The long-run effects of monetary policy

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Northwestern
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Motivation

A new worry for policymakers

Janet Yellen, Federal Reserve Chair, 2016:

"The first question I would like to pose concerns the distinction between aggregate supply and aggregate demand: **Are there circumstances in which changes in aggregate demand can have an appreciable, persistent effect on aggregate supply?** .... More research is needed, however, to better understand the influence of movements in aggregate demand on aggregate supply."

This paper

Outline of the paper

Question:

monetary interventions $\rightarrow$ macro outcomes 10-12 yrs after?

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Methods:

data:	historical panel, 115 years x 17 ; GDP, capital, labor, TFP
identification:	trilemma of international macroeconomics
method:	local projections instrumental variables (LP-IV)
robustness:	lots; focus on exclusion restriction evaluation
precedents:	check validity for US/UK

This paper

Outline of the key findings

Empirical

- large persistent effects of monetary shocks
- labor returns to pre-trend level, capital and TFP persistently lower
  - asymmetry: loosening shocks harmless, tightening shocks harmful

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Other monetary shocks

- US
  - Brunnermeier, Palia, Sastry, and Sims (2021, AER)
  - Miranda-Agrippino and Ricco (2021, AEJ Macro)
- UK
  - Cesa-Bianchi, Thwaites, and Vicondoa (2020, EER)

Outline of related literature

Identified responses to monetary shocks

- Romer & Romer (1989, 2004); **Bernanke & Mihov (1998); Christiano, Eichenbaum, & Evans (1999, 2005)**; di Giovanni, McCrary & von Wachter (2009), Cloyne & Hürtgen (2014); Tenreyro & Thwaites (2016); Ramey (2016); Coibion, Gorodnichenko, & Ulate (2017); **Jordà, Schularick, & Taylor (2019)**, ...

Hysteresis channels linking interest rates and potential output

- DeLong and Summers (2012); Anzoategui, Comin, Gertler, & Martinez (2019); Benigno & Fornaro (2018); Bianchi, Kung, & Morales (2019); Garga & Singh (2021); Guerron-Quintana & Jinnai (2019); Moran & Queraltó (2018); Fornaro & Wolf (2021)

Empirical evidence on persistent effects of transitory shocks

- crises: **Cerra & Saxena (2008)**; Fernald Hall Stock & Watson (2017); Fatás & Summers (2018); Galí (2016); Reifschneider, Wascher, & Wilcox (2015); Yagan (2019), Huckfeldt (2022)
- non-crises: Furlanetto, Lepetit, Robstad, Rubio-Ramirez & Ulvedal (2021), government spending: Ilzetzki (2021), Antolin-Diaz & Surico (2022), corporate taxes: Cloyne, Martinez, Mumtaz and Surico (2022), sixteenth century: Palma (2021)

This paper
Roadmap

1. **Identification**
2. **Empirics**
3. **Other Monetary Shocks**

Theory

Small open-economy New Keynesian model

Economies: Vary by exchange rate regime choice

- Home: small open economy, peg (hard) or float (MP=interest rate rule)
- Foreign: a large base country to which home pegs

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Households: Consume, save, and supply labor

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- real bond (d_t, in tradable units), interest R_t, home nominal bond (B_t), interest R_t^n

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Firms: Two sectors

- non-tradable sector (N) with one-period rigid prices (Obstfeld & Rogoff 1995)
- tradable good (T): endowment, obeys LOOP

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Government: **Key result will be equivalence of two policy scenarios**

- peg p: constant nominal exchange rate + shock to R_t^*
- benchmark b: interest rate rule $R_t^n = \bar{R}^n e^{\epsilon_t}$ (+ equilibrium selection)

Details

Theory

trilemma property via Euler equations

First-order conditions on home's demand for bonds:

$$\frac{1}{C_{Tt}} = \frac{\zeta}{C_{Tt+1}} R_t \qquad \text{(tradables-denominated real bond)} \tag{1}$$

$$\frac{1}{C_{Tt}} = \frac{\zeta}{C_{Tt+1}} \frac{R_t^n P_{Tt}}{P_{Tt+1}} \qquad \text{(home nominal bond)} \tag{2}$$

