The long-run effects of monetary policy

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Are there circumstances in which changes in aggregate demand can have an appreciable, persistent effect on aggregate supply?

— Chair Janet Yellen

question and methods

question:
monetary interventions $\rightarrow$ macro outcomes 10-12 years after

methods:

- **long panel + data:** 125 years, 17 countries, output (capital, labor)
- **monetary experiments:** trilemma
- **methods:** local projections instrumental variables
- **robustness:** exclusion restriction evaluation, structural breaks, alternate identifications, control for global business cycle, sample cuts

findings

panel data:

- large persistent effects with instrument + regression control for pegs
- mainly through capital (and TFP)

US quarterly data:

- moderate effects with an active policy rule
- Evans (1992) critique: utilization adjusted TFP caused by monetary shocks

medium scale DSGE NK model:

- hysteresis effects contingent on policy rule
- aggressive inflation stabilization / hysteresis correction does not generate appreciable persistent effects

outline

- panel LP-IV
  - data and instrument
  - main findings
  - robustness
- US LP-IV
- medium-scale DSGE model

data

annual 1890–2015 (excluding world wars) for 17 advanced economies

Jordà, Schularick & Taylor (2017)
www.macrohistory.net/data/
Interest rates, output, price level, investment, house prices, stock prices, consumption ...

Bergeaud, Cette & Lecat (2016)
www.longtermproductivity.com
hours worked, number of employees, capital stock (machines and buildings)...

trilemma: a quasi-natural experiment

theory of trilemma: peg + open to capital $\rightarrow$ asset returns equalization

instrument: base rate movements $\rightarrow$ home rate movements

local average treatment effect: (Jordà Schularick and Taylor 2019)

- identification for open pegs, not for floats or bases

instrument construction

some definitions: Jordà, Schularick and Taylor (2019, JME)

3 subpopulations: bases, pegs, floats

$q_{i,t} \in \{0, 1\}$ if peg in t and $t-1$

$k_{i,t} \in [0, 1]$ Quinn, Schindler, and Toyoda (2011), 1 is open

$z_{i,t} = k_{i,t}(\Delta r_{b(i,t),t} - \Delta \widehat{r}_{b(i,t),t})$ using $x_{b(i,t),t}$ controls

- *intervention:* $\Delta r_{i,t}$ 3-mo govt. bill
- *instrument:* $z_{i,t}$

first-stage iv evidence

$$\Delta r_{i,t} = a_i + z_{i,t}b + x_{i,t}g + \eta_{i,t}$$

pegs ($q = 1$)	All years	PreWW2	PostWW2
z	0.52^{***}	0.35^{**}	0.56^{***}
t-statistic	[8.62]	[2.05]	[8.97]
Obs	672	148	524

implementation details

x: 2 lags, variables in log differences $\times 100$, except interest rates and credit to GDP ratio

- log real GDP pc; log real C pc; log real I pc
- log CPI
- short-term (3m) + long-term (5y) govt. rates
- log real stock prices; log real house prices
- credit to GDP

annual sample: 17 advanced economies, yearly 1890-2015

local average treatment effect—late

panel local projections with **external** instruments: LP-IV

Under relevance, exogeneity and monotonicity, for pegs only, i.e., $q = 1$

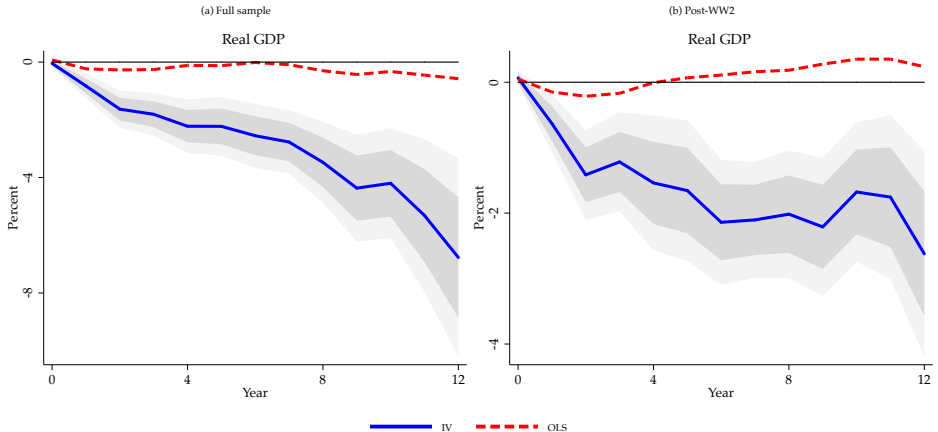
$$\begin{aligned} y_{i,t+h} - y_{i,t-1} &= \alpha_{i,h} + x_{i,t}\boldsymbol{\gamma}_h + \widehat{\Delta r}_{i,t}\beta_h + \nu_{i,t+h} \\ \Delta r_{i,t} &= a_i + x_{i,t}g + z_{i,t}b + \eta_{i,t} \\ h &= 0, \ldots, H-1 \end{aligned}$$

$$\mathcal{R}_{LATE} = E(y_1 - y_0 | \Delta r, x, z; q = 1) = \boldsymbol{\beta} = (\beta_0, \ldots, \beta_{H-1})'$$

why late?

