Evaluating Policy Institutions
—150 years of US Monetary Policy—

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December 10, 2023

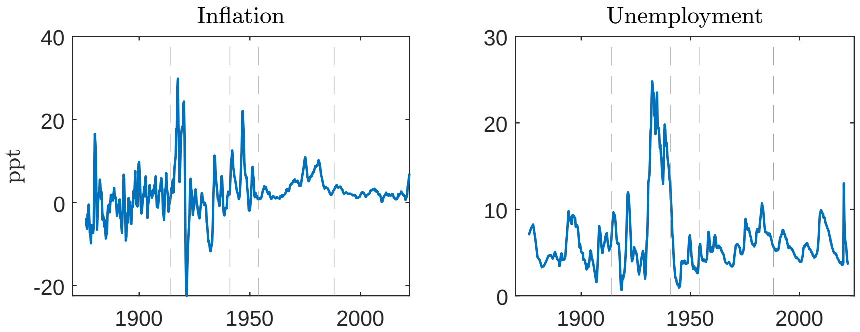
Motivating question

- How to evaluate/compare performance of a policy institution/maker?
  - Did the Fed in 1930s perform better wrt Fed in 2000s?
  - Did the Fed perform better compared to ECB in 2008?
  - Did Democratic presidents perform better compared to Republican?

Naive approach

- Compare performance based on realized outcomes, e.g.
  - Inflation and unemployment outcomes for a central bank
  - GDP growth for a president, and so on ...

Naive approach: Compare realized outcomes



Naive approach: Compare realized outcomes

	Pre Fed 1879-1912	Early Fed 1913-1941	Post WWII 1951-1984	Post Volcker 1990-2019
$\overline{\pi}$	0.4	1.9	4.3	2.0
$\overline{u}$	5.3	10.2	5.6	5.9
$\text{Var}(\pi)$	19.4	90.1	7.7	0.5
$\text{Var}(u)$	3.5	48.6	3.2	2.6

Problems with naive approach

Different policy makers face

(i) different initial conditions
$\rightarrow$ can inherit a stronger or weaker economy

(ii) different economic disturbances
$\rightarrow$ a financial crisis or an energy price shock

(iii) different economies
$\rightarrow$ a steeper or flatter Phillips curve

Ideal experiment

Create controlled environment for all policy makers with

- same initial conditions
- same underlying economic structure
- same sequence of macro shocks

then compare their average performance

As a first step ...

- Same sequence of macro shocks does not happen ...
- But different policy makers often exposed to same *types* of shocks

Idea

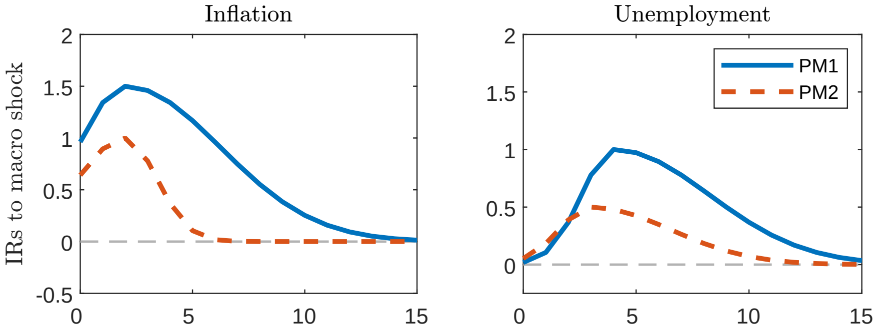
PM1 exposed to big oil shocks but small financial shocks

PM2 exposed to big financial shocks but small oil shocks

How to compare PM1 and PM2?

- **Insight**: both PMs were exposed to *some* oil shocks
- **Idea**: estimate average effect of oil shock under PM1 vs PM2
  $\rightarrow$ compare *Impulse Responses* to oil shocks, i.e. Γ
- **Possible evaluation**: assess which IRs are most "stable"

A less naive approach ...



- Equalizes the type of shocks and initial conditions

Still leaves open ...

- Policy makers face different environments ...
- pending environment it is easier/harder to offset shocks ...
- need to know what PM could have done given environment

$\Rightarrow$ this is given by $\mathcal{R}$, the IRs of Y to policy shock

$\Rightarrow$ changes in reaction to ξ can be traced out by $\mathcal{R}$

Putting two pieces together...

(i) Γ: what PM did on average

(ii) $\mathcal{R}$: what PM could have done

$\Rightarrow$ Allows to measure distance to optimal reaction function

- No need to know/estimate reaction function: only IRs needed
- Distance to optimal reaction is comparable across PMs

This paper ...

