The long-run effects of monetary policy

Òscar Jordà [*] Sanjay R. Singh [‡] Alan M. Taylor [§]

[*] Federal Reserve Bank of San Francisco; University of California, Davis

[‡] University of California, Davis

[§] University of California, Davis; NBER; CEPR

old question, new methods

QUESTION:

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

old question, new methods

QUESTION:

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

METHODS:

long panel: 125 yrs, 17 countries, output (capital, labor, TFP)

instrument: international finance trilemma

methods: local projections instrumental variables (LPIV)

robustness:

- exclusion restriction evaluation
- structural breaks
- control for global business cycle

takeaways

key findings:

- large persistent effects of monetary policy

takeaways

key findings:

- large persistent effects of monetary policy
- where do these persistent effects come from?
  - capital and TFP persistently lower
  - labor returns to pre-trend level

reconciling new facts in a DSGE model:

- embed reduced-form hysteresis $\rightarrow$ hysteresis elasticity estimate

evidence against long-run money neutrality

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 $\rightarrow$ correlated interest rates

instrument construction: Jordà, Schularick and Taylor (2019, JME)

3 subpopulations: bases, pegs, floats

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

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

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

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

Details

In the paper: identification with a small open economy model

strong first-stage: the instrument is relevant

- *intervention:* $\Delta i_{j,t}$ 3-mo govt. bill
- *instrument:* $z_{j,t}$: relevant and not weak

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	0.58***	0.61***
t-statistic	[7.56]	[8.30]

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

relevance + exogeneity + monotonicity + $q = 1$

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

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

what else is on the right hand side?

implementation details

- 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

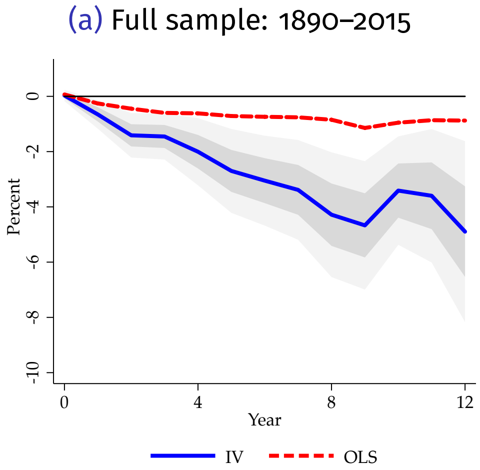
transformations: log differences $\times$ 100
(except interest rates and credit to GDP ratio)

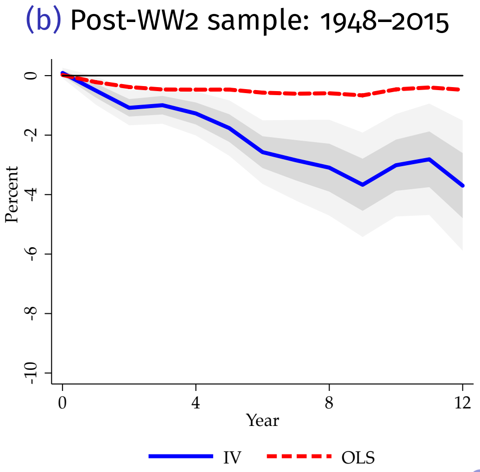
sample: 1890-2015, 17 advanced economies