LP-IV only valid for pegs, not bases or floats

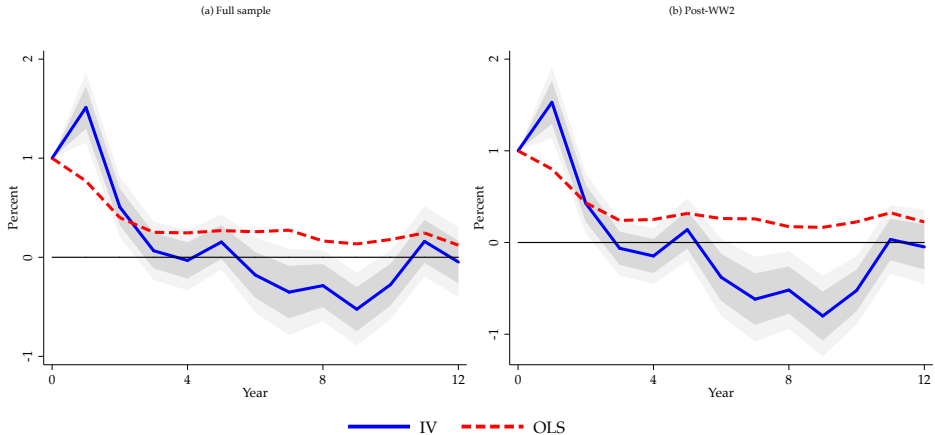
the long shadow



‡ confidence bands: 68% and 90%, cluster robust se

CPI

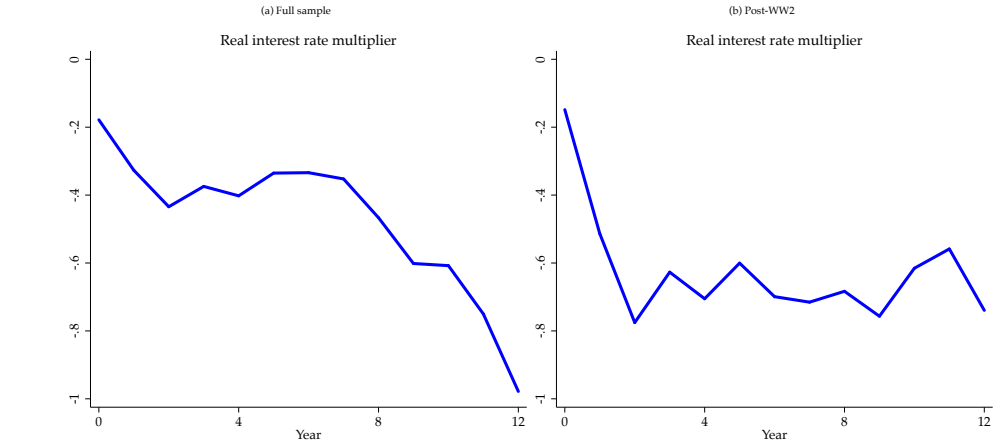
short term nominal interest rate



‡ confidence bands: 68% and 90%

dynamic multiplier

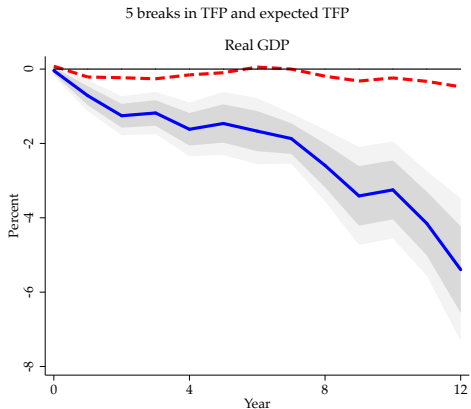
cumulative change in GDP to the area under the real interest rate path (fiscal multiplier: Ramey and Zubairy 2018)

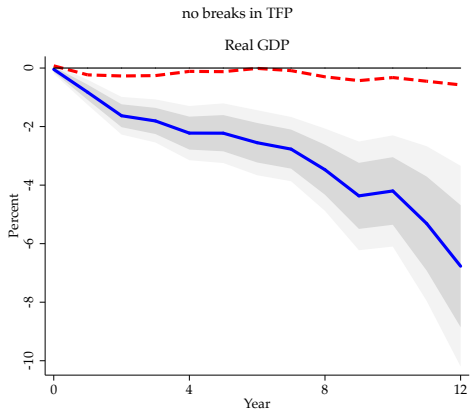


structural breaks in TFP

$$y_{i,t+h} - y_{i,t-1} = \alpha_{i,h} + \sum_{k-1}(D_{i,k,t} + D_{i,k,t+h}) + \widehat{\Delta r}_{i,t}\beta_h + \mathbf{x_{i,t}}\gamma_h + \nu_{i,t+h},$$

where $D_{i,k,t+h}$ is country-specific dummy for TFP growth regime k (Bai-Perron) at horizon $h = 0, ..., H-1$ and $k \in (1, 5)$