(i) Set-up

- Summarize all actions of PM in reaction function
- Aggregate economic variables Y in some loss function

(ii) Measure distance to optimal reaction to specific non-policy shocks

(iii) Compare policy makers (across time or space) based on distance to optimal reaction to same type of shock

(iv) Can compute that distance to optimality from **two sufficient statistics** : Γ, $\mathcal{R}$ — easy to estimate using existing literature

(v) Use this to evaluate US monetary policy over last 150 years

Some literature on policy evaluation

- Fair (1978) naive (unconditional) approach is not appropriate
- Blinder & Watson (2016) *project out* contribution of macro shocks
  $\rightarrow$ we emphasize the importance of examining performance *conditional on* same macro shocks
- Structural modeling approach: evaluate the reaction function in the context of a model
  (e.g. Gali & Gertler 2007 and many others)
- Estimate a policy rule and verify Taylor principle
  (e.g. Clarida, Gali, Gertler 1999, Bullard, 2022, and many others)

Limitation of earlier reaction fct evaluation

- Relies on (possibly mis-specified) model for non-policy block
- Relies on (possibly mis-specified) model for policy rule
  - "it is difficult to see how [...] algebraic policy rules could be sufficiently encompassing" **Taylor, 1993**
  - "Taylor-type rules are too restrictive and mechanical, not taking into account all relevant information, and the ability to handle the complex and changing situations faced by policy makers". **Svensson, 2017**
- Taylor principle ($\phi_\pi \lesseqgtr 1$) is a rough criterion

This talk

(i) Explain intuition in simple NK model

(ii) Generalize to any linear DSGE model

(iii) Evaluate US monetary policy over past 150 years

Simple illustration...

$$
\begin{aligned}
\pi_t &= \mathbb{E}_t \pi_{t+1} + \kappa x_t + \xi_t && \text{Phillips curve} \\
x_t &= \mathbb{E}_t x_{t+1} - \frac{1}{\sigma}(i_t - \mathrm{E}_t \pi_{t+1}) && \text{(IS) curve} \\
i_t &= \phi_\pi \pi_t + \phi_\xi \xi_t + \epsilon_t && \text{Policy rule}
\end{aligned}
$$

- Describe economy with
  - struct. parameters $\theta = (\kappa, \sigma)$
  - policy parameters $\phi = (\phi_\pi, \phi_\xi)$ and policy shock ϵ_t
  - non-policy shocks ξ_t
- Evaluation criteria / Loss function

$$\mathcal{L}_t = Y_t^{'} Y_t \quad \text{with} \quad Y_t = (\pi_t, x_t)'$$

Defining impulse responses

Given unique equilibrium, model solution gives

$$Y_t = \mathcal{R}\epsilon_t + \Gamma\xi_t \qquad \text{where} \qquad Y_t = (\pi_t, x_t)'$$

with

$$\mathcal{R} = \underbrace{\begin{bmatrix} \frac{-\kappa/\sigma}{1+\kappa\phi_\pi/\sigma} \\ \frac{-1/\sigma}{1+\kappa\phi_\pi/\sigma} \end{bmatrix}}_{\text{IR to policy shock}} \qquad \text{and} \qquad \Gamma = \underbrace{\begin{bmatrix} \frac{1-\kappa\phi_\xi/\sigma}{1+\kappa\phi_\pi/\sigma} \\ \frac{-\phi_\pi/\sigma-\phi_\xi/\sigma}{1+\kappa\phi_\pi/\sigma} \end{bmatrix}}_{\text{IR to non-policy shock}}$$

IRs as sufficient statistics for reaction function evaluation (1)

$$i_t = \phi_\pi \pi_t + \phi_\xi \xi_t + \epsilon_t \ ,$$

- Consider an adjustment $\phi_\xi \rightarrow \phi_\xi + \tau$:

$$i_t = \phi_\pi \pi_t + \phi_\xi \xi_t + \tau \xi_t + \epsilon_t$$

- Solving model gives

$$\begin{aligned} Y_t &= \mathcal{R}\epsilon_t + \Gamma \xi_t + \mathcal{R} \times \tau \xi_t \\ &= \mathcal{R}\epsilon_t + \left(\Gamma + \mathcal{R}\tau\right) \xi_t \end{aligned}$$

- That is

$$\Gamma \rightarrow \Gamma + \mathcal{R}\tau$$

IRs as sufficient statistics for reaction function evaluation (2)

- Look for optimal adjustment

$$\min_{\tau} \mathbb{E} Y_t^{'} Y_t \qquad \text{s.t.} \qquad Y_t = \mathcal{R}\epsilon_t + (\Gamma + \mathcal{R}\tau)\,\xi_t$$

- Or

$$\min_{\tau} (\Gamma + \mathcal{R}\tau)^{'} (\Gamma + \mathcal{R}\tau)$$

- Solution is Optimal Reaction Adjustment (ORA)

$$\tau^* = -(\mathcal{R}^{'}\mathcal{R})^{-1}\mathcal{R}^{'}\Gamma$$

Four observations

(i) To evaluate ϕ do not need to know ϕ
$\Rightarrow$ IRs encode effects of ϕ

(ii) At optimality $\tau^* = 0$ implying $\mathcal{R}'\Gamma = 0$
$\Rightarrow$ IR policy orthogonal IR non-policy

