Demographic Trends and the Transmission of Monetary Policy

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ASSA
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[1] *Disclaimer: The views expressed here are those of the authors alone and do not necessarily represent the views of the Bank of Italy or the Eurosystem*

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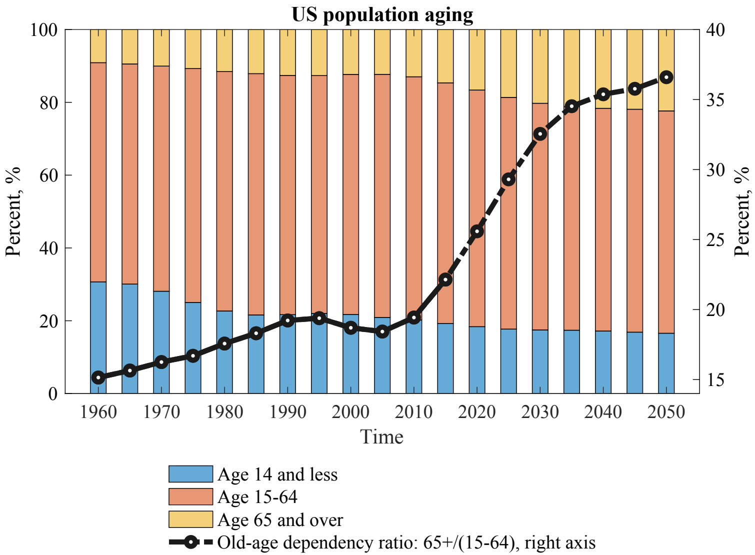
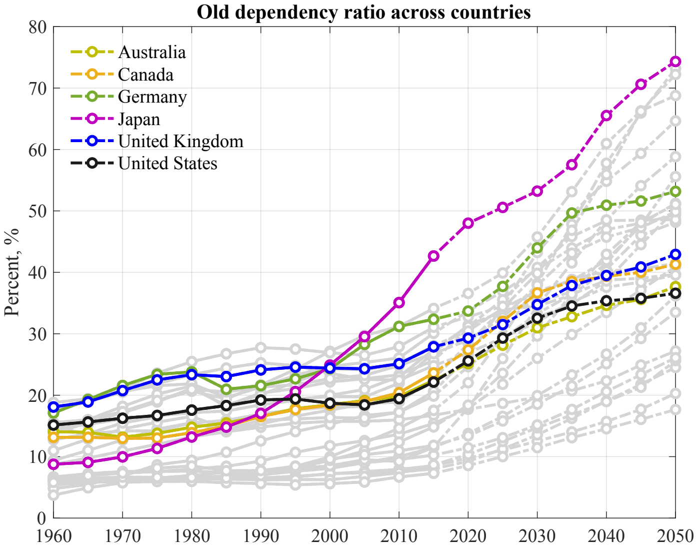
Demographic trends, *Source*: UN (2017) World Population Prospects



Demographic trends, *Source*: WB Population Estimate and Projection



Motivation

- **Demographic trends** are likely to influence different aspects of the economy (e.g., pension system, savings rates, investment, etc.)

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- There are long-term effects for monetary policy (MP) as well (e.g., steady-state levels of inflation and interest rates)
- What about short-term implications?

This paper

Propose and analyze a **new channel**:

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⇒ Population aging decreases the frequency of price adjustment

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⇒ Output responds more to MP shocks

Main results

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  - **Why?**
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  - Services adjust their prices on average every 13 months whereas goods every three months
  - The average frequency ranges from 8.2 months for young HHs to almost 10 for older HHs

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- **From Micro to Macro**:
  - Output in U.S. states with higher old-age dependency ratio is more responsive to MP shocks (not shown today) ▸ Macro evidence

Main results

- Develop a **two-sector OLG-NK** model to:
  - Estimate the impact of demographic trends on MP propagation
    - ⋆ 6% (+10%) in the **responsiveness of output** from 1980 to 2010 (2050) due to demographic trends alone
  - Quantify the size of the new channel (i.e., consumption heterogeneity)
    - ⋆ Without consumption heterogeneity output responsiveness would increase by only 5.3% by 2050

Related literature

- **Monetary policy and demographic trends**:
  Theory: Fujiwara and Teranishi (2008), Carvalho et al. (2016), Yoshino and Miyamoto (2017), Aksoy et al. (2019), Eggertsson et al. (2019), Papetti (2019), Lis et al. (2020), Bielecki et al. (2020), Lisack et al. (2021), Brzoza-Brzezina and Kolasa (2021), ...
  Empirics: Wong (2014), Bobeica et al. (2017), de Albuquerque et al. (2020), Leahy and Thapar (2022), Berg et al. (2021), Wong (2021), Kopecky (2022), ...
  - *Propose new channel through which dem. trends affect MP effectiveness*

- **Time-varying effects of monetary policy**: Boivin et al. (2010), Imam (2014), Galesi and Rachedi (2018), Kronick and Ambler (2019), Paul (2020), ...
  - *Pop. aging and consumption heterogeneity increase output responsiveness to MP shocks*

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Age-group level price stickiness

Combine data of:

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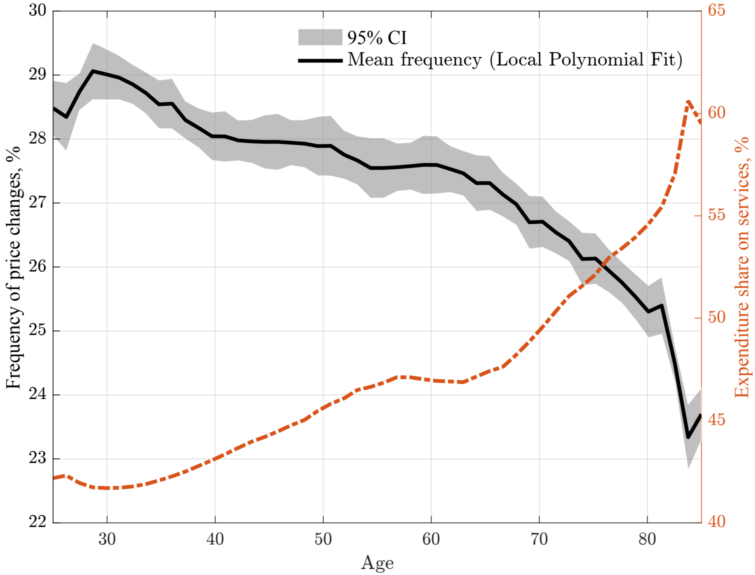
Age-group price stickiness level defined as:

$$\theta_t^a = \sum_{j \in J} \omega_{t,j}^a \theta_j$$

with $\omega_{t,j}^a = \frac{C_{t,j}^a}{\sum_j C_{t,j}^a}$ the **expenditure weight** on category j for age group a

▸ Expenditure weights

Frequency of price adjustment across age groups



- Over time
- Expenditure differences
- Expenditure weights
- Excluding sales
- Consumption quantiles
- Education
- Service share
- Alternative aggregation

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OLG-NK model

The **two-sector OLG-NK model** in a nutshell:

- Households
- Firms
- Government
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  - Born at age $j = 1$ (real-life age of 15) and live max $J = 85$ years
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  - Work until $jw = 50$ (real-life age of 64) and then retire
  - N_j denotes the relative size of cohort j, $\sum_{j=1}^{J} N_j = 1$
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  - Choose aggregate consumption $c_{t,j}$
  - $c_{t,j}$ is a CES function of services $c^S_{t,j}$ and goods $c^G_{t,j}$
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  - **Workers** supply labor, **retirees** receive pension
  - Capital, bonds, and firms' shares are transferred to perfectly competitive and risk-neutral investment funds Equations
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  - Monopolistically competitive intermediate-good producers
  - Services need to be consumed once produced
  - Calvo price adjustment mechanism: a fraction θ of firms **cannot** reset their prices each period
  - From the data services adjust prices every 13 months, goods every 3 $\Rightarrow \theta^S > \theta^G$
- Government
- Monetary Authority

OLG-NK model

The **two-sector OLG-NK model** in a nutshell:

- Households
- Firms
- Government
  - Taxes labor income of workers ▸ Equations
  - Provides pension benefit for retirees
- Monetary Authority
  - Sets interest rate based on a Taylor rule

Households

The value function of the representative household of age j at time t is:

$$V_{t,j} = \max_{c_{t,j}, l_{t,j}, a_{t+1,j+1}} u\left(c_{t,j}, l_{t,j}\right) + \beta s_j \mathbb{E}_t V_{t+1,j+1},$$

with

$$c_{t,j} = \left[\alpha_j^{\frac{1}{\eta}} (c^S_{t,j})^{\frac{\eta-1}{\eta}} + (1-\alpha_j)^{\frac{1}{\eta}} (c^G_{t,j})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

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subject to:

$$P_{t,j} c_{t,j} + a_{t+1,j+1} = a_{t,j} R_t^a + y_{t,j}$$

$$y_{t,j} = (1-\tau_t) w_t n_{t,j} h_j \mathbf{I}_{j \leq jw} + pen_t \mathbf{I}_{j > jw} + beq_t$$

$$a_{t,0} = 0 \qquad a_{t+J+1,J+1} = 0$$

The utility function takes the form:

$$u\left(c_{t,j}, l_{t,j}\right) = \left(\frac{c_{t,j}^{1-\sigma}}{1-\sigma} - \nu \frac{l_{t,j}^{1+\eta}}{1+\eta}\right)$$

Quantitative analysis

- The model is used to compare the transmission of MP shocks around **3 steady states**:
  - 1980 (baseline), when CEX data becomes available
  - 2010
  - 2050, using population projection from World Bank

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  - population distribution N_j Population distribution
  - mortality rate $(1 - s_j)$ Mortality rate
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Answer the following **questions**:

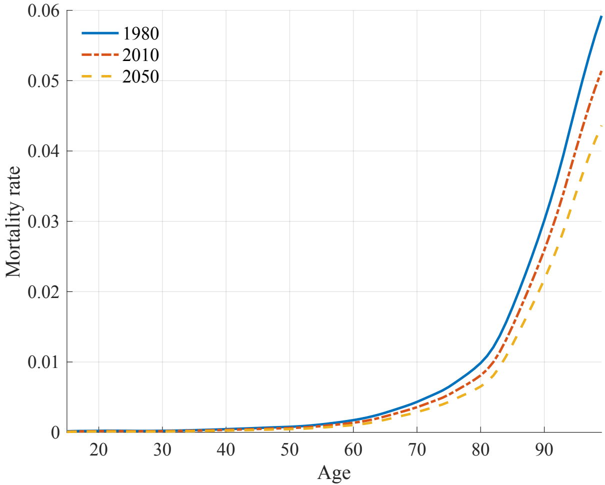
- Do demographic trends change the way MP propagates in the U.S.?
- To what extent consumption heterogeneity across age groups contributes?