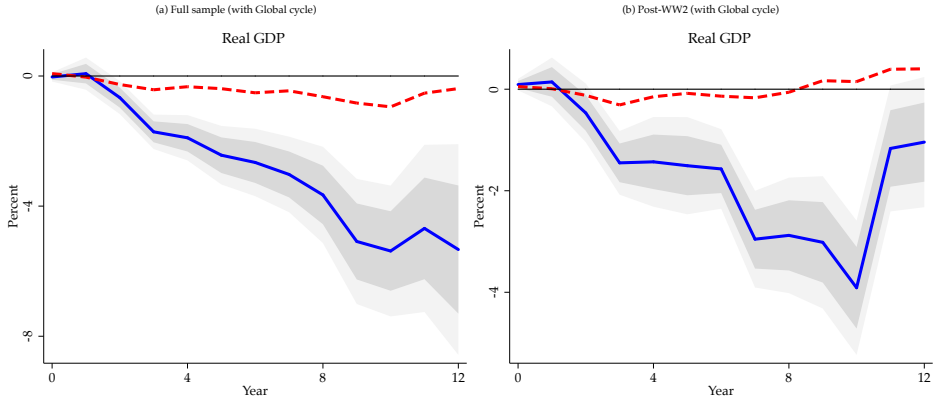




future global variables: exclusion restriction

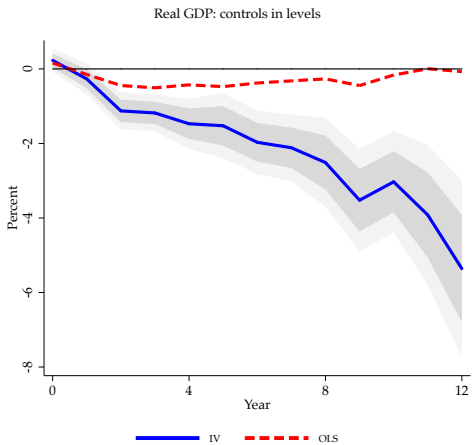
$$y_{i,t+h} - y_{i,t-1} = \alpha_{i,h} + \widehat{\Delta r}_{i,t}\beta_h + \mathbf{x_{i,t}}\gamma_\mathbf{h} + G_{t+h}\hat{\gamma}_h + \nu_{i,t+h}, \qquad \text{for } h = 0, ..., H-1$$

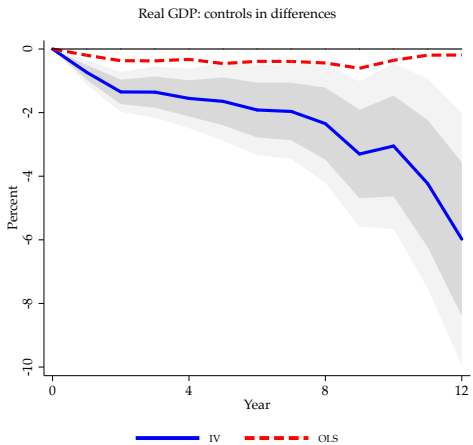
where G_{t+h} is global gdp growth at time $t+h$



controls in levels vs differences

control for variables in levels instead of differences





other robustness

- use GDP per capita
- exclude Great Recession
- (current and future) structural breaks in TFP, GDP, GDP per capita (Bai Perron 1998)
- exclusion restriction: spillover correction through synthetic control function (Conley, Hansen & Rossi 2012)
- 5 lags of control variables

VAR-p vs LP : detecting long-run effects

Under invertibility, MA(∞) and AR(∞) estimate the same

$$y_t = u_t + \theta_1 u_{t-1} + \theta u_{t-2} + ... \iff y_t = \Phi_1 y_{t-1} + \Phi_{t-2} y_{t-2} + ... + u_t$$

i.e.

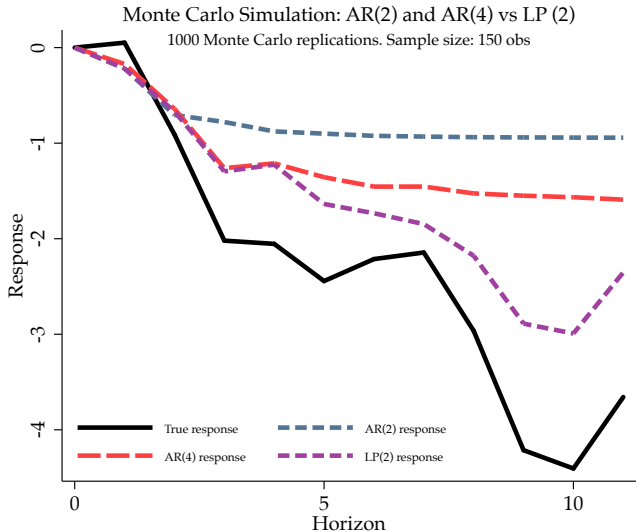
$$y_t = (1 + \theta_1 L + ...)(1 - \Phi_1 L - ...) y_t$$

In finite samples, estimate AR(∞) with AR(p) $\rightarrow$ MA terms beyond lag p based on the estimated p parameters

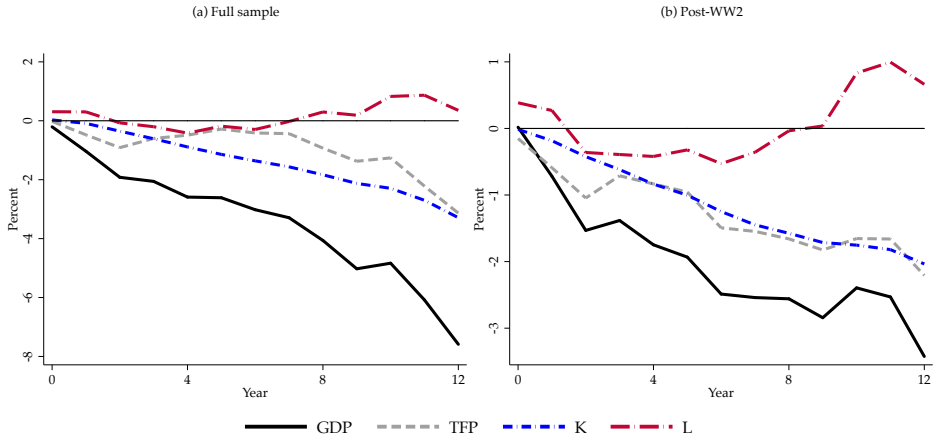
When # of lags p small, likely introduce bias.