(iii) Solution $\tau^* = -(\mathcal{R}'\mathcal{R})^{-1}\mathcal{R}'\Gamma$
$\Rightarrow$ Regression in impulse response space

(iv) We have

$$(\phi_\pi, \phi_\xi + \tau^*) \in \Phi^{\text{opt}}$$

$\Rightarrow$ optimal response to ξ_t = optimal reaction function

Comparing policy makers across time and country

- Given two PMs in two different environments
  - PM1 with reaction fct ϕ_1 in economy θ_1 with $\{\xi_t\}_{t=t_1}^{T_1}$
    $\rightarrow$ Fed in the 1930s
  - PM2 with reaction fct ϕ_2 in economy θ_2 with $\{\xi_t\}_{t=t_2}^{T_2}$
    $\rightarrow$ Fed in the 2000s
- How to compare PM1(ϕ_1) and PM2(ϕ_2)?

  $\rightarrow$ Compare their ORAs to *same* non-policy shock: τ
- Requirements: $\mathcal{R}$ and Γ for each PM

Comparing PMs: Projection interpretation

(i) Project Y_t on sub-space spanned by common shock ξ_t

- Compare the IRs Γ: response to the *same* non-policy shock
- Avoid confounding from different shock histories
- **But** $\Gamma = \Gamma(\phi, \theta)$ with θ outside PM's control

(ii) What PM could have done to better stabilize Γ?

- Use

$$\Gamma \to \Gamma + \mathcal{R}\tau \qquad \text{or} \qquad \frac{\partial \Gamma}{\partial \tau} = \mathcal{R}$$

- Find and compare the distances τ^* to best stabilizing Γ

General dynamic framework

- Results hold for large class of linear DSGE models (LREM, VARMA, NK, HANK)
- Key difference is dynamics: policy becomes a *policy path*

Generic macro model

$$\begin{aligned} \mathcal{A}_{yy}\mathsf{Y} - \mathcal{A}_{yp}\mathsf{P} &= \mathcal{B}_{y\xi}\Xi \\ \mathcal{A}_{pp}\mathsf{P} - \mathcal{A}_{py}\mathsf{Y} &= \mathcal{B}_{p\xi}\Xi + \boldsymbol{\epsilon} \end{aligned}$$

- $\mathsf{P} = (p_0', p_1', \ldots)'$: path for policy instruments
- $\mathsf{Y} = (y_0', y_1', \ldots)'$: path for non-policy variables

- $\Xi = (\xi_0', \xi_1', \cdots)$ non-policy shocks
- $\boldsymbol{\epsilon} = (\epsilon_0', \epsilon_1', \ldots)'$ policy shocks

- Economic environment $\theta = \{\mathcal{A}_{yy}, \mathcal{A}_{yp}, \mathcal{B}_{y\xi}\}$
- Reaction function $\phi = \{\mathcal{A}_{pp}, \mathcal{A}_{py}, \mathcal{B}_{p\xi}\}$

Evaluation criterion

Loss function

$$\mathcal{L} = \frac{1}{2}\mathbb{E}\mathsf{Y}'\mathcal{W}\mathsf{Y}$$

Optimal reaction functions

$$\Phi^{\text{opt}} = \left\{ \phi : \phi \in \underset{\phi \in \Phi}{\arg\min}\, \mathcal{L} \quad \text{s.t} \quad \text{(model)} \;\; \text{with } \epsilon = 0 \right\}$$

Defining the IRs

Given unique equilibrium, model solution gives

$$\mathsf{Y} = \Gamma \Xi + \mathcal{R}\boldsymbol{\epsilon}$$

with

- Γ and $\mathcal{R}$ are now maps of IRs
- IRs depend on policy rule coefficients ϕ and environment θ

Optimal Reaction Adjustment

- As in simple model, consider reaction adjustment $\mathcal{T}$

$$\mathcal{A}^0_{pp}\mathsf{P} - \mathcal{A}^0_{py}\mathsf{Y} = (\mathcal{B}^0_{p\xi} + \mathcal{T})\Xi + \boldsymbol{\epsilon}$$

- Implies

$$\mathsf{Y} = (\Gamma + \mathcal{R}\mathcal{T})\Xi + \mathcal{R}\boldsymbol{\epsilon}$$

- Compute Optimal Reaction Adjustment (ORA)

$$\mathcal{T}^* = \arg\min_{\mathcal{T}} \mathcal{L} \qquad \text{s.t.} \quad \mathsf{Y} = (\Gamma + \mathcal{R}\mathcal{T})\Xi + \mathcal{R}\boldsymbol{\epsilon}$$

- Or

$$\mathcal{T}^* = -(\mathcal{R}'\mathcal{W}\mathcal{R})^{-1}\mathcal{R}'\mathcal{W}\Gamma$$

Properties

Proposition

Given the generic model, we have that $\phi^* \in \Phi^{\text{opt}}$ *where* $\phi^* = \{\mathcal{A}^0_{pp}, \mathcal{A}^0_{py}, \mathcal{B}^0_{p\xi} + \mathcal{T}^*\}$.