frequency: annual

baseline result: real GDP

the long shadow

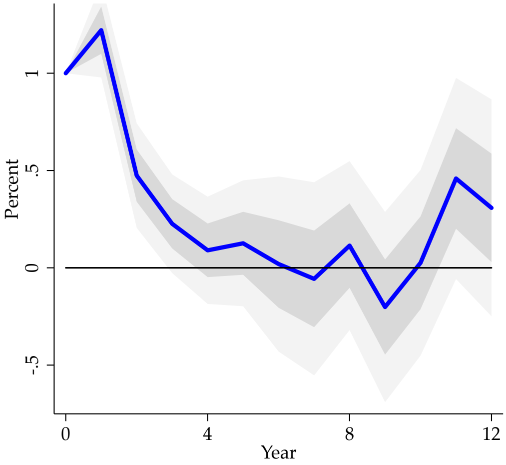




† confidence bands: 1 se and 2 se, cluster robust

CPI

short term nominal interest rate



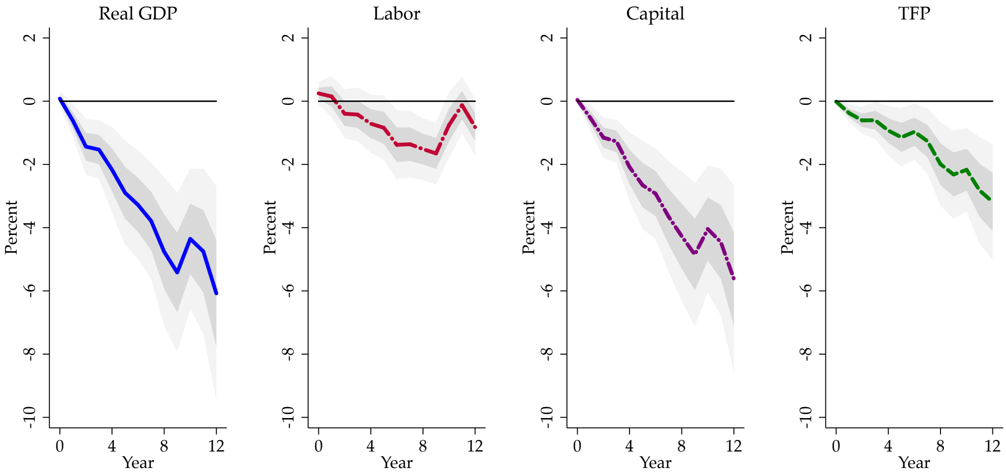
† confidence bands: 1 se and 2 se, cluster robust, sample: 1890–2015

robustness checks: a long list

- do model-implied spillover correction
- use GDP per capita, exclude Great Recession
- current (and future) structural breaks in growth of TFP, GDP, GDP per capita (Bai & Perron, 1998)
- correcting for the global business cycle with global GDP
- correcting for base 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

Spillover Correction | GDP per capita | Levels | Open Economy Controls | Breaks in TFP | Breaks in GDP | Full Set

Solow decomposition



† confidence bands: 1 se and 2 se, cluster robust, sample: 1890–2015

Imbs

taking stock

- monetary policy has persistent effects on output
- this finding survives a variety of robustness checks
- after a monetary shock:
  - capital and TFP decline
  - but hours worked returns to pre-trend

next

- How do we reconcile these new facts?

embed hysteresis effects in a reduced form/ accounting sense

- many micro-founded models that give similar/exact equation: Anzoategui, Comin, Gertler & Martinez (2019), Benigno & Fornaro (2018), Bianchi, Kung & Morales (2019), Garga & Singh (2020)
- no micro level data to test or discriminate among mechanisms (yet)
- reduced form enough to explore macro implications
- identify a moment that quantitative models need to match
- implications for policy rules

medium-scale NK DSGE model

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

a simple extension: η the hysteresis elasticity

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

microfoundations: Anzoategui et al (2019), Benigno & Fornaro (2018), Bianchi Kung & Morales (2019), Garga & Singh (2016)

the key moment to match

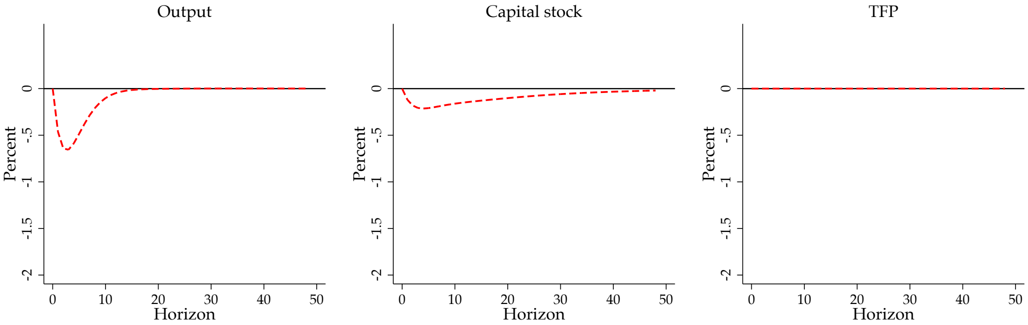
η - hysteresis elasticity using LP estimates