No arbitrage: $R_t = R_t^*$

$$\textbf{(1) + (2)} \; + \; \text{LOOP} \; (\; P_{Tt} = \mathcal{E}_t \, P_t^*) \quad \Longrightarrow \quad R_t^n = R_t \, \frac{P_{Tt+1}}{P_{Tt}} = R_t \, \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \, \frac{P_{t+1}^*}{P_t^*}$$

wlog, let $P^* = 1$ (rigid prices in foreign)

Theory

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(1) + (2) + LOOP ($P_{Tt} = \mathcal{E}_t P_t^*$) $\implies$ $R_t^n = R_t \frac{P_{Tt+1}}{P_{Tt}} = R_t \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \frac{P_{t+1}^*}{P_t^*}$

wlog, let $P^* = 1$ (rigid prices in foreign)

Trilemma result follows:

Under a peg, $\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} = 1 \implies R_t^n = R_t = R_t^*$

Shock to foreign interest rate transmits to home's nominal interest rate

Theory

identified response in an NK-NOEM

Assume constant aggregation weights in the construction of GDP.

let the (first-order) responses of interest be

- $\gamma_p \equiv \frac{dy_t^p}{dR_t^*}$ response to a unit base interest rate shock in peg
- $\beta \equiv \frac{dy_t^b}{d\epsilon_t}$ response to a unit domestic policy shock in benchmark

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Equivalence result follows:

$$\beta = \gamma_p$$

Effect on home GDP of shock to home policy rule (parameter of interest) same as effect on home GDP of shock foreign interest rate

Theory
extensions and robustness

- dirty floats / soft pegs (correlation < 1 but still identified)
- endogenous tradable goods
- modeling a feedback to producer inflation in domestic policy rule
- **spillovers (relax exclusion restriction)**

Theory

extension with trade spillovers

Consider export demand dependence on foreign interest rate

$$\hat{Y}_{Tt} = \alpha \hat{R}^*_t, \quad \alpha < 0$$

(e.g., Galí & Monacelli, 2016)

Theory

extension with trade spillovers

Consider export demand dependence on foreign interest rate

$$\hat{Y}_{Tt} = \alpha \hat{R}^*_t, \quad \alpha < 0$$

(e.g., Galí & Monacelli, 2016)

Then, **equivalence result holds with a correction term**:

$$\beta = \gamma_p - \alpha \left(\frac{P_T Y_T}{PY} + (1 - \zeta) \frac{P_N Y_N}{PY} \right)$$

Now: Effect on home GDP of shock to home policy rule (parameter of interest) equals effect on home GDP of shock foreign interest rate and a bias correction (to net out spillover contraction in base demand)

Identification

trilemma: a quasi-natural experiment

theory of trilemma: peg + open to capital $\rightarrow$ correlated interest rates
instrument construction: Jordà, Schularick and Taylor (2019, JME)
3 subpopulations: bases (b), pegs, floats

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

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

$$z_{j,t} = k_{j,t}(\Delta i_{b(j,t),t} - \Delta \widehat{i}_{b(j,t),t}) \quad \text{(base "pre-cleaned" using } x_{b(j,t),t} \text{ controls, à la RR)}$$

- *intervention:* $\Delta i_{j,t}$ short-rate proxy, 3-mo govt. bill
- *instrument:* $z_{j,t}$ trilemma IV (for $q_{j,t} = 1$; LATE)
- *outcomes:* home output and its components (at $t, t+1, ..., t+H$)

Details

Identification

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

assumption that instrument is valid, conditional on controls x (saturate)
relevance + monotonicity + exogeneity (pre-cleaned + "Fed ignores Argentina etc.")

$$\Delta i_{j,t} = a_j + x_{j,t}g + z_{j,t}b + \eta_{j,t} \rightarrow \widehat{\Delta i}_{j,t} \qquad \text{(first stage)}$$

$$y_{j,t+h} - y_{j,t-1} = \alpha_{j,h} + x_{j,t}\gamma_h + \widehat{\Delta i}_{j,t}\beta_h + \nu_{j,t+h} \qquad \text{(second stage LP)}$$

Identification

data: annual 1900–2015 (excluding world wars) for 17 advanced economies

Data requirement: long span of data for outcomes/controls and the IV

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

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

17 advanced economies in our sample:
Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, U.K., and U.S.