(i) $\mathcal{T}^*$ measures distance to optimal reaction function

(ii) Compare PM1 (ϕ_1, θ_1) and PM2 (ϕ_2, θ_2) with

$$\mathcal{T}^*(\phi_1, \theta_1) \quad \text{vs} \quad \mathcal{T}^*(\phi_2, \theta_2)$$

Role of news shocks ...

$\Xi = (\xi_0', \xi_1', \cdots)$ and $\boldsymbol{\epsilon} = (\epsilon_0', \epsilon_1', \ldots)'$ include future shocks

- Unless we "observe" future shocks Γ and $\mathcal{R}$ not identified
- We can decompose

$$\xi_t = \sum_{j=0}^{t} \underbrace{\mathbb{E}_j \xi_t - \mathbb{E}_{j-1} \xi_t}_{\xi_{t,j}} \qquad \text{and} \qquad \epsilon_t = \sum_{j=0}^{t} \underbrace{\mathbb{E}_j \epsilon_t - \mathbb{E}_{j-1} \epsilon_t}_{\epsilon_{t,j}}$$

- To identify Γ and $\mathcal{R}$ at $t = 0$ we need news shocks

$$\Xi_0 = \mathbb{E}_0 \Xi = (\xi_{0,0}', \xi_{0,1}', \cdots) \qquad \text{and} \qquad \boldsymbol{\epsilon}_0 = \mathbb{E}_0 \boldsymbol{\epsilon} = (\epsilon_{0,0}', \epsilon_{0,1}', \ldots)'$$

In practice: Subset ORA

- Not possible to identify all policy and non-policy news shocks
- But can compare PMs based on optimality distance of *specific* reaction coefficients
- For each PM, compute subset ORA

$$\mathcal{T}_{ab}^{*} = -(\mathcal{R}_a'\mathcal{W}\mathcal{R}_a)^{-1}\mathcal{R}_a'\mathcal{W}\Gamma_b$$

where

  - $\mathcal{R}_a^0$ is subset of IRs to policy shocks
  - Γ_b^0 is subset of IRs to non-policy shocks

Subset ORA: example

- "How good is contemporaneous response of fed funds rate to contemporaneous oil shock ξ?"

$$\tau^* = \phi_{\xi,0}^{\text{opt}} - \phi_{\xi,0} = -(\mathcal{R}_0'\mathcal{R}_0)^{-1}\mathcal{R}_0'\Gamma_0$$

  - $\mathcal{R}_0$: IR to contemporaneous monetary shock
  - Γ_0: IR to contemporaneous oil shock

- Compare PM1 and PM2 from subset ORAs τ^*

- IRs after ORA adjustment: $\Gamma_0 \to \Gamma_0 + \mathcal{R}_0\tau^*$

Some pros and cons

- (subset) ORA statistics are attractive for comparing PMs
  $\Rightarrow$ invariant to initial conditions, shock histories, environment
- Price to pay: no direct economic interpretation
- subset ORA statistics answer very specific question well
  $\Rightarrow$ specific policy in response to specific non-policy shock
- Does not speak to other instruments or shocks

ORA-based historical counterfactuals

- Adjusted IRFs

$$\Gamma_b + \mathcal{R}_a \tau^*_{ab}$$

- ORA-based historical decompositions

$$\Delta \mathsf{Y}_t = \mathcal{R}_a \mathcal{T}^*_{ab} \Xi_{b,t} \quad \text{and} \quad \Delta \mathsf{P}_t = \mathcal{R}_{p,a} \mathcal{T}^*_{ab} \Xi_{b,t}$$

- ORA-based adjusted loss

$$\Delta \mathcal{L}_t = (\Delta \mathsf{Y}_t)' \mathcal{W} (\Delta \mathsf{Y}_t)$$

$\Rightarrow$ none of these are invariant to θ, yet they are economically interesting

