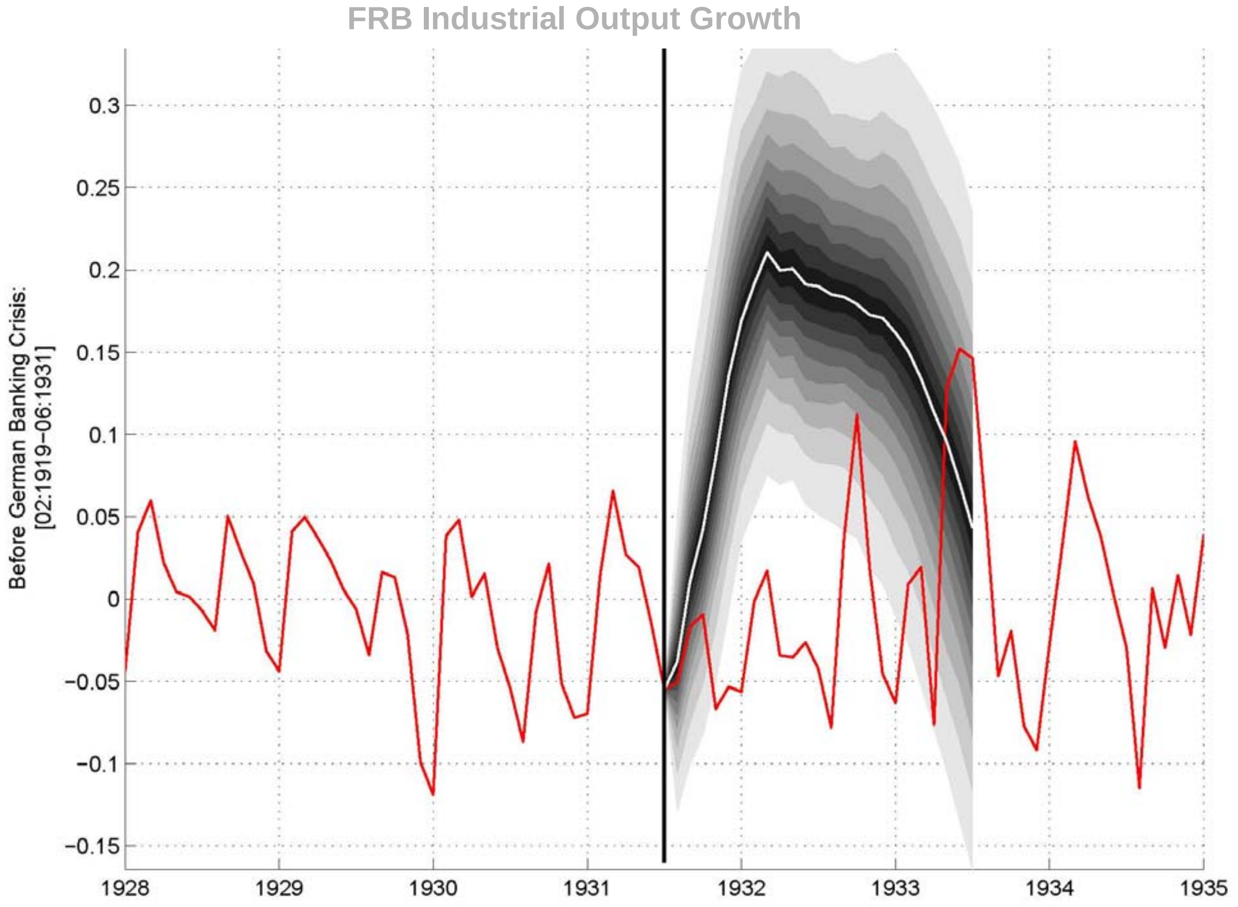
Baseline Forecast from November 1930
No Policy Instrument