Calibration

Parameter	Value	Description	Target
β	0.999	Discount factor	Annual interest rate between 4 and 5 %
δ	0.02	Depreciation rate	Capital-output ratio between 2 and 2.7
σ	1	Intertemporal elasticity of substitution	Standard value
ϕ	2	Frisch elasticity of labor supply	Standard value
N_j	Population distribution	Population shares. Source: World Bank	
s_j	Mortality rate	Survival probability. Source: Social Security Administration	
α_j	Service share	Share of consumption devoted to services. Source: CEX	
h_j	Labor efficiency	Individual life-cycle labor supply in efficiency units from Fullerton (1999)	Wage profile
ϵ	6	Elasticity of demand for each intermediate good	Steady-state markup of 20 %
θ^S	0.75	Calvo Frequency Services. Source: Nakamura and Steinsson (2008)	Price adjustment every 13 months
θ^G	0.25	Calvo Frequency Goods. Source: Nakamura and Steinsson (2008)	Price adjustment every 3 months
α	0.33	Capital share	Standard value

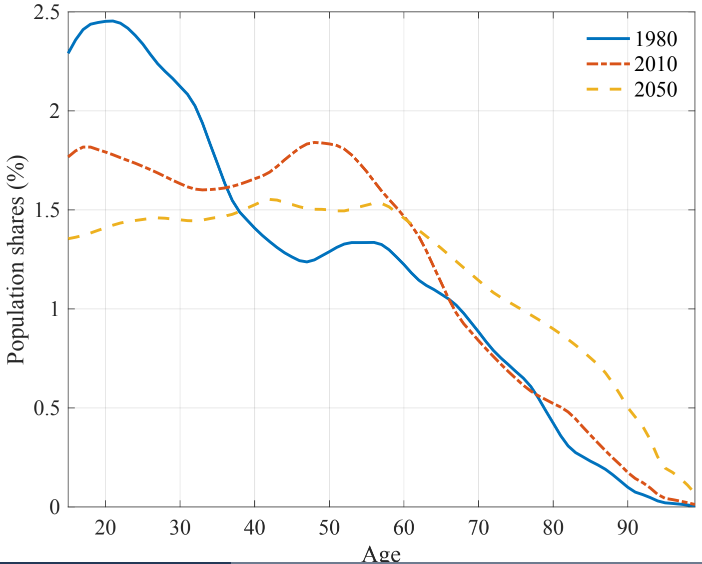
The most important parameters are N_j, s_j and α_j

Mortality rate across age groups ▸ Back

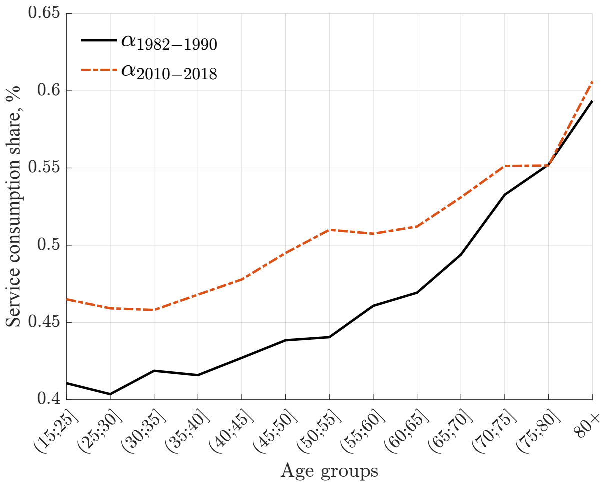


Mortality rate has decreased over time

Pop. distribution, *Source*: UN (2017) World Population Prospects ▸ Back

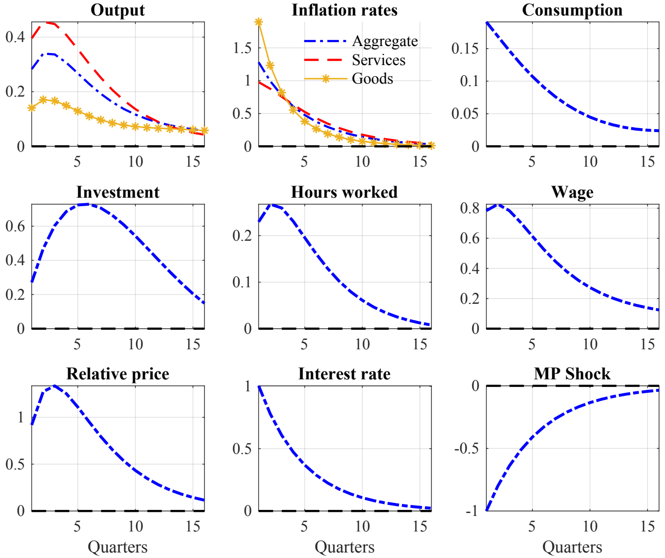


Service consumption share, *Source*: Own calculation, CEX data ▸ Back



Income and price effects have increased the share of services consumed

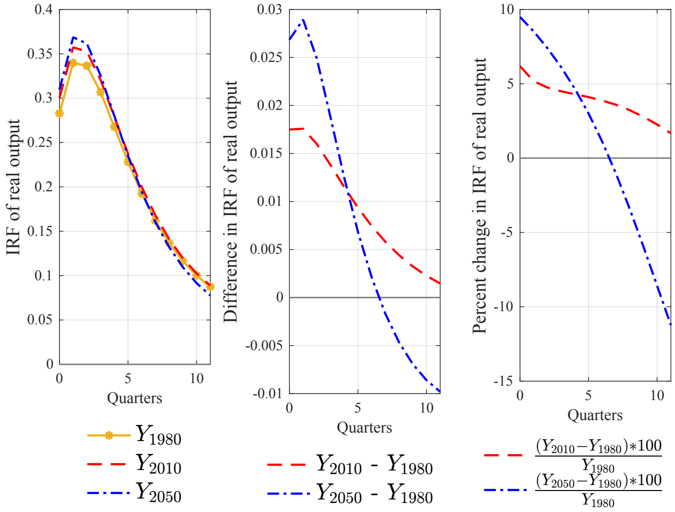
Model impulse response function to MP shock