Sample	1890–2015	1948–2015
η	0.25	0.67
95% CI	$[0.21, 0.30]$	$[0.34, 0.99]$

Delong & Summers (2012): $\eta \approx 0.24$

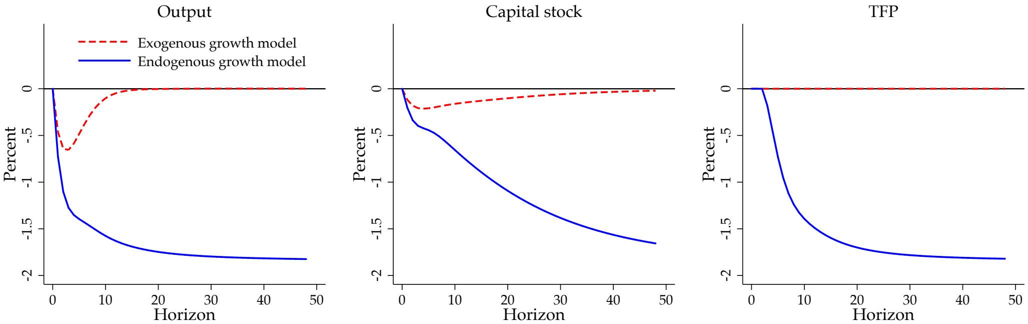
100 bps $\uparrow \epsilon_t^{mp}$ + no hysteresis ($\eta = 0$)

Taylor Rule: $1 + i_t = (1 + i_{t-1})^{0.8} \left[(\pi_t / \pi_{ss})^{1.5} \, y_t^{0.05} \right]^{1-0.8} \epsilon_t^{mp}$



100 bps $\uparrow \epsilon_t^{mp}$ + with hysteresis ($\eta = 0.25$)

Taylor Rule: $1 + i_t = (1 + i_{t-1})^{0.8} \left[(\pi_t / \pi_{ss})^{1.5} \, y_t^{0.05} \right]^{1-0.8} \epsilon_t^{mp}$



Summary

evidence against long-run money neutrality

- a monetary shock:
  - causes output to decline over a long period of time
  - causes the capital stock to decline sharply
  - causes a decline in TFP

in the manuscript, we provide

- small-open economy NK model to formalize identification
- various robustness exercises
- alternate identification schemes

additional slides

positioning

3 strands of the literature

identified responses to monetary shocks

- **Bernanke & Mihov (1998); Romer & Romer (2004)**; Christiano, Eichenbaum, & Evans (2005); Cloyne & Hürtgen (2014); Ramey (2016); Coibion, Gorodnichenko, & Ulate (2017);**Jordà, Schularick, & Taylor (2019)**

linking interest rates and productivity

- Caballero, Hoshi, & Kashyap (2008); Gopinath, Kalemli-Özcan, Karabarbounis, & Villegas-Sánchez (2017)
- Anzoategui, Comin, Gertler, & Martinez (2019); Benigno & Fornaro (2018); Bianchi, Kung, & Morales (2019); Garga & Singh (2016); Moran & Queraltó (2018)

empirical evidence on hysteresis

- Cerra & Saxena (2008); Fernald Hall Stock & Watson (2017); Fatás & Summers (2018); Galí (2016); Reifschneider, Wascher, & Wilcox (2015); Yagan (2019)

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

Back

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 (0.21)	0.70 (0.31)	0.76 (0.24)	0.74 (0.30)

Back

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

Back

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

Spillover correction:

Using the model,

$$\theta = \underbrace{\text{tradable share in y}}_{\equiv \Phi \in [0,\ 0.3]} \times \underbrace{\text{responsiveness of export demand to foreign output}}_{\text{upper bound } = \beta_h}$$