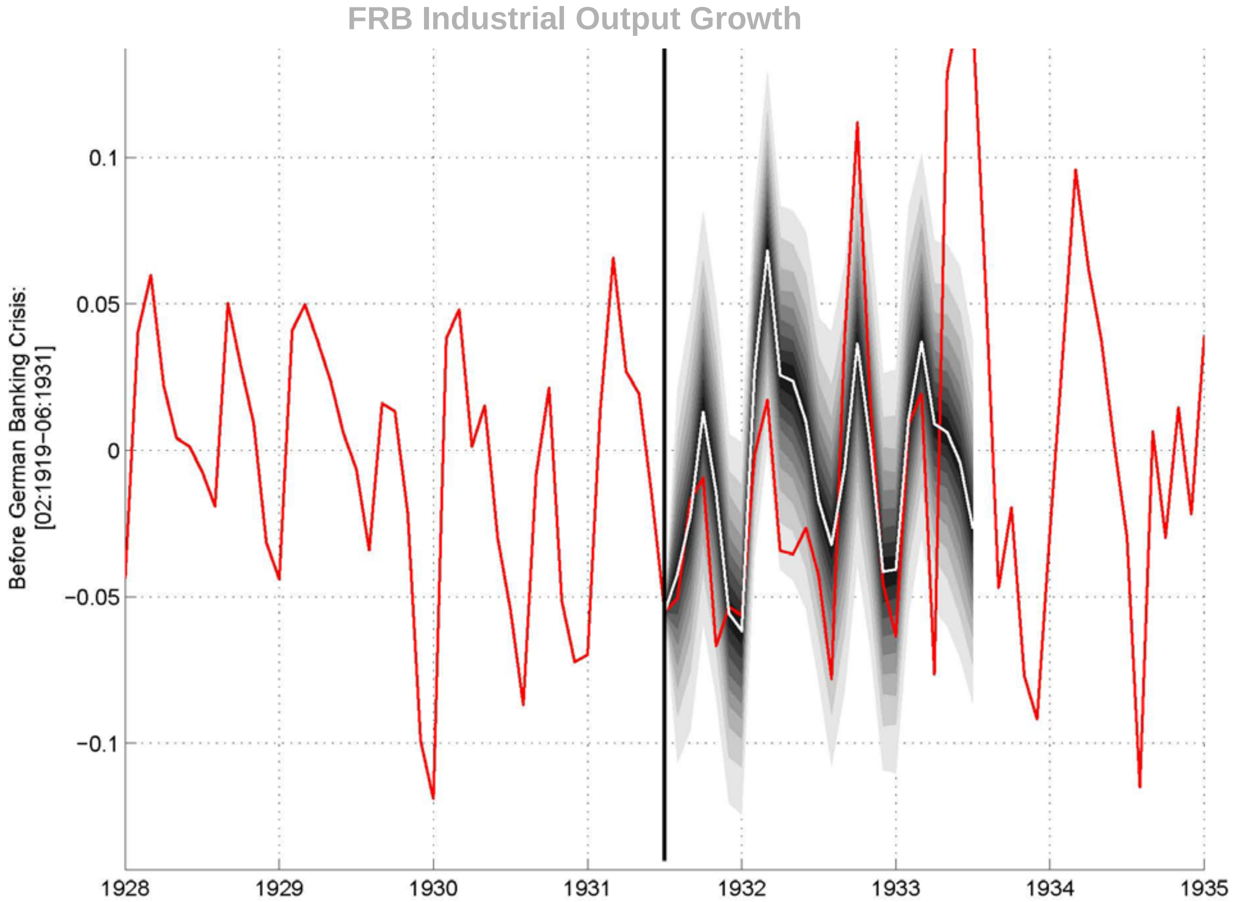
Baseline Forecast from November 1930 & M0 as Policy Instrument