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

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

strong first-stage: the instrument is relevant and not weak

- *intervention:* $\Delta i_{j,t}$ 3-mo govt. bill
- *instrument:* $z_{j,t}$ trilemma IV

First Stage: $\Delta i_{j,t} = a_j + z_{j,t} b + x_{j,t} g + \eta_{j,t}$

	pegs ($q = 1$)	
	All years	PostWW2
b	0.59***	0.61***
t-statistic	[9.47]	[9.02]

coefficients ≈ Obstfeld, Shambaugh & Taylor (2005)

Identification

what are the controls?

implementation details on choice of x:

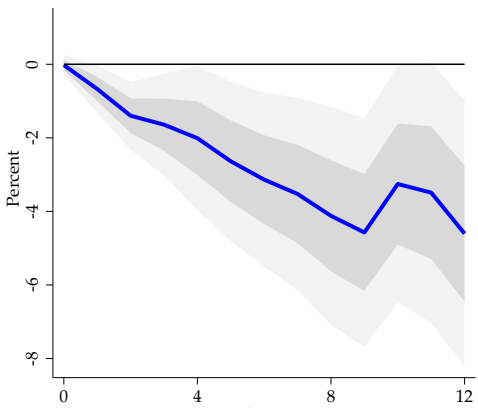
- log real GDP; log real C; log real I
- log CPI
- short-term (3m) + long-term (5y) govt. rates
- log real stock prices; log real house prices
- credit to GDP
- log real global GDP: common global shocks
- log real base-country GDP: trade linkages

lags:	2
transformations:	log differences $\times$ 100 (except interest rates and credit to GDP ratio)
sample:	1900–2015, 17 advanced economies, annual frequency