LP-VVARs

Generate data using the estimated IRFs from a MA(12)



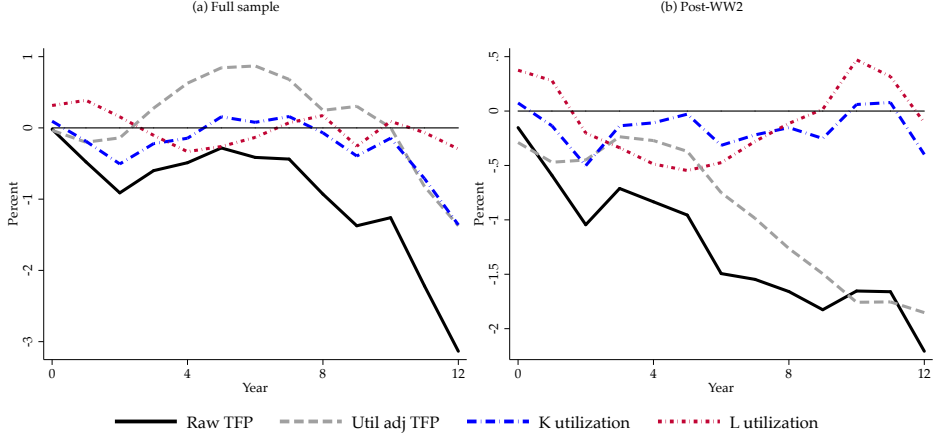
Solow decomposition



utilization adjustment

adjust for time-varying factor utilizations (Imbs 1999)

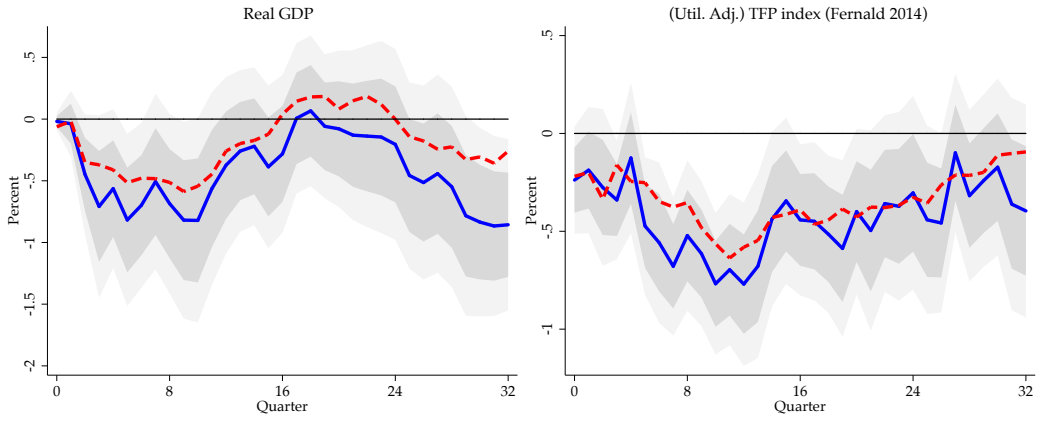
$$TFP_t \equiv \frac{Y_t}{K_t^{\alpha} L_t^{1-\alpha}} = A_t \times u_t^{\alpha} e_t^{1-\alpha}$$



LP-IV results for US

US: LP-IV + RR instruments

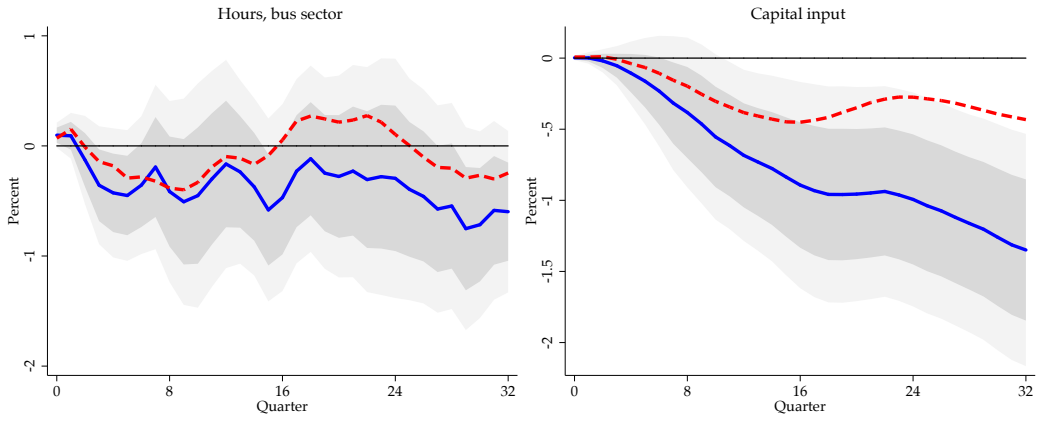
1969Q2: 2007Q4 + Romer & Romer (2004) forecast errors + Fernald (2014) util-adjusted TFP