IRFs to a 100 bp expansionary MP shocks ▸ Age responses

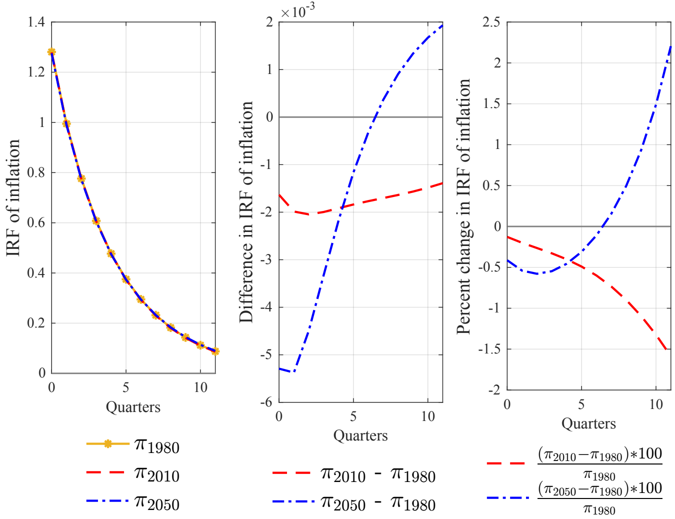
Outline

IRFs difference wrt baseline (changing only dem.), output



IRFs with N_j and s_j for $\{1980, 2010, 2050\}$,
α_j **fixed** at 1980 values

IRFs difference wrt baseline (changing only dem.), inflation



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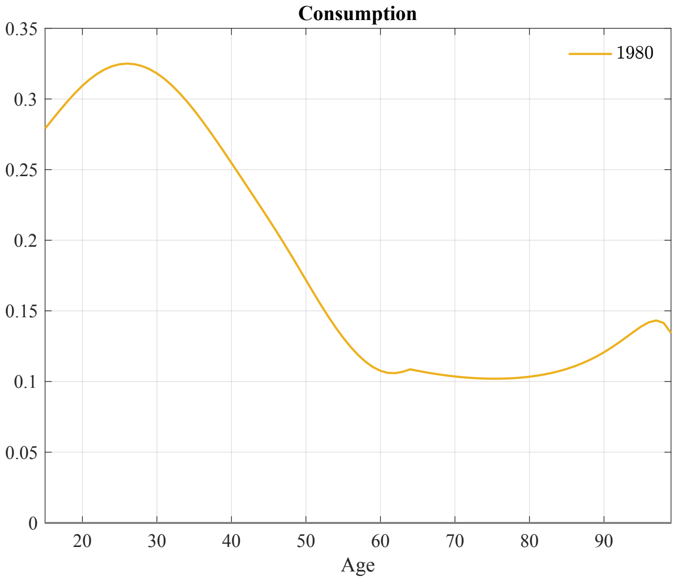
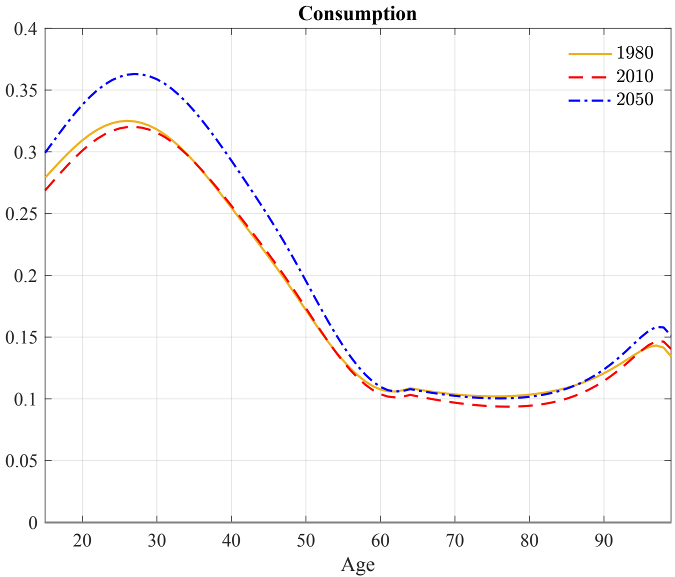
IRF by age