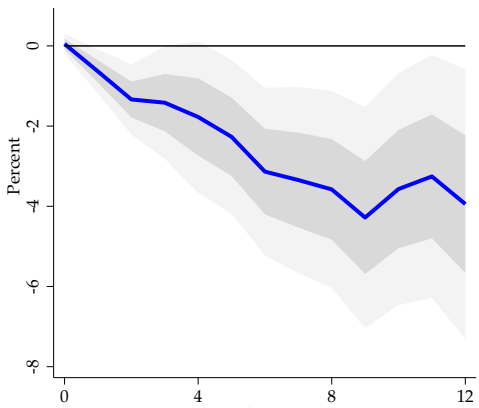
Empirics

baseline result: real GDP — the long shadow

(a) Full sample: 1900–2015



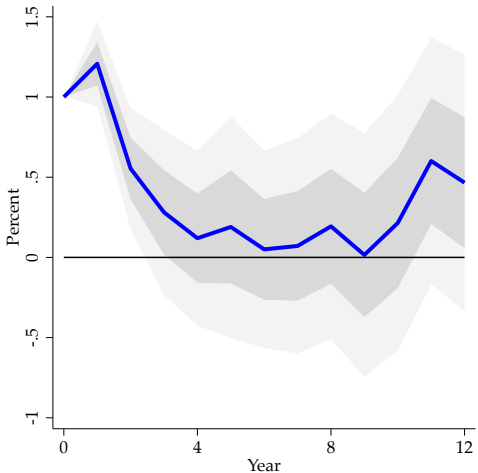
(b) Post-WW2 sample: 1948–2015



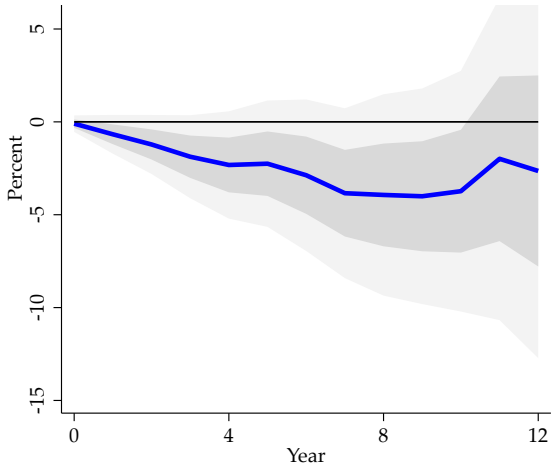
† confidence bands: 68% and 95% Driscoll & Kraay (1998) standard errors

short term nominal interest rate and CPI

(a) Short term nominal rate



(b) CPI



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Empirics

spillover: exclusion restriction violation

If the instrument $z_{j,t}$ affects the outcome through other channels θ

$$y_{j,t+h} - y_{j,t} = \alpha_{j,h} + x_{j,t}\gamma_h + \widehat{\Delta i}_{j,t}\beta_h + z_{j,t}\theta + \nu_{j,t+h}$$

- e.g. a recession in base reduces demand for home exports

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- e.g. a recession in base reduces demand for home exports

Spillover correction:

Employ a **control function approach**, by using a NK open economy model to get a bound:

$$\theta = \underbrace{\begin{array}{c}\text{share of exported tradables} \\ \text{in home output}\end{array}}_{\text{calibrate: } \Phi \in [0,\ 0.3]} \times \underbrace{\begin{array}{c}\text{responsiveness of exported} \\ \text{tradable demand to base interest rate}\end{array}}_{\text{assumption: upper bound } = \beta_h}$$

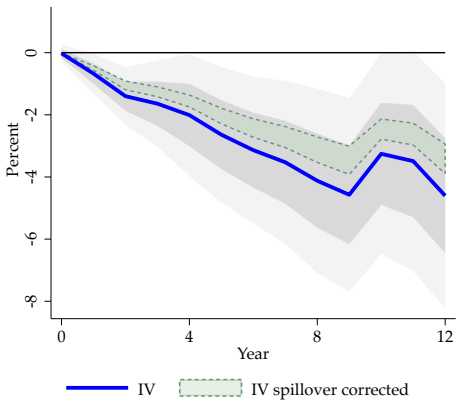
$\rightarrow$ Estimate an augmented LP :

$$y_{j,t+h} - y_{j,t} = \alpha_{j,h} + +x_{j,t}\gamma_h + \left(\widehat{\Delta i}_{j,t} + \Phi z_{j,t}\right)\beta_h + \nu_{j,t+h}$$