150 years of US monetary policy

- Evaluate US monetary policy over 1879-2019
- Loss function

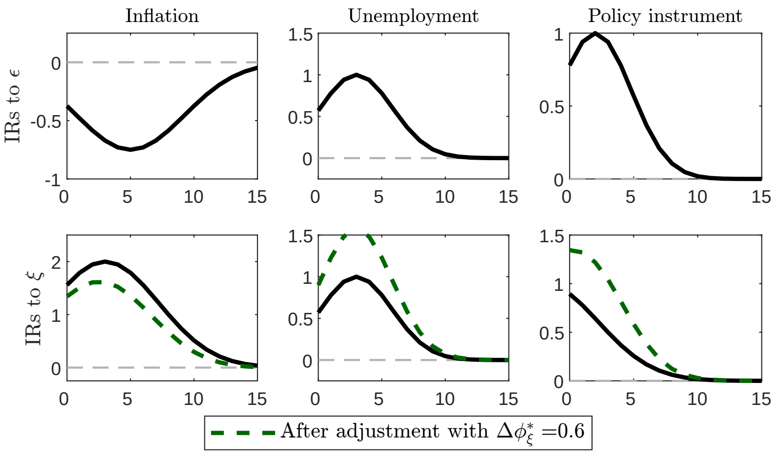
$$\mathcal{L}_t = \left\|\Pi_{t:t+H}\right\|^2 + \left\|U_{t:t+H}\right\|^2$$

  for $H = 30$

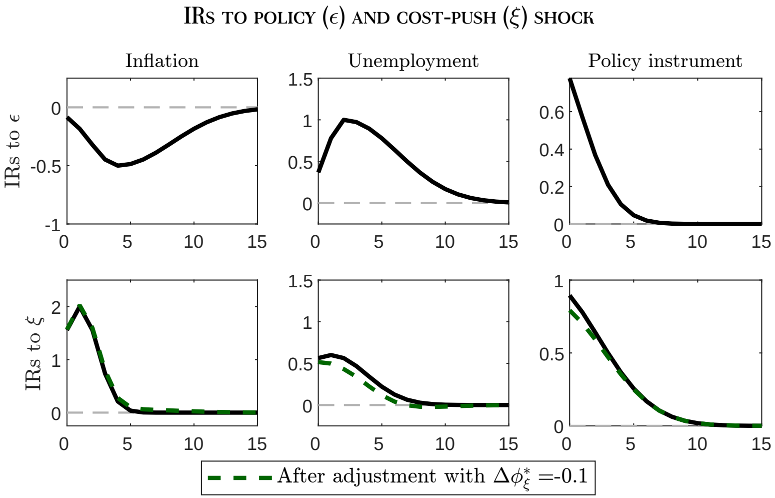
- Report:
  - ORA $\tau^* = -(\mathcal{R}_a'\mathcal{R}_a)^{-1}\mathcal{R}_a'\Gamma_b$
  - ORA-improved IRs: $\Gamma_b = \Gamma_b + \mathcal{R}_a\tau_{ab}^*$

Example: “bad” PM1

Figure: IRs to policy (ϵ) and cost-push (ξ) shock



Example: "good" PM2



Performance evaluation

- Evaluate performance using 5 distinct macro shocks
  (i) Financial shocks
  (ii) Government spending shocks
  (iii) Energy price shocks
  (iv) Inflation expectations shocks
  (v) TFP shocks

- ... over 4 distinct regimes
  (i) 1876-1912: Pre Fed
  (ii) 1915-1941: Early Fed
  (iii) 1951-1984: Post WW-II Fed
  (iv) 1990-2019: Post-Volcker Fed

Empirical challenge: IR estimation

- Bayesian VAR with $\left(z_t^{\xi}, z_t^{\epsilon}, \pi_t, u_t, p_t, w_t\right)$
- Estimate IRs to 6 distinct shocks
  (i) Monetary shocks
  (ii) 5 Non-policy shocks
- Estimate IRs over 4 distinct regimes
- Need to identify 24 shocks!
- **But** can draw on extensive macro-metrics literature (Ramey, 2016)

Identifying contemporaneous monetary shocks

- 1876-1912: Gold rush discoveries
- 1913-1941: Friedman-Schwartz (1963) narrative dates: 1920q1, 1931q3, 1933q1, 1937q1
- 1951-1984: Romer-Romer (2004)
- 1990-2019: High-frequency identification, FF4 (Gurkaynak et al, 2005)

$\Rightarrow$ Robustness checks in paper: sign restrictions and zero restrictions

Identifying macro shocks

- Government spending shocks: Ramey-Zubairy (2018)
- Financial shocks:
  - banking panics (Reinhart-Rogoff, 2009, Romer-Romer 2017)
  - innovations to BAA-AAA spread
- Energy shocks, inspired by Hamilton (2003)
  value by which energy price rises above its 3-year maximum or falls below its 3-year minimum
- TFP shocks: Gali (1999)
  long-run identification
- Inflation expectation shocks
  innovations to π^e, as measured by Livingston survey post WWII or by Cecchetti (1992) for pre WWII

Shocks convention

We consider *adverse* shocks

- Fin shock: raises u
- G shock lowers G: raises u
- Energy shock raises P^{energy}: raises π
- π^e shock raises π
- TFP shock lowers productivity: raises π