Baseline Forecast from June 1931
No Policy Instrument



Baseline Forecast from June 1931 & M0 as Policy Instrument



Baseline Forecast from June 1931 & NY Fed Rate as Policy Instrument

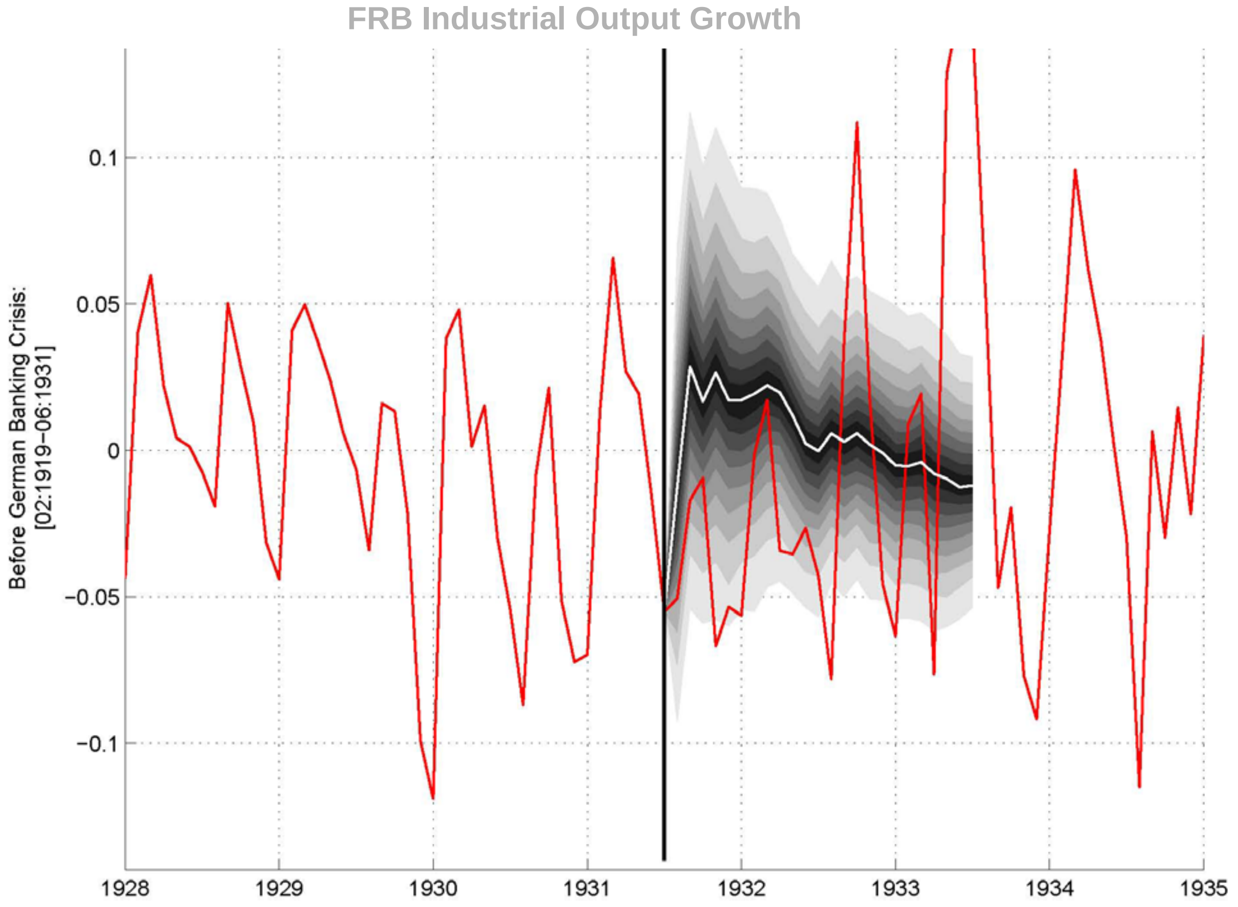


Table 6: **RMSFE at horizon 3 for different mo**

Horizon: 3	FRB Ind. Prod.	CPI Inflation
	Commercial Paper Rate Model	
Before Great Crash	10.25,[18.37,5.08]	2.27,[4.19,1.25]
Before 1^{st} Banking Crisis	13.40,[22.12,6.76]	2.86,[4.69,1.57]
Before German Banking Crisis	7.02,[13.53,3.43]	1.60,[2.87,0.92]
Before Devaluation of £	5.33,[10.14,2.84]	1.37,[2.31,0.82]
Before "Banking Holiday"	4.58,[7.70,2.60]	1.28,[1.92,0.85]
	Discount Rate Model	
Before Great Crash	8.09,[11.60,5.43]	1.46,[2.26,1.04]
Before 1^{st} Banking Crisis	5.54,[9.91,4.06]	1.20,[1.99,0.95]
Before German Banking Crisis	5.43,[7.39,4.26]	1.04,[1.36,0.91]
Before Devaluation of £	6.26,[9.06,4.73]	1.14,[1.62,0.93]
Before "Banking Holiday"	5.35,[6.[illegible]5,4.33]	1.02,[1.28,0.90]
	M0 Model	
Before Great Crash	3.17,[4.05,2.72]	1.07,[1.26,0.97]
Before 1^{st} Banking Crisis	3.11,[4.16,2.[illegible]7]	1.04,[1.24,0.96]
Before German Banking Crisis	3.00,[3.53,2.7[illegible]]	1.02,[1.17,0.95]
Before Devaluation of £	3.15,[3.80,2.78]	1.05,[1.23,0.96]
Before "Banking Holiday"	3.55,[4.67,2.86]	1.08,[1.29,0.97]
	M1 Model	
Before Great Crash	3.34,[4.45,2.61]	0.92,[1.15,0.79]
Before 1^{st} Banking Crisis	3.61,[4.94,2.8[illegible]]	0.96,[1.18,0.81]
Before German Banking Crisis	3.27,[4.41,2.5[illegible]]	0.90,[1.13,0.77]
Before Devaluation of £	3.09,[3.77,2.[illegible]9]	0.85,[0.99,0.76]
Before "Banking Holiday"	3.43,[4.76,2.[illegible]7]	0.94,[1.16,0.80]
	M2 Model	