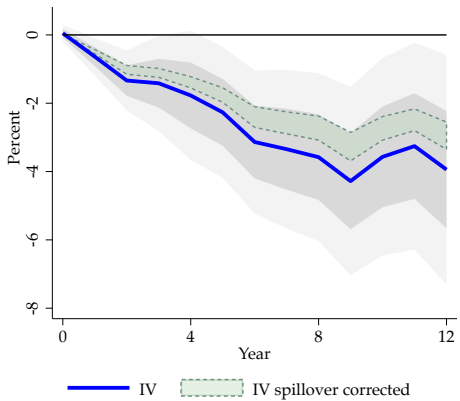
Empirics

model-based spillover correction

(a) Real GDP: 1900–2015



(b) Real GDP: 1948–2015



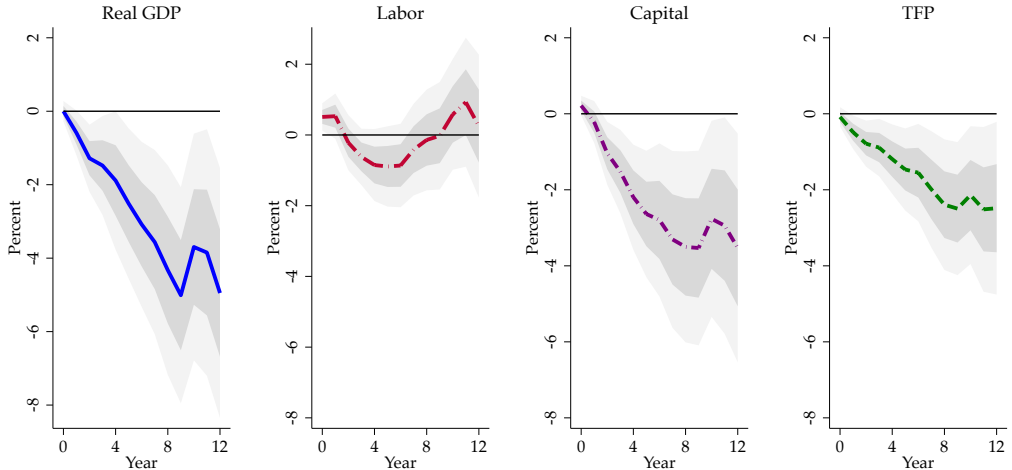
Empirics
robustness checks

For the baseline GDP result:

- do model-implied spillover correction
- structural breaks in growth of TFP, GDP, GDP per capita (Bai & Perron, 1998)
- control for the global business cycle with global GDP
- control forbase country spillovers with base GDP
- other exclusion restriction violations:
  current account, exchange rate with respect to float
- other: 5 lags of control variables, control variables in levels

Empirics

inspecting the mechanism – LPs for the Solow decomposition



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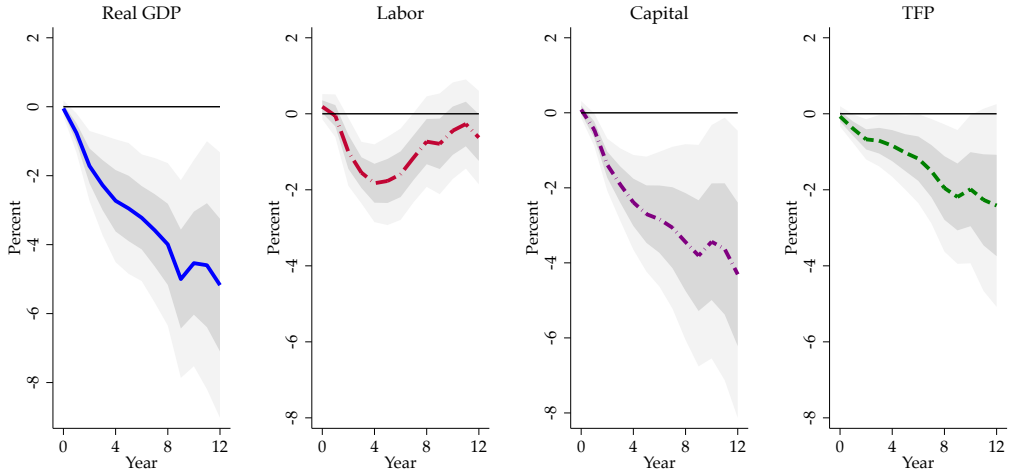
Empirics