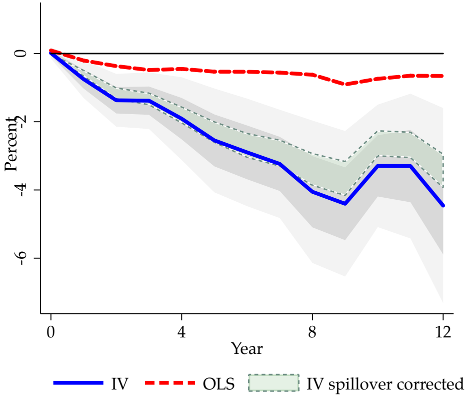
Estimate:

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

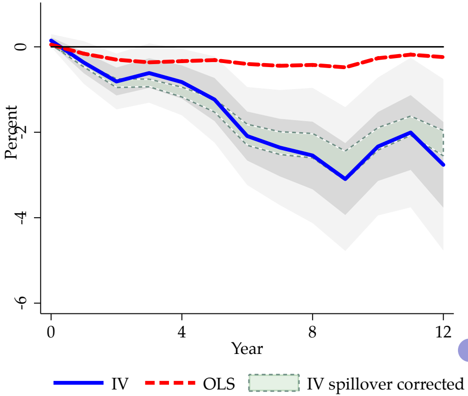
spillover correction: exclusion restriction

model based correction

(a) Real GDP: 1890–2015

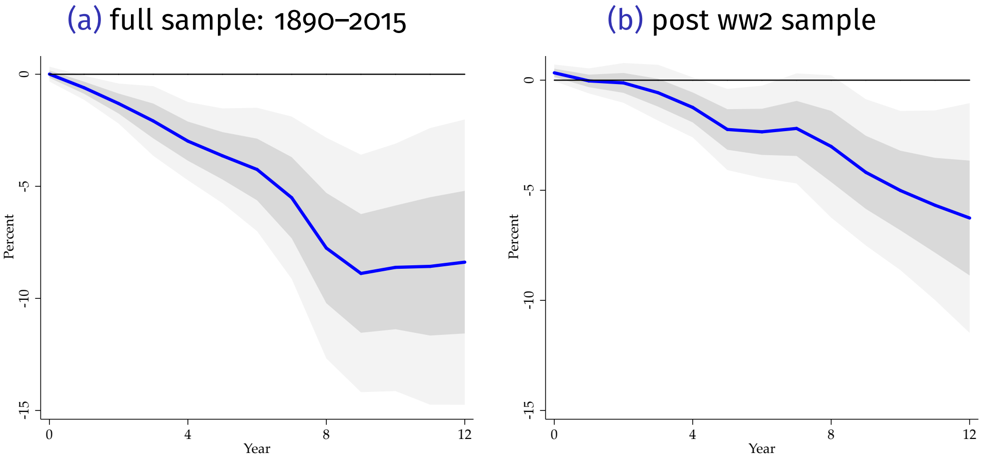


(b) Real GDP: 1948–2015



Back

CPI


(a) full sample: 1890–2015
Percent
0
-5
-10
-15
0
4
8
12
Year
(b) post ww2 sample
Percent
0
-5
-10
-15
0
4
8
12
Year