Before Great Crash	5.24,[6.[illegible]4,4.84]	0.66,[0.98,0.47]
Before 1^{st} Banking Crisis	5.10,[5.90,4.80]	0.67,[0.99,0.47]
Before German Banking Crisis	5.35,[6.24,4.90]	0.68,[0.97,0.47]
Before Devaluation of £	5.20,[6.01,4.83]	0.88,[1.39,0.55]
Before "Banking Holiday"	5.46,[6.75,4.89]	0.67,[1.01,0.47]
	No Policy Instrument Model	
Before Great Crash	5.67,[6.27,5.37]	3.19,[4.03,2.76]
Before 1^{st} Banking Crisis	5.13,[6.16,4.53]	7.24,[7.81,7.00]
Before German Banking Crisis	5.52,[6.49,4.90]	11.41,[12.48,10.40]
Before Devaluation of £	4.33,[5.07,3.91]	10.32,[11.48,9.19]
Before "Banking Holiday"	5.11,[5.61,4.84]	6.33,[7.20,5.67]

The table reports the median root mean squared forecast errors (RMSFE in brackets for the respective models under consideration.

Summary

- FAVAR & SR identification to deal with irregularities of interwar period
  → Surprise shocks to MP no greater than in postwar period
  → Largely passive stance of systematic MP
- Systematic policy component has predictive power
  - Consistent with Friedman / Schwartz (1963)
  - Not Lucas compatible [?]
  - For M0, M1, effects persist even after 12 months
  - Predicts turning points quite well
  - Does not predict a Great Depression in 1929
- No evidence of reduced MP effects after banking crises [not shown here]

Further perspectives

- More analysis of systematic policy effects (coming soon)
- More subsample analysis for 1930s, including 1938 recession (coming soon)

- TVAR coeffs and VCVs (next paper)
- TVAR CB reaction fct (next paper)

Bonus material

- Factor identification
- Gibbs sampler

Factor identification

- Define rotation on F such that:

$$F_t^* = A\, F_t - B\, Y_t$$

with A_{KxK} nonsingular and B_{KxM}.