asymmetric responses, contractionary shocks



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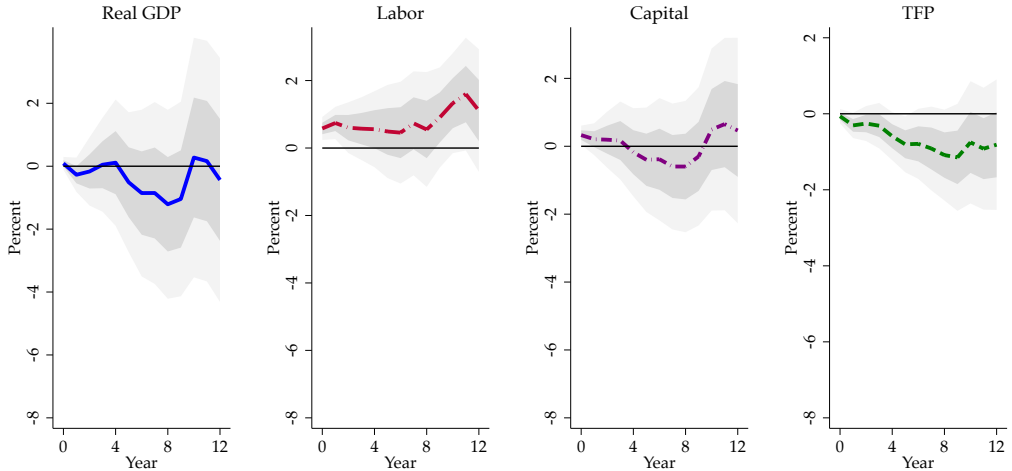
Empirics

asymmetric responses, expansionary shocks



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Other Monetary Shocks: US Economy

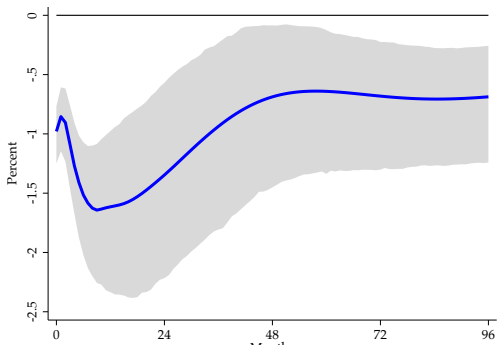
Extend replication code of published studies to 8-year horizon

1. Miranda-Agrippino and Ricco (2021 AEJ Macro, 2023 JME)
   - high-frequency surprises around FOMC announcements + Greenbook forecasts
   - monthly Bayesian proxy-VAR(12)
   - Sample 1979:1– 2014:12
2. Brunnermeier, Palia, Sastry, and Sims (2021, AER)
   - identification by heteroskedasticity (Rigobon 2003)
   - ten-variable monthly Bayesian SVAR(10) model
   - Sample 1973:1–2015:6

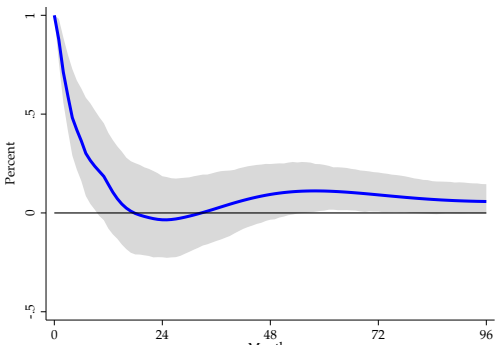
Miranda-Agrippino and Ricco (2021, AEJ Macro)

Extend replication code of published studies to 8-year horizon

(a) Industrial Production



(b) One-year T-bond



Shaded areas denote 90% posterior coverage bands in panels (a) and (b).

Brunnermeier, Palia, Sastry, and Sims (2021, AER)

Extend replication code of published studies to 8-year horizon

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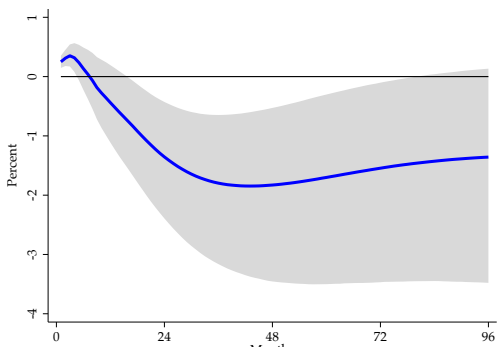
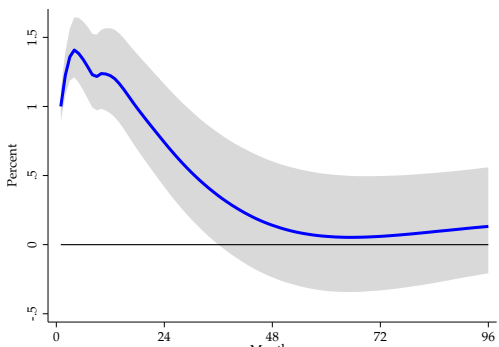


(b) Fed Funds Rate



Shaded areas denote 90% posterior coverage bands in panels (a) and (b).