Young households are the most exposed to MP shocks

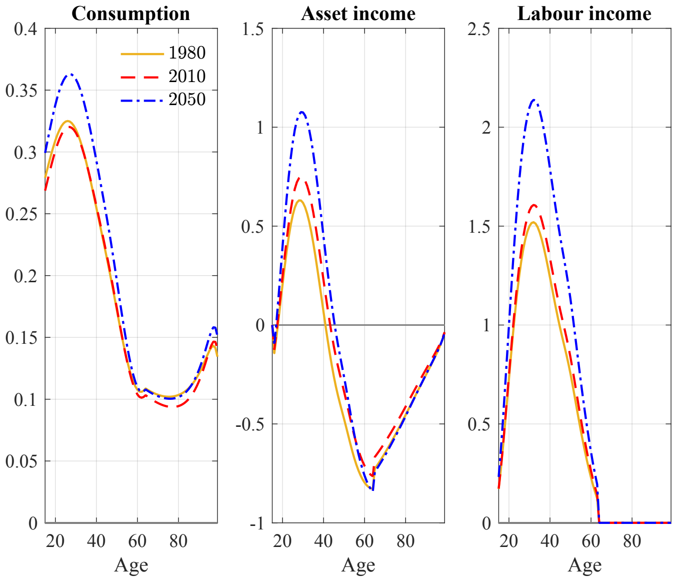
IRF by age over time



The consumption of young households is also increasing in responsiveness

▸ Empirical evidence

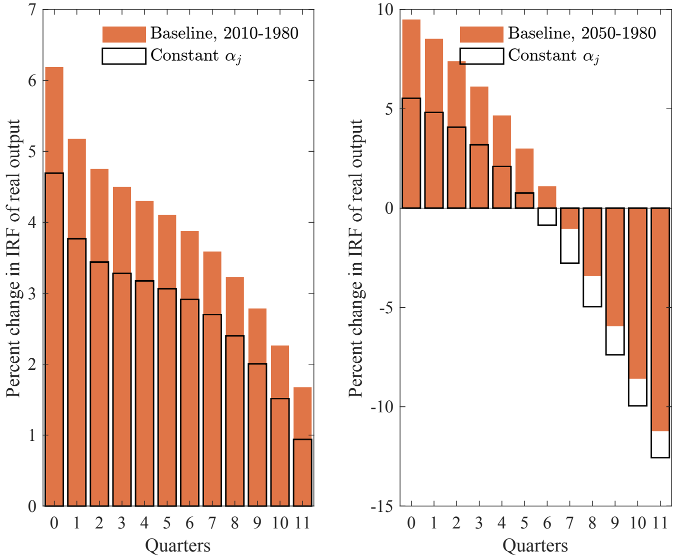
IRF by age over time



Asset and labour income are becoming more responsive

Outline

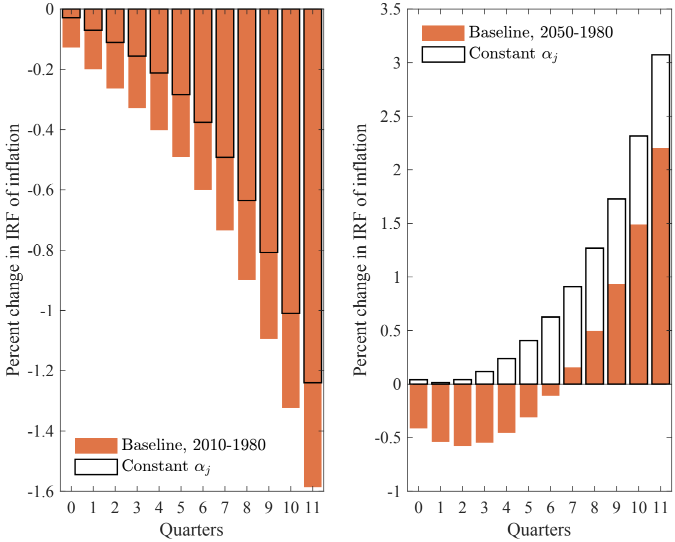
Size of the new channel, Output



IRFs with change in N_j and s_j;
Age-specific α vs Constant α

Contribution demographics

Size of the new channel, Inflation



IRFs with change in N_j and s_j;
Age-specific α vs Constant α

Sensitivity analysis

Response of Output and Inflation - Robustness Checks

	Output response (%)			Inflation response (%)		
	Time 0	After 1 year	After 2 years	Time 0	After 1 year	After 2 years
Baseline	6.18	4.30	3.22	-0.12	-0.40	-0.89
Different ψ	5.63	4.01	2.93	-0.07	-0.26	-0.64
Different ϵ	5.07	3.72	2.83	-0.15	-0.34	-0.63
Different ϕ	6.97	4.58	2.95	-0.12	-0.36	-0.82
Constant τ	5.79	4.03	3.02	-0.09	-0.31	-0.71
$\theta^G = \theta^S$	2.78	3.85	2.79	-0.02	-0.21	-1.09

Percent change in IRFs of output and inflation between 1980 to 2010 under alternative assumptions of the model ▸ Different θ

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Conclusion

Main results:

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Policy implications for Central Banks:

- Population aging matters for MP short-term decisions as well
- Dem. trends increase price stickiness ⇒ Output more responsive
- Younger households are more exposed ⇒ Fiscal policies to stabilize

Thank you for your attention!