‡ confidence bands: 68% and 90%

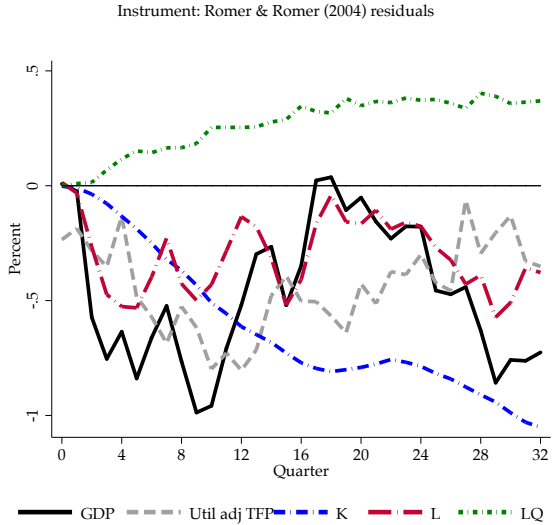
Evans (1992) critique

US: decomposition



‡ confidence bands: 68% and 90%

US: decomposition



taking stock

Panel LP-IVs

- use 125 years of data show persistent effects of monetary shocks
- persistently lower capital and TFP
- pass a variety of robustness exercises

LP-IVs and monetary policy shocks for US

- eight years out, lower output and capital stock
- Evans (1992) critique for quarterly utilization -adjusted TFP

medium scale DSGE model

medium-scale NK DSGE model

Christiano-Eichenbaum-Evans (2005), Smets-Wouters (2007)
+ hysteresis effects (Stadler 1990, Delong and Summers 2012)

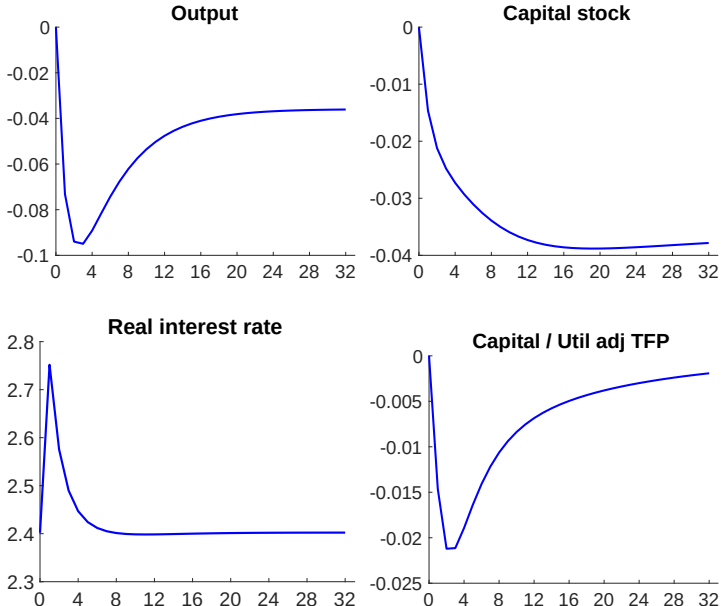
$$\log Z_t = \log Z_{t-1} + \mu_t + \eta \log\left(Y_{t-1}/Y_{t-1}^{f,t-1}\right)$$

microfoundations: Benigno & Fornaro (2018), Garga & Singh (2016)

η - hysteresis elasticity $\in (0.18, 0.48)$

	pegs (trilemma)		US (RR)
Data	1890-2015	1948-2015	1969Q2 - 2015Q4
η	0.18	0.42	0.48

standard Taylor rule



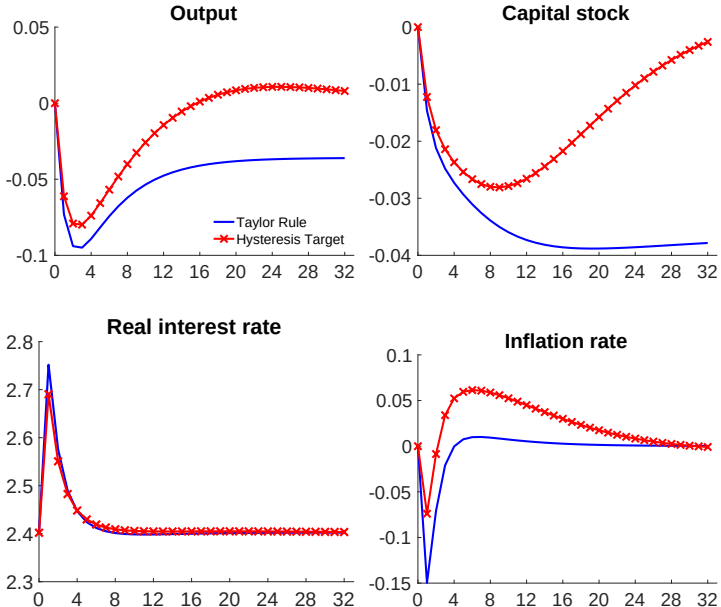
hysteresis-augmented Taylor rule

$$\frac{1+i_t}{1+i_{ss}} = \left(\frac{1+i_{t-1}}{1+i_{ss}}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi_{ss}}\right)^{\phi_\pi} \left(\frac{Y_t}{Y_t^{f,t}}\right)^{\phi_y} \left(\frac{H_t}{H_t^{f,t}}\right)^{\phi_H}\right]^{1-\rho_R} \left(\frac{Y_t/Y_{t-1}}{Y_t^{f,t}/Y_{t-1}^{f,t-1}}\right)^{\phi_{dy}} \epsilon_t^{mp}$$