Results

Non-policy shock Shock sign convention	Bank panics $u\uparrow$	G $u\uparrow$	Energy $\pi\uparrow$	π^e $\pi\uparrow$	TFP $\pi\uparrow$
Pre Fed 1879–1912	−0.9* (−1.5,−0.3)	−0.6* (−1.3,0)	−0.1 (−0.5,0.4)	—	0.6 (−0.2,1.1)
Early Fed 1913–1941	−1.2* (−1.9,−0.8)	−0.5* (−0.9,−0.1)	0.0 (−0.3,0.3)	0.7* (0.3,1.0)	0.1 (−0.2,0.5)
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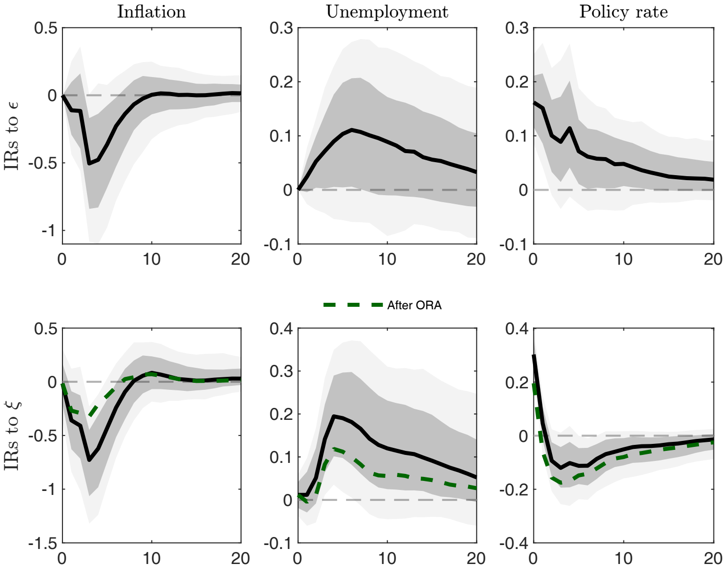
Reaction to financial shock, Pre Fed 1876-1912



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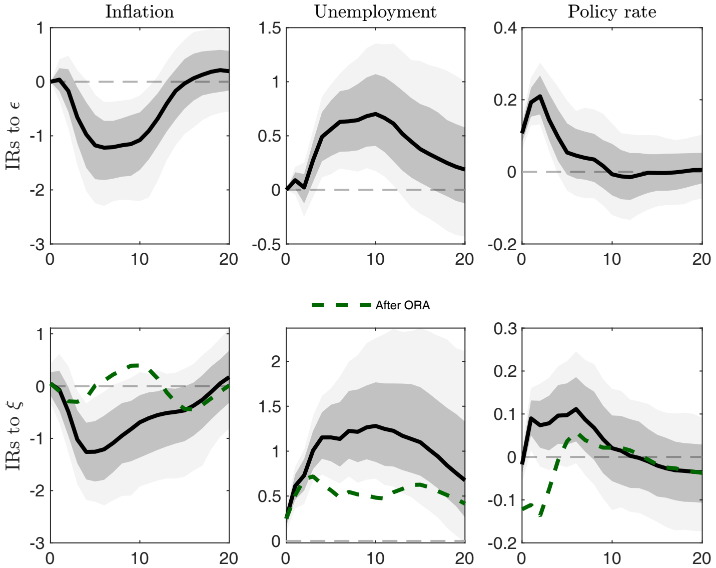
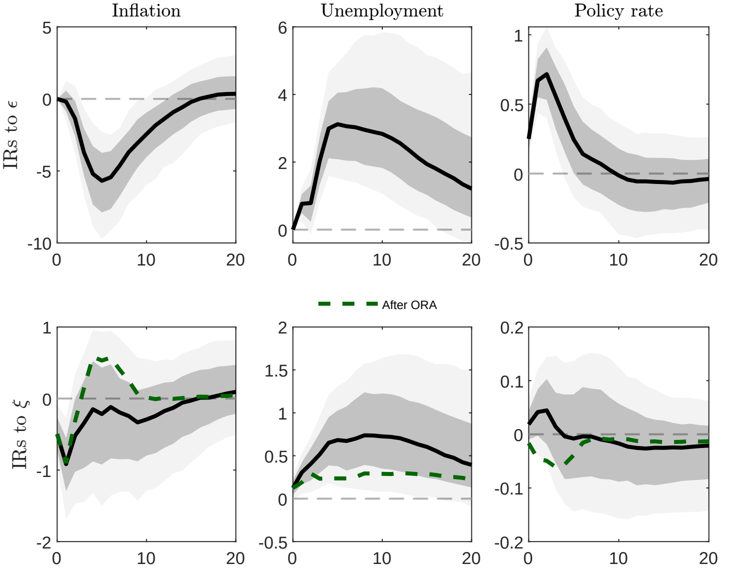
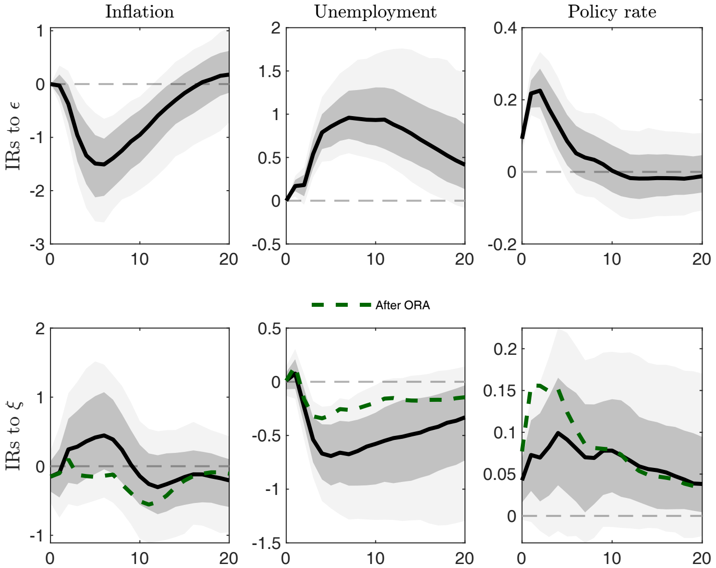
Reaction to financial shock, Early Fed 1915-1941