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Old-age dependency ratio, service share, and price stickiness

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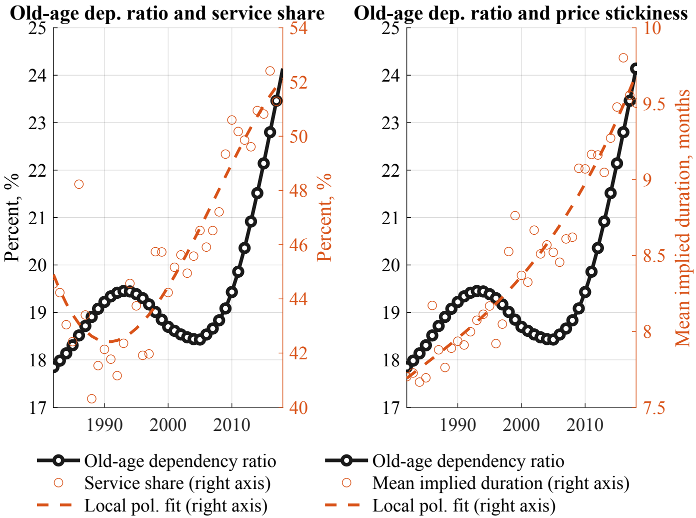

Across age groups and time

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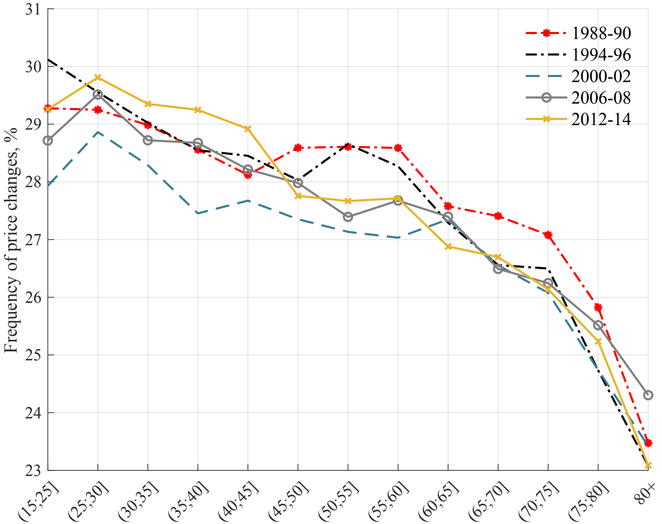

Frequency of price adjustment excluding sales

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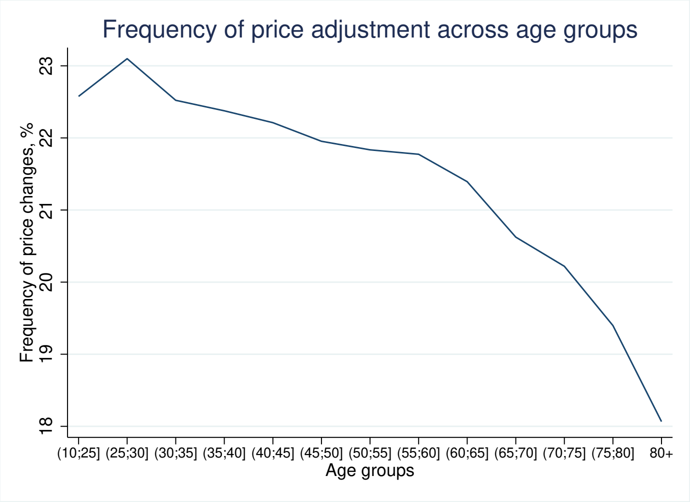

Across age groups and consumption quantiles

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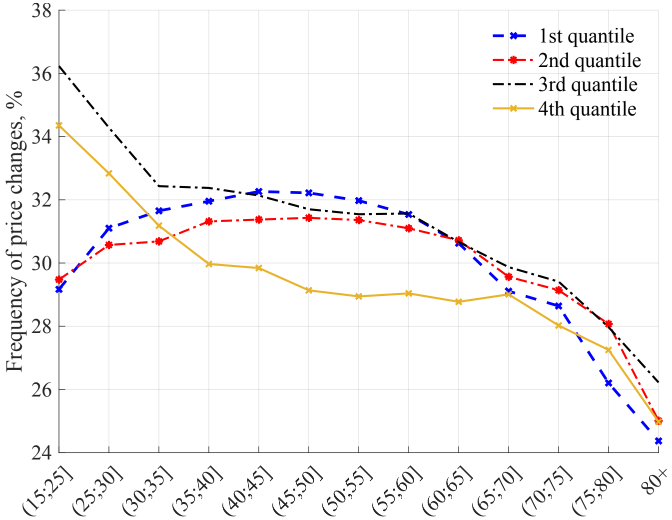