where H_t is hysteresis and follows the law motion given by:

$$H_t = H_{t-1} + g_t - g_t^f$$

hysteresis-augmented Taylor rule



Policy Implications

Usual prescription of inflation stabilization works

- Nominal rigidities introduce usual inefficiency with long-run effects
- Hysteresis appears under constrained policy
  - Fixed exchange rates in the historical data
  - ZLB for advanced economies (Garga & Singh 2016)

Alternate tool: hysteresis correction works

- forward guidance tool
- If hysteresis elasticity η high enough, may approximate welfare gains under optimal policy

Summary

- use 125 years of data to investigate persistent effects
- identification with quasi-natural experiment (trilemma) + RR instrument
- Yellen's Q $\rightarrow$ constrained policy implies large persistent effects
- capital does not recover
- Evans (1992) critique for quarterly utilization -adjusted TFP
- model: aggressive inflation stabilization / hysteresis correction does not generate appreciable persistent effects

additional slides

home—base country links by era

Base country interest rate	Pre-WW1	Interwar	Bretton Woods	Post-BW
UK (Gold standard/BW base)	All countries		Sterling bloc: AUS*	
UK/USA/France composite (Gold standard base)		All countries		
USA (BW/Post-BW base)			All other countries	Dollar bloc: AUS, CAN, CHE, JPN, NOR
Germany (EMS/ERM/Eurozone base)				All other countries

* we treat AUS as moving to a dollar peg in 1967

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summary statistics

average peg: 21 years (note: gold + Bretton Woods)
Obstfeld and Rogoff (1995): 5yrs (developing countries)

pegs are more open than floats

average degree of capital openness: $\bar{k}$

all years		postWW2	
pegs ($q = 1$)	floats ($q = 0$)	pegs ($q = 1$)	floats ($q = 0$)
0.87	0.70	0.76	0.74
(0.21)	(0.31)	(0.24)	(0.30)

how often do countries switch exchange rate regime?

excluding wars

	1870–2013		1870–1939		1948–2015	
	Frequency	%	Frequency	%	Frequency	%
float to peg	19	2	6	3	13	2
no change	954	96	191	93	763	97
peg to float	19	2	8	4	11	1
Total	992	100	205	100	787	100

identification with external instruments

assumptions

relevance and exogeneity assumption:

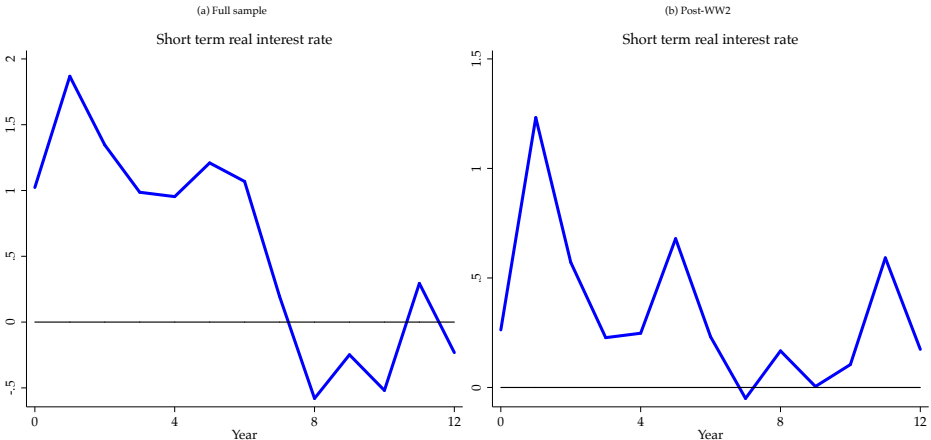
$$L(\Delta r|x,z;q=1) \neq L(\Delta|x;q=1) \qquad \text{relevance}$$
$$L(y_j|x,\Delta r,z;q=1) = L(y_j|x,\Delta r;q=1) \quad \text{for } j=0,1 \qquad \text{exogeneity}$$