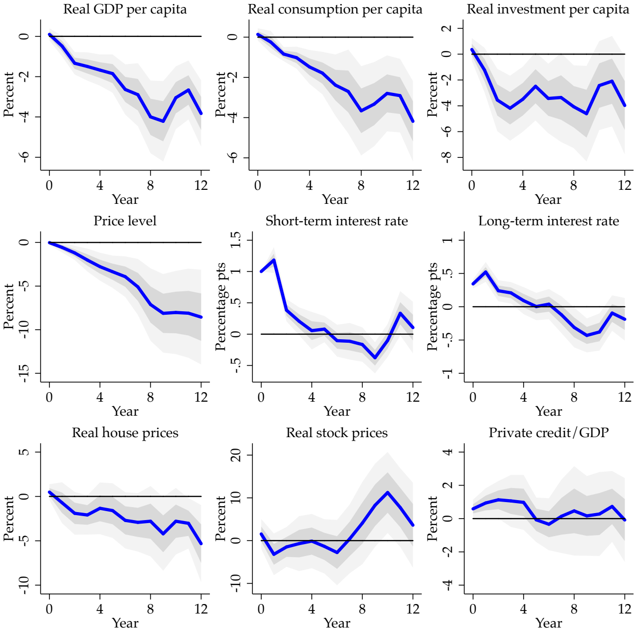
Back

Responses of real GDP per capita 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)
$h = 0$	0.05	-0.02	0.52	0.02	0.04	0.76
	(0.03)	(0.11)		(0.02)	(0.07)	
$h = 2$	-0.35**	-1.88***	0.00	-0.37**	-1.41***	0.00
	(0.14)	(0.36)		(0.14)	(0.25)	
$h = 4$	-0.32	-2.73***	0.00	-0.35*	-2.00***	0.00
	(0.22)	(0.53)		(0.21)	(0.39)	
$h = 6$	-0.45	-3.36***	0.00	-0.28	-3.00***	0.00
	(0.37)	(0.70)		(0.31)	(0.51)	
$h = 8$	-0.63*	-4.90***	0.00	-0.27	-3.36***	0.00
	(0.35)	(1.10)		(0.31)	(0.70)	
$h = 10$	-0.62*	-4.40***	0.00	0.06	-3.20***	0.00
	(0.35)	(1.02)		(0.31)	(0.73)	
$h = 12$	-0.62	-6.50***	0.00	0.04	-4.02***	0.00
	(0.40)	(1.68)		(0.36)	(0.87)	
KP weak IV		47.54			62.43	
H_0: $LATE = 0$	0.00	0.00		0.00	0.00	
Observations	963	774		710	585	

Back

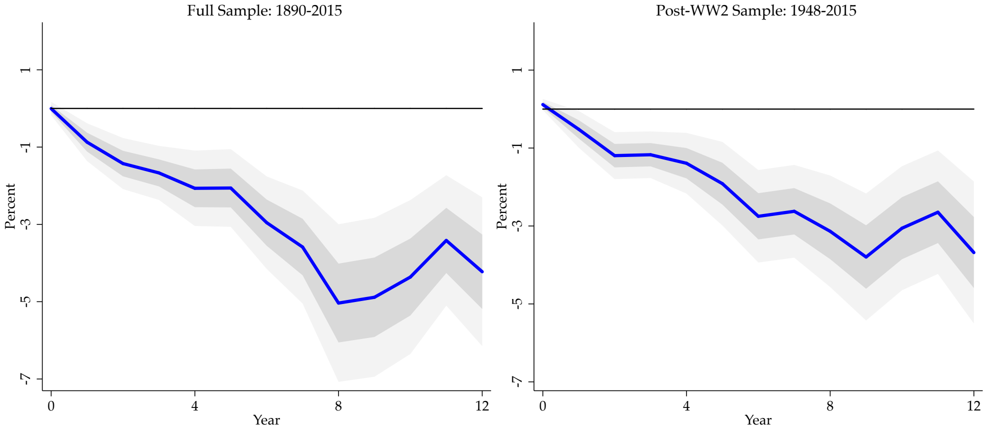
full set of IRFs



Back

Robustness

GDP per capita



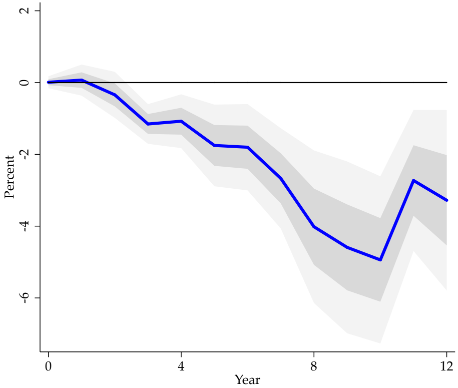
† confidence bands: 1 se and 2 se, cluster robust

Back

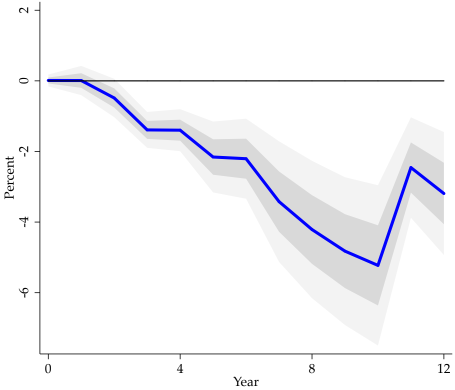
open economy variables: exclusion restriction