- Impose restrictions only on B, i.e. on observation equation.

Factor identification

- Substitute into obs. equation to obtain:

$$X_t = \Lambda_f A^{-1} F_t^* + (\Lambda_Y + \Lambda_f A^{-1} B) Y_t + e_t$$

Factor identification

- Unique identification requires:

$$\Lambda_f A^{-1} = \Lambda_f$$

- Restrict the channels by which the Y contemporaneously affect the X

$$\Lambda_Y + \Lambda_f A^{-1} B = \Lambda_Y$$

Identification of shocks

- From FAVAR model: $u_t = Av_t^f$

$$Q_u = AA'$$

- with $$Q_v = I$$

- Then $$a = A\alpha$$

  is an impulse vector for some α of unit length. Feed that back into state equation.

Estimation: Gibbs Sampler

1. Choose prior on hyperparameters θ_0
2. Draw trial values of factors F_T^1 , conditional on θ_0 and data X_T, from conditional pdf

$$p(F_T \mid X_T, \theta_0)$$

3. Update to θ_1 from conditional pdf

$$p(\theta \mid X_T, F_T^1)$$

- Iterate on last two steps until convergence

Algorithm 1 FAVAR estimation via Multi-move Gibbs sampling

Step 0, [Initialization]: $p_0(F^0, \lambda^{f0}, \lambda^{y0}, b^0, R_e^0, Q_u^0)$.

```
Set g ⇝ 0.
 Get initial values for states and parameters.
Set g ⇝ 1.
```

Step 1, [Evaluate likelihood of latent states]: $p(F^T \mid X^T, \lambda, R_e, b, Q_u) \sim FFBS$

```
 Do forward filtering and backward sampling
```

Step 2, [Sample parameters from observation equation]: $p(\lambda_n, R_{e,nn} \mid X^T, F^T)$

$2.a: \quad p(R_{e,nn} \mid \lambda_n^{(g-1)}, X^T, F^T) \sim f_{\mathcal{IG}}$

$2.b: \quad p(\lambda_n \mid R_{e,nn}^{(g)}, X^T, F^T) \sim f_{\mathcal{N}}$

```
 Sample equation by equation due to conditional Gaussianity.
```