Other Monetary Shocks: UK Economy

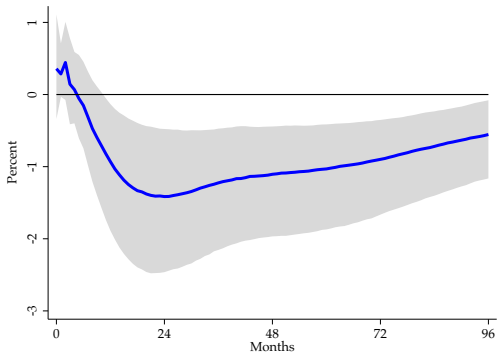
Extend replication code of published studies to 8-year horizon

1. Cesa-Bianchi, Thwaites, and Vicondoa (2020, EER)
   - series of monetary policy surprises for the UK using intra-day three-month Sterling futures data
   - monthly proxy SVAR(4)
   - Sample 1992:1–2015:1

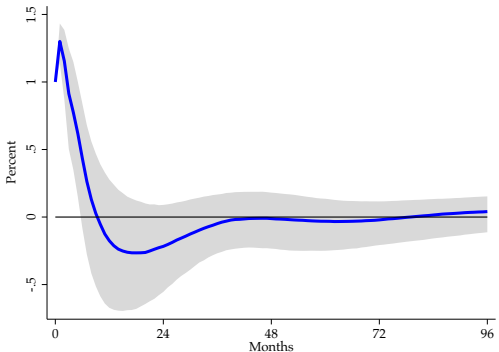
Cesa-Bianchi, Thwaites, and Vicondoa (2020, EER)

Extend replication code of published studies to 8-year horizon

(a) Monthly estimate of GDP



(b) One-year Gilt Rate



Shaded areas denote 68% confidence intervals computed using moving block bootstrap with 5,000 replications.

Conclusion: Pushing on a long string?

long-run money neutrality may not hold

- a monetary tightening shock:
  - causes output to decline over a long period of time
  - because it causes the capital stock and TFP to decline

evidence based on

- small-open economy NK model to formalize identification
- LP-IV estimation using universe of available historical data
- various robustness exercises and alternative identification schemes

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additional slides

Households

$$\max_{\{C_t, l_t, B_{t+1}\}} \sum_{t=0}^{\infty} \zeta^t \left[\log(C_t) - \varphi \frac{l_t^{1+\nu}}{1+\nu} \right]$$

subject to

$$P_{Tt} C_{Tt} + P_{Nt} C_{Nt} + P_{Tt} d_t + B_t = W_t l_t + P_{Tt} Y_{Tt} + P_{Tt} \frac{d_{t+1}}{R_t} + \frac{B_{t+1}}{R_t^n} + T_t + Z_t$$

$$C_t = \left(\frac{C_{Tt}}{\omega} \right)^{\omega} \left(\frac{C_{Nt}}{1-\omega} \right)^{1-\omega}$$

ζ is the discount factor, ν is the (inverse) Frisch elasticity of labor supply, and φ is a scaling parameter, C_{Tt} is tradable good, C_{Nt} is non-tradable good, and $\omega \in (0,1)$ is the tradable share

Production of non-tradables

A Dixit-Stiglitz aggregate over a continuum of products

$$C_{Nt} \equiv \left(\int_0^1 C_{Nt}(i)^{(\epsilon_p - 1)/\epsilon_p} di \right)^{\epsilon_p/(\epsilon_p - 1)}$$

where $\epsilon_p > 1$ is the elasticity of substitution.