$L(\Delta r|x,z)$ refers to linear projection of Δr on x and z

in IV identification depends on covariances only

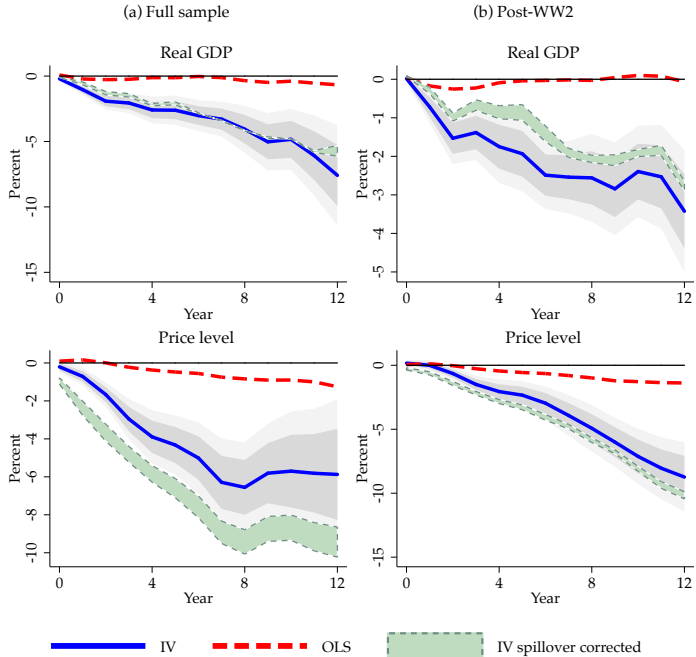
also need **monotonicity** for $z \to \Delta r$: $\frac{\partial E(\Delta r|x,z)}{\partial z} \geq 0$

persistence of the shock



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GDP and CPI



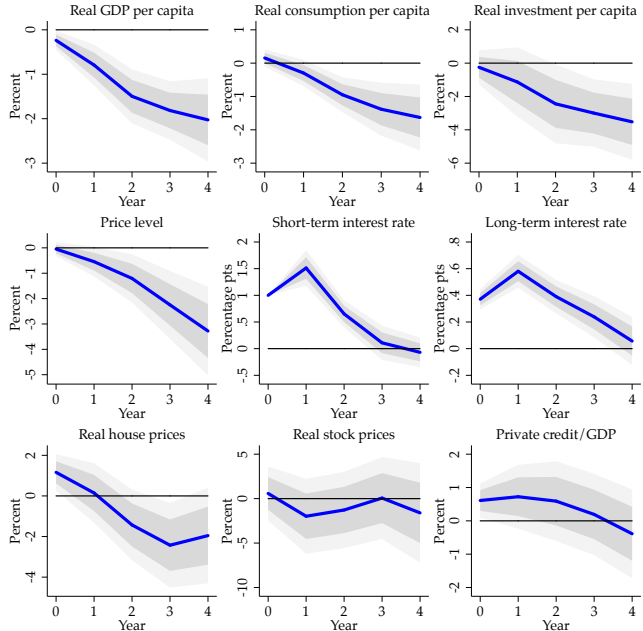
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Responses of real GDP at years 0 to 10 ($100 \times \log$ change from year 0 baseline).

	(a) Full Sample		*OLS-IV*	*(b) Post-WW2*		*OLS-IV*
Year	LP-OLS (1)	LP-IV (2)	*p-value* (3)	LP-OLS (4)	LP-IV (5)	*p-value* (6)
$h = 0$	0.08**	-0.04	0.18	0.05**	0.07	0.79
	(0.03)	(0.09)		(0.02)	(0.07)	
$h = 2$	-0.27	-1.63***	0.00	-0.21	-1.42***	0.00
	(0.16)	(0.39)		(0.13)	(0.42)	
$h = 4$	-0.11	-2.22***	0.00	-0.01	-1.54**	0.01
	(0.26)	(0.56)		(0.21)	(0.63)	
$h = 6$	-0.01	-2.55***	0.00	0.11	-2.14***	0.00
	(0.29)	(0.67)		(0.22)	(0.58)	
$h = 8$	-0.30	-3.47***	0.00	0.18	-2.02***	0.00
	(0.29)	(0.85)		(0.22)	(0.59)	
$h = 10$	-0.33	-4.20***	0.00	0.35	-1.68***	0.00
	(0.36)	(1.15)		(0.27)	(0.65)	
$h = 12$	-0.58	-6.77***	0.00	0.24	-2.62***	0.00
	(0.42)	(2.08)		(0.33)	(0.95)	
KP weak IV		68.34			69.18	
H_0: $LATE = 0$	0.00	0.00		0.00	0.00	
Observations	607	607		482	482	

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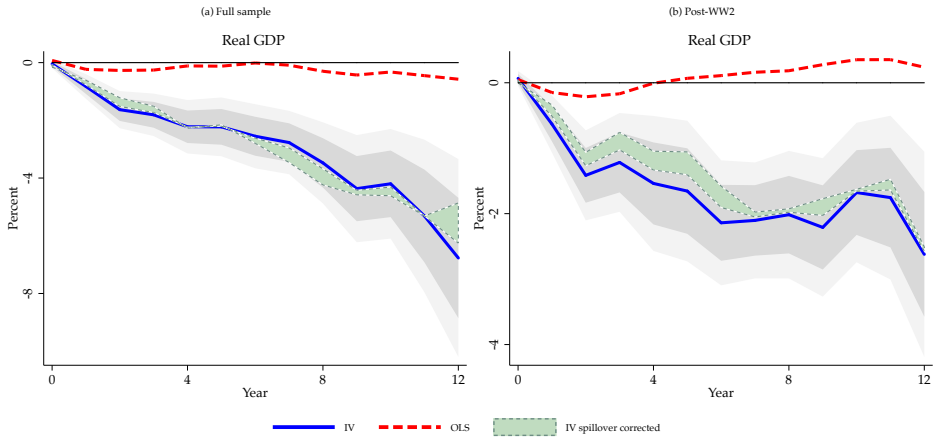
full set of IRFs