Step 3, [Sample parameters from state equation]: $p(b, Q_u \mid X^T, F^T)$

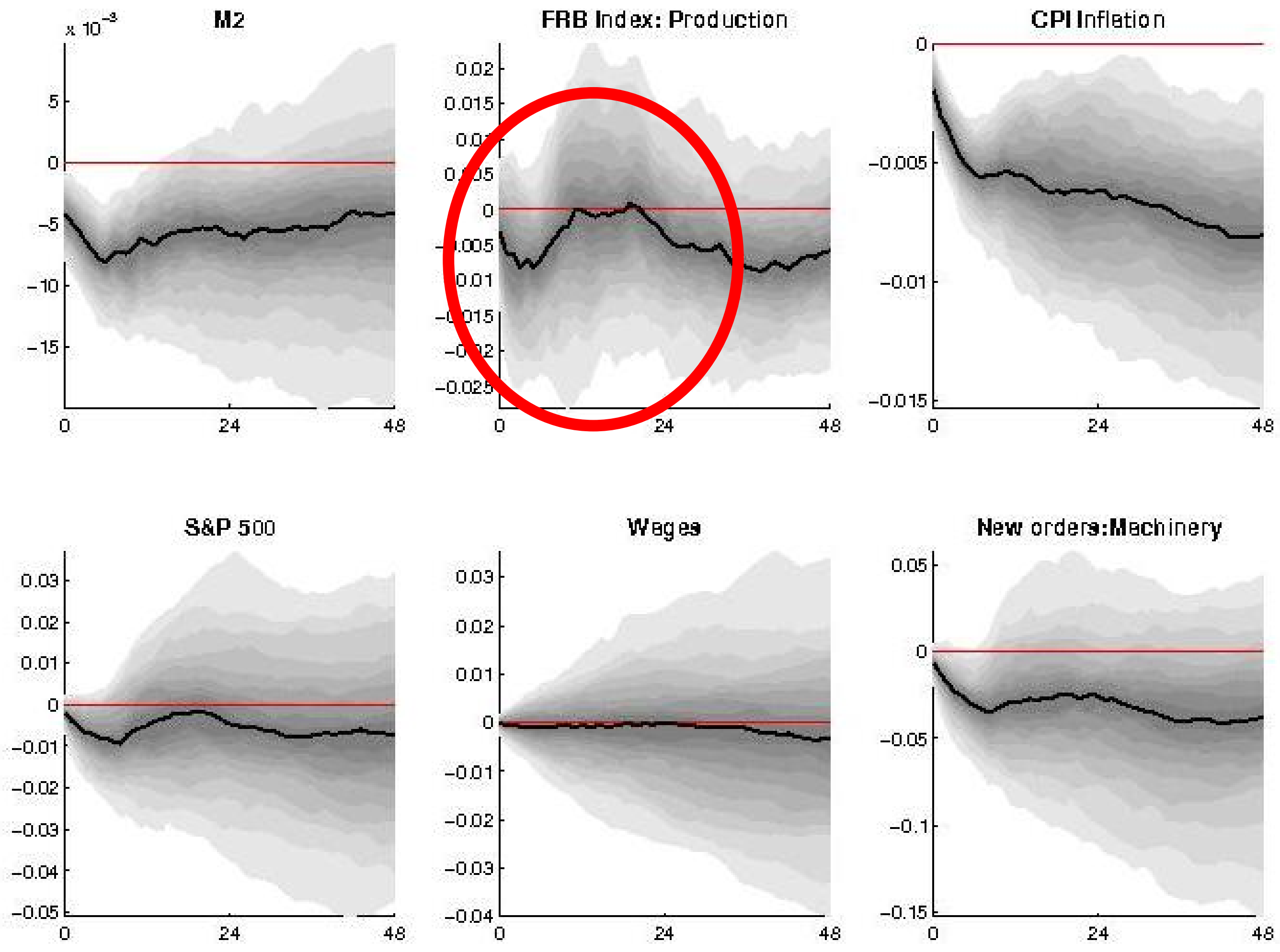
$3.a: \quad p(Q_u \mid F^{T(g)}, X^T) \sim f_{\mathcal{IW}}$