Each monopolistically competitive firm has identical technology

$$Y_{Nt}(i) = L_{Nt}(i)$$

Prices are set one-period in advance as in Obstfeld and Rogoff (1995).

Policy and Market Clearing

Monetary Policy Rule in

1. the Benchmark Economy:

$$R_t^n = \bar{R}^n e^{\epsilon_t}; \quad (+ \text{ equilibrium selection})$$

2. the Peg economy

$$\mathcal{E}_t = 1$$

Non-tradable goods and labor:

$$l_t = L_{Nt} = Y_{Nt} = C_{Nt}$$

External budget constraint:

$$C_{Tt} + d_t = Y_{Tt} + \frac{d_{t+1}}{R_t}$$

Assume constant weights on GDP aggregator

Equilibrium

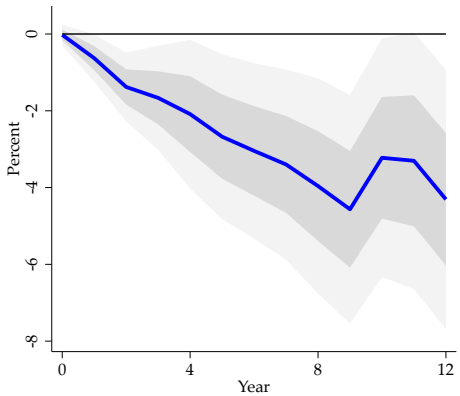
- Analyze the economy starting at a deterministic steady state indexed by d_1.
- One-time unanticipated shock
  1. to a domestic policy rule in the benchmark economy configuration
  2. to a large economy interest rate in the peg economy configuration

Details

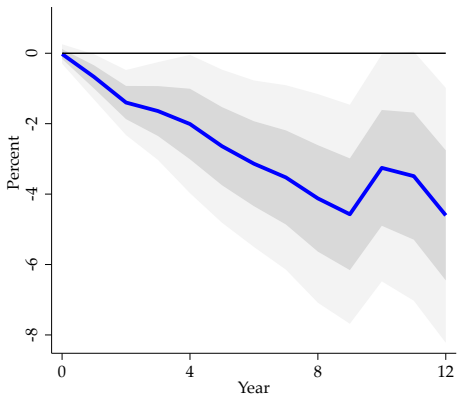
open economy variables: exclusion restriction

control for (i) base country GDP, (ii) global GDP, (iii) own current account and (iv) exchange rate wrt USD

(a) "Open economy" controls



(b) Baseline IRF of real GDP



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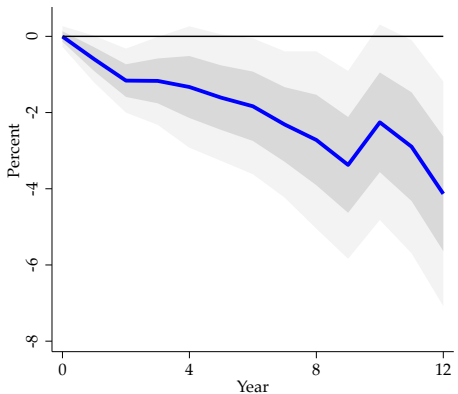
IRFs of real GDP: structural breaks in TFP

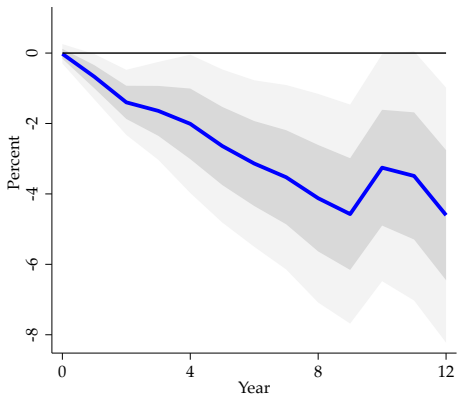
Fernald, 2007, 2014; Gordon 2016

Allow intercept to be regime-dependent based on Bai & Perron (1998)

(a) Structural breaks in TFP growth



(b) Baseline IRF of real GDP



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