Across age groups and education levels

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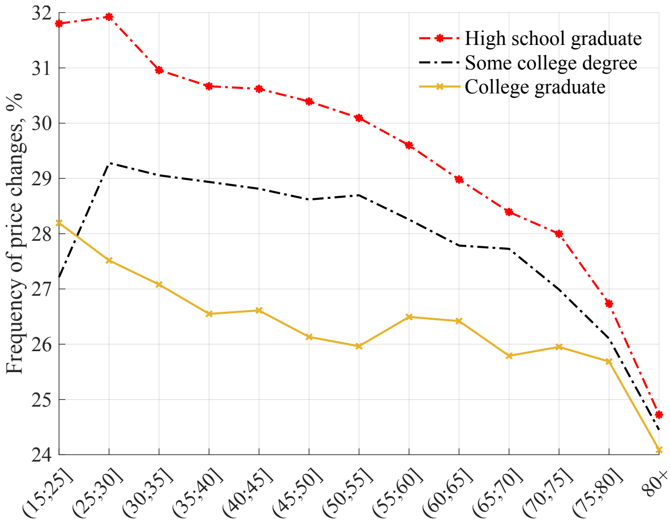
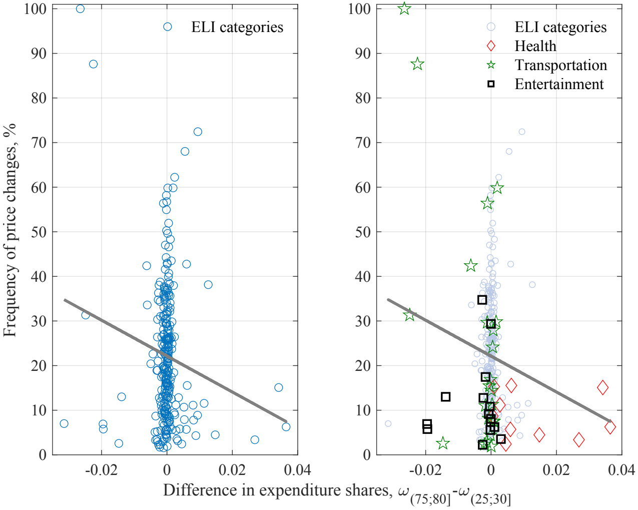
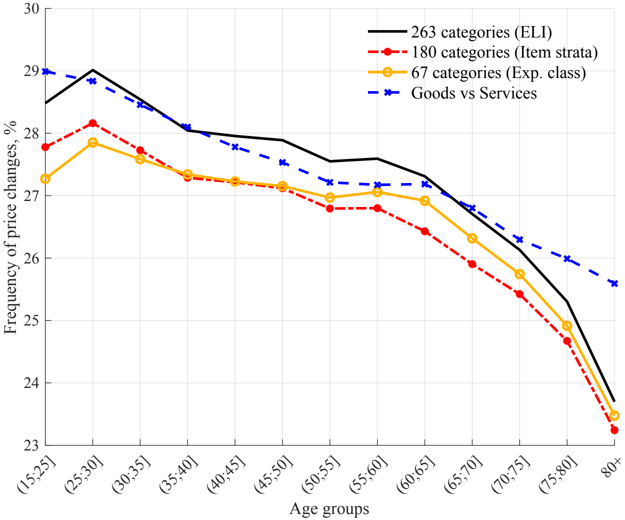


Expenditure differences across age group



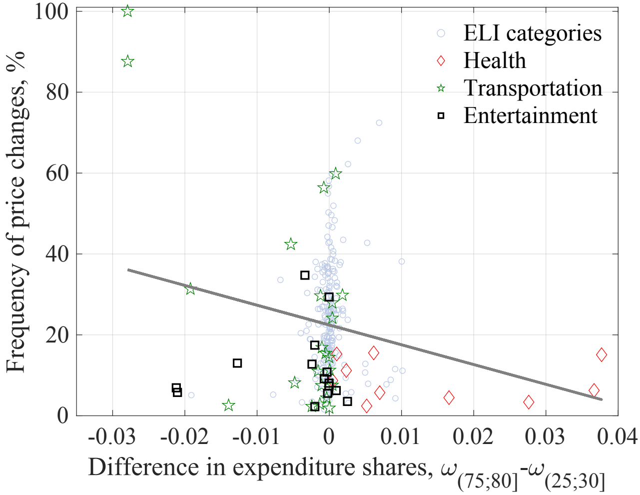
Alternative aggregation

Back

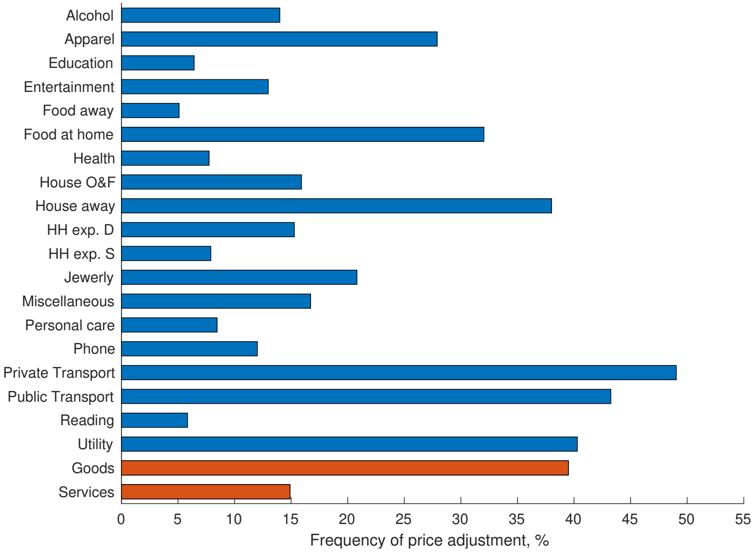


Expenditure differences across age group

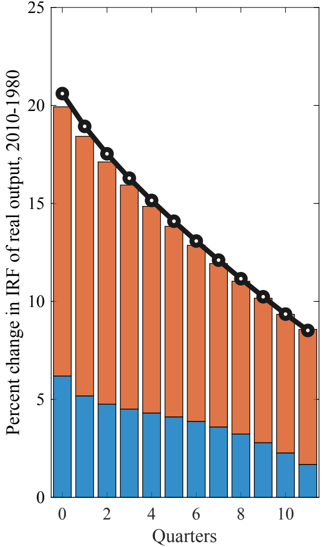
Back

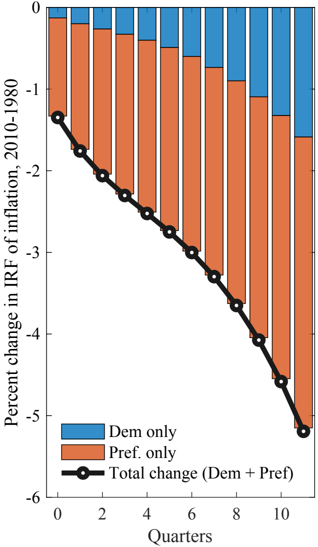


Price stickiness across categories ▸ Back



Contribution from demographics change





Blue bars: change in N_j and s_j; fixed α_j

Orange bars: fixed N_j and s_j; change in α_j

Back

Within-between decomposition

What percentage of the increase in the share of services in total consumption is explained by changes in the age distribution?