Back

synthetic control function: spillover correction

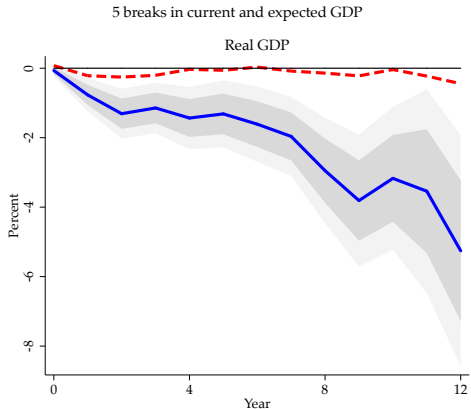
Conley, Hansen and Rossi (2012): “plausibly exogenous”

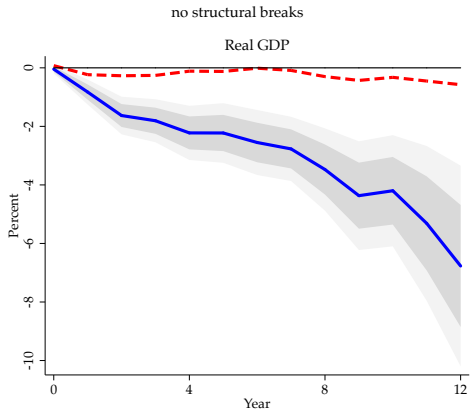


Structural Breaks in GDP

$$y_{i,t+h} = \alpha_{i,h} + \sum_{k-1}(D_{i,k,t} + D_{i,,k,t+h}) + \widehat{\Delta r}_{i,t}\beta_h + \mathbf{x_{i,t}}\gamma_h + \nu_{i,t+h},$$

where $D_{i,k,t+h}$ is country-specific dummy for GDP growth regime k at horizon $h = 0, ..., H-1$





utilization adjustment

Partial equilibrium model of factor hoarding (Imbs 1999)

$$Y_t = A_t \left(K_t u_t\right)^{\alpha} \left(L_t e_t\right)^{1-\alpha}; \quad \delta_t = \delta u_t^{\phi}; \quad \phi > 1$$

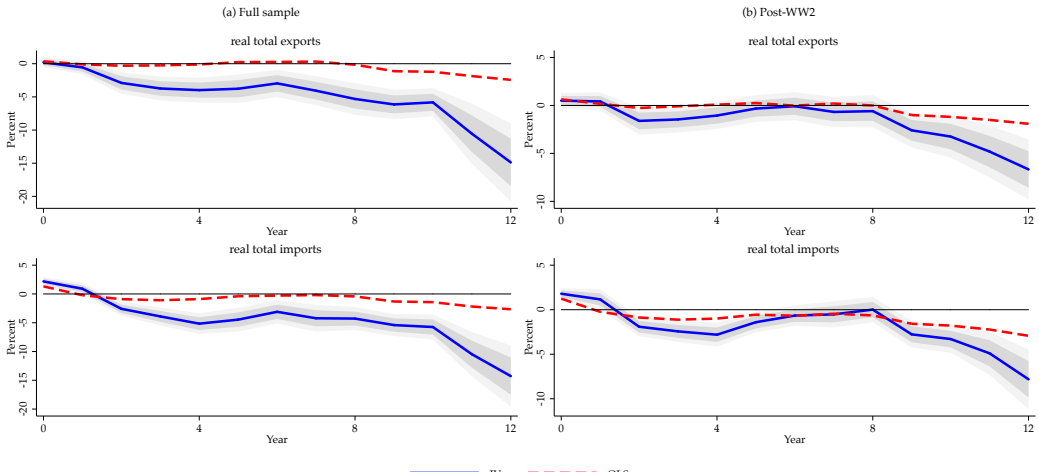
Firm: $\max_{e_t, u_t, K_t} A_t \left(K_t u_t\right)^{\alpha} \left(L_t e_t\right)^{1-\alpha} - w(e_t) L_t - (r_t + \delta u_t^{\phi})) K_t$

HH: $\max_{C_t, L_t, e_t} \sum_{t=0}^{\infty} \beta^t \left[\ln C_t - \chi \frac{\left(e_t L_t\right)^{1+\nu}}{1+\nu} \right]$ s.t. budget constraint

Reduces to a function of structural variables that can be measured directly (normalization: $\bar{e} = \bar{u} = 1$)

$$u_t = \left(\frac{Y_t / K_t}{Y / K} \right)^{\frac{\delta}{r+\delta}}; \quad e_t = \left(\frac{Y_t / C_t}{Y / C} \right)^{\frac{1}{1+\nu}} \frac{L}{L_t}$$

Trade


(a) Full sample
real total exports
Percent
0
-5
-10
-15
-20
0
4
8
12
Year
(b) Post-WW2
real total exports
Percent
5
0
-5
-10
0
4
8
12
Year
real total imports
Percent
5
0
-5
-10
-15
-20
0
4
8
12
Year
real total imports
Percent
5
0
-5
-10
0
4
8
12
Year
IV
OLS

quarterly data

1969Q2 - 2015Q4, US

Romer & Romer (2004) extended by Wieland & Yang (2016)
Johannes Wieland's webpage
Greenbook staff forecast errors

Fernald (2014)
Federal Reserve Bank of San Francisco
growth rate of output, capital, labor, labor quality, utilization adjusted TFP,...