Reaction to G shock, Early Fed 1915-1941



Reaction to π^e shock, Early Fed 1915-1941



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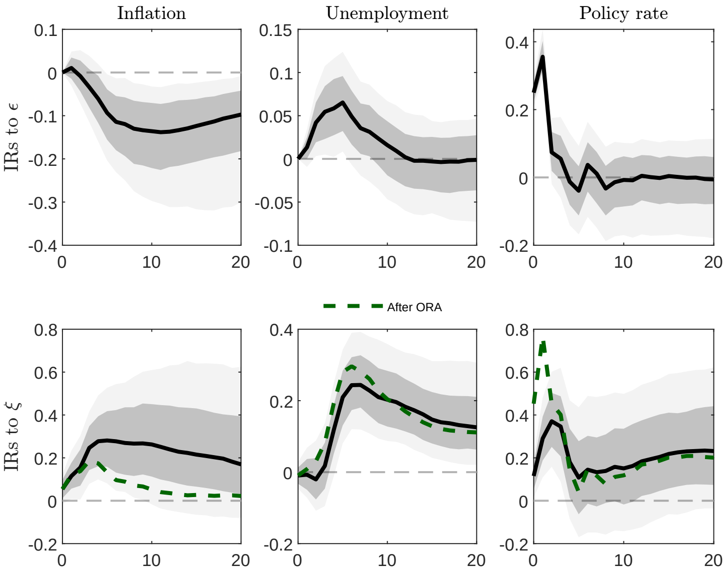
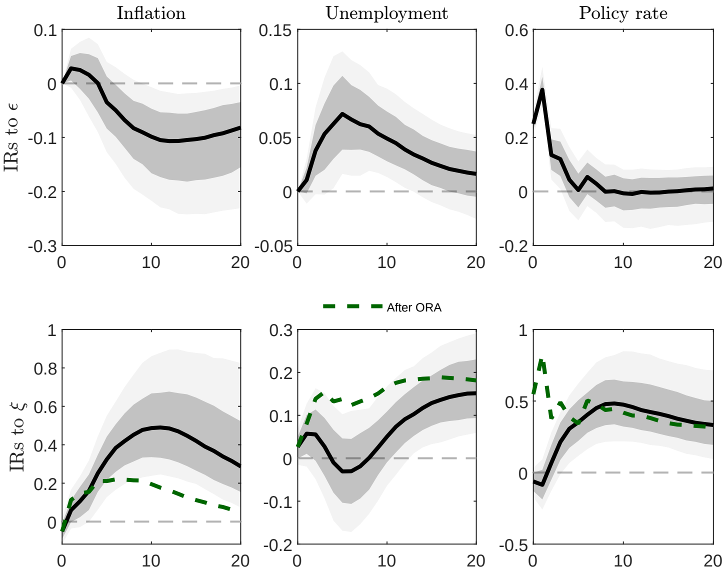
Early Fed 1913−1941	−1.2* (−1.9,−0.8)	−0.5* (−0.9,−0.1)	0.0 (−0.3,0.3)	0.7* (0.3,1.0)	0.1 (−0.2,0.5)
Post WWII 1951−1984	—	−0.2 (−0.8,0.3)	0.8* (0.1,1.4)	1.2* (0.6,1.8)	0.5 (−0.2,1.2)
Post Volcker 1990−2019	−0.1 (−0.5,0.5)	0.1 (−0.7,1.0)	0.2 (−0.5,1.1)	−0.1 (−0.4,0.4)	−0.1 (−0.6,0.2)