At each horizon h, control (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



Back

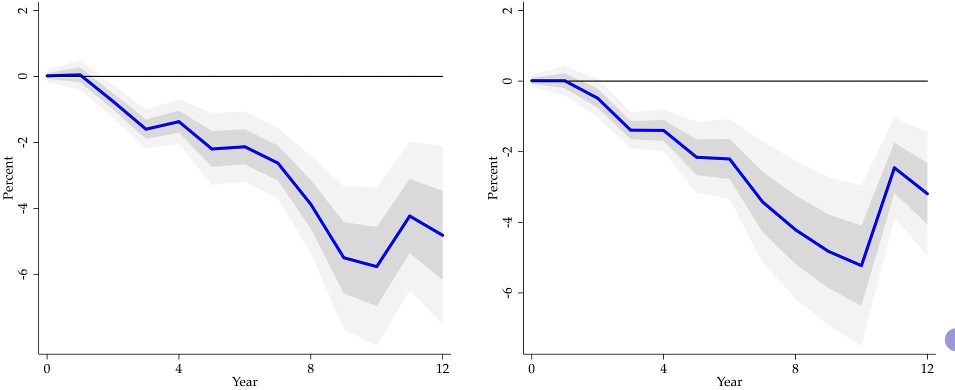
IRFs of real GDP: structural breaks in TFP

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

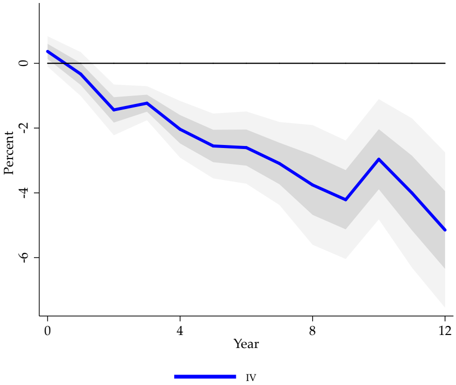


Back

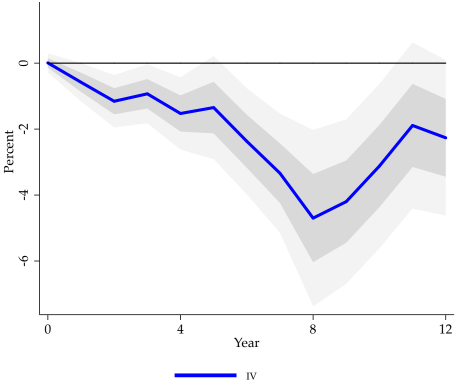
IRFs of real GDP: controls in levels vs differences

control for variables in levels instead of differences, and 5 lags of control variables in differences

(a) controls in levels



(b) 5 lags of controls in differences

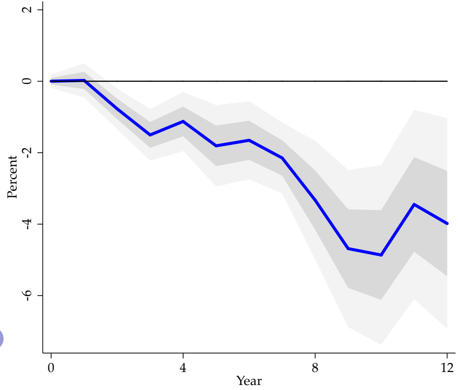


Back

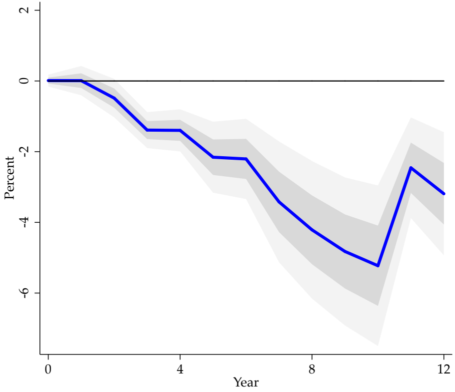
IRFs of real GDP: Structural Breaks in GDP per capita

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

(a) Structural breaks in GDP p.c. growth



(b) Baseline IRF of real GDP



Back

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

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

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

Back