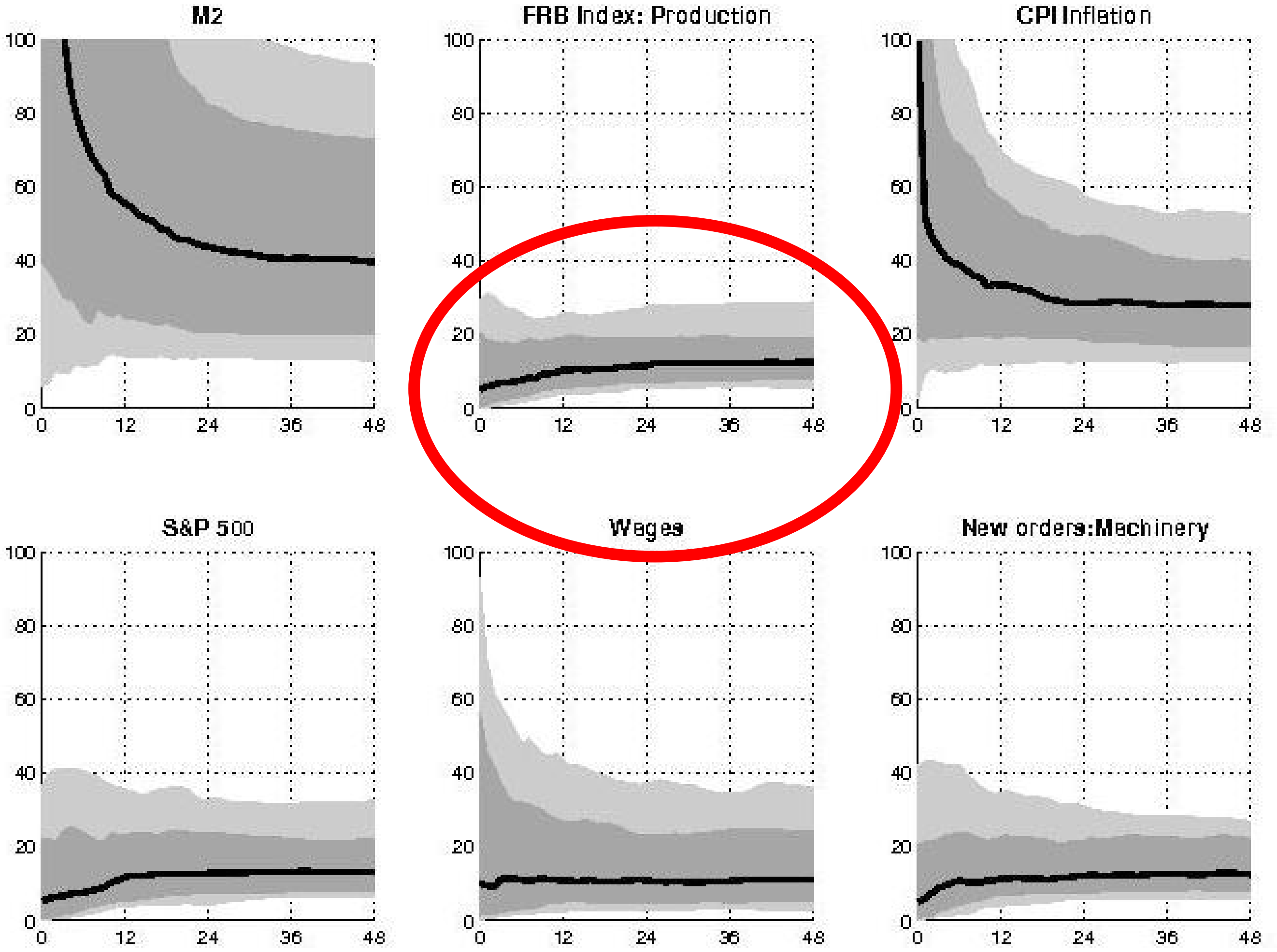
$3.b: \quad p(b \mid Q_u^{(g)}, F^{T(g)}, X^T) \sim f_{\mathcal{N}}$

```
 Sample parameters from a normal inverted Wishart density.
If g ≤ G set g ⇝ g+1 and go to Step 1. Otherwise stop.
```

Monetary Policy Shock

- Assume wide monetary aggregate (M2) is the policy instrument (doubtful..)


M2
x 10^-3
5
0
−5
−10
−15
0
24
48
FRB Index: Production
0.02
0.015
0
0
24
48
CPI Inflation
0
−0.005
−0.01
−0.015
0
24
48
S&P 500
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
−0.04
−0.05
0
24
48
Wages
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
−0.04
0
24
48
New orders:Machinery
0.05
0
−0.05
−0.1
−0.15
0
24
48


M2
FRB Index: Production
CPI Inflation
S&P 500
Wages
New orders:Machinery
100
80
60
40
20
0
0
12
24
36
48