Reaction to energy price shock, Post WWII 1951-1984



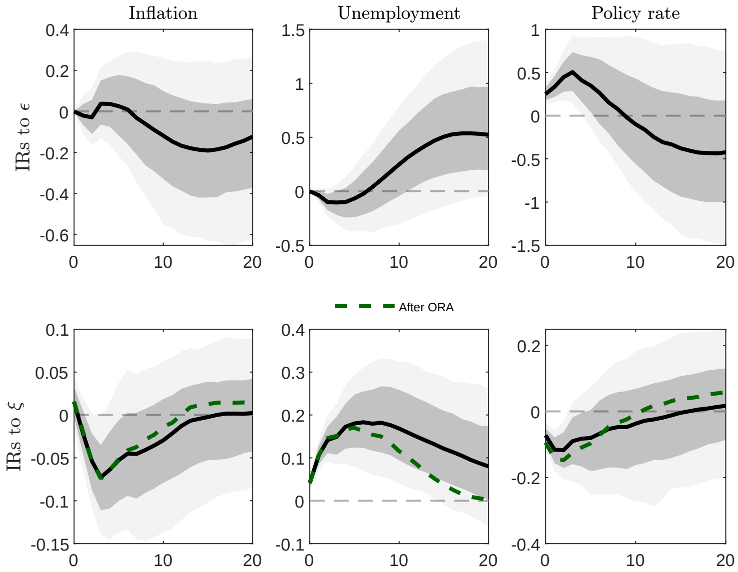
Reaction to π^e shock: Post WWII 1951-1984



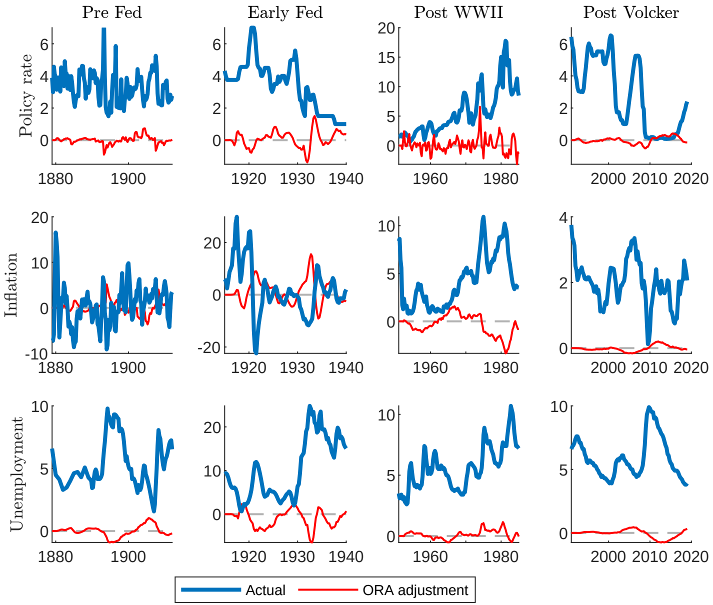
Results

Non-policy shock Shock sign convention	Bank panics $u \uparrow$	G $u \uparrow$	Energy $\pi \uparrow$	π^e $\pi \uparrow$	TFP $\pi \uparrow$
Pre Fed 1879−1912	-0.9^* (−1.5,−0.3)	-0.6^* (−1.3,0)	-0.1 (−0.5,0.4)	—	0.6 (−0.2,1.1)
Early Fed 1913−1941	-1.2^* (−1.9,−0.8)	-0.5^* (−0.9,−0.1)	0.0 (−0.3,0.3)	0.7^* (0.3,1.0)	0.1 (−0.2,0.5)
Post WWII 1951−1984	—	-0.2 (−0.8,0.3)	0.8^* (0.1,1.4)	1.2^* (0.6,1.8)	0.5 (−0.2,1.2)
Post Volcker 1990−2019	-0.1 (−0.5,0.5)	0.1 (−0.7,1.0)	0.2 (−0.5,1.1)	-0.1 (−0.4,0.4)	-0.1 (−0.6,0.2)

Reaction to financial shock: Post Volcker 1990-2019



ORA corrections over history



Results

(i) Performance during early Fed years on par with performance during Gold Standard

(ii) Overall, historical Fed response has been too passive all the way until the post Volker period

(iii) Big historical improvements in response to financial shocks

(iv) Pre Volcker, response to inflation is too timid across the board: after energy, π^e, TFP and even G shocks

Conclusion

- IRs are not only **portable identified moments** (Nakamura-Steinsson 2018) but also **sufficient** moments for many macro questions
- Here, ORAs are portable, identified and sufficient moments for PMs evaluation/comparison
- Policy evaluation/improvement in many other dimensions
  - macro stabilization: fiscal policy, exchange rate mgmt, foreign reserve mgmt
  - redistribution/efficiency: inequality reduction/long-run growth/climate change policy