The **share of services** in aggregate consumption can be written as:

$$\alpha_t^s = \frac{\sum_a C_t^{s,a}}{\sum_a \sum_j C_t^{j,a}} = \sum_a \alpha_t^{s,a} s_t^a$$

with $\alpha_t^{s,a} = \frac{C_t^{s,a}}{\sum_j C_t^{j,a}}$ and $s_t^a = \frac{\sum_j C_t^{j,a}}{\sum_a \sum_j C_t^{j,a}}$

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The change in services between t_1 and t_2 can then be decomposed in:

$$\Delta\alpha_t^s = \underbrace{\sum_a \Delta\alpha^{s,a}\bar{s}^a}_{\text{Within}} + \underbrace{\sum_a \bar{\alpha}^{s,a}\Delta s^{s,a}}_{\text{Between}}$$

with $\Delta x = x_{t_2} - x_{t_1}$ and $\bar{x} = \frac{x_{t_2} - x_{t_1}}{2}$ for any variable x.

Within-between decomposition

$$\Delta\alpha_t^s = \underbrace{\sum_a \Delta\alpha^{s,a}\bar{s}^a}_{\text{Within}} + \underbrace{\sum_a \bar{\alpha}^{s,a}\Delta s^{s,a}}_{\text{Between}}$$

Within-between decomposition, 1982-1990 to 2010-2018

	Service share	Contribution	Implied duration, months
Within	0.044	72.3 %	0.42 (+5.4 %)
Between	0.017	27.7 %	0.16 (+2.1 %)
Total	0.061	100 %	0.58 (+7.5 %)
	(46.69 % to 52.75 %)		(7.83 to 8.42)

U.S. states, data and empirical specification ▸ Back

Micro-level evidence suggests:

$\uparrow$ old-age dependency ratio $\Rightarrow$ $\uparrow$ demand of services $\Rightarrow$ $\uparrow$ price stickiness $\Rightarrow$
$\Rightarrow$ $\uparrow$ output responsiveness at macro-level

U.S. states, data and empirical specification ▸ Back

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U.S. states, data and empirical specification ▸ Back

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U.S. states, data and empirical specification ▸ Back

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  - 2010 - U.S. 20%; States [14%, 27%]
  - Average within-state increase in old-dep. ratio is around 3pp

U.S. states, data and empirical specification ▸ Back

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- *Prediction*: Economic activity in "*older*" U.S. states should **react more** to MP shocks

▸ State variation ▸ Services ▸ Health

Average state level response

Prediction: Economic activity in "*older*" U.S. states should **react more** to MP shocks

Estimate the average state level response to MP shock with Local Projection à la Jordà (2005):

$$y_{i,t+h} = \alpha_{i,h} + \beta_h MP_t + \theta_{i,h} X_{i,t-1} + \gamma_h X_{t-1} + \epsilon_{i,t+h}$$

for $h = 1, ..., 16$

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- Dependent variable $y_{i,t}$ for state i at time t:
    - Real Personal Income from the Bureau of Economic Analysis (BEA)
    - Annual inflation rate from Hazell et al. (2022)
    - GDP from the BEA (annual frequency)
- MP_t are the Romer and Romer (2004) shocks

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- MP_t are the Romer and Romer (2004) shocks
- State controls $X_{i,t-1}$: lagged dependent variable and population size
- Aggregate controls X_{t-1} as in Ramey (2016): IP, CPI, FFR, unemployment rate and commodity price index
- Standard errors are clustered at state level

Percentile level responses

Prediction: Economic activity in "*older*" U.S. states should **react more** to MP shocks

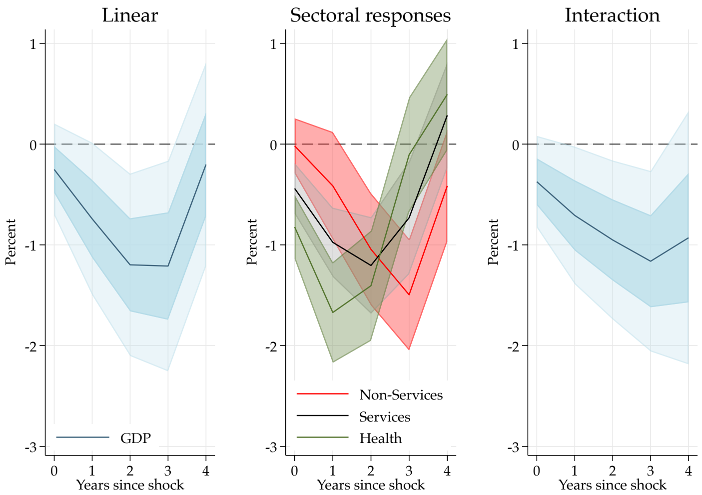
To evaluate the role of demographic structure, extend baseline specification:

$$y_{i,t+h} = \alpha_{i,h} + \beta_h MP_t + \theta_{i,h} X_{i,t-1} + \gamma_h X_{t-1} + \epsilon_{i,t+h}$$

with dummy variable $D^O_{i,t}$ equal 1 for top quintile of the old-age dependency distribution:

$$y_{i,t+h} = \alpha_{i,h} + \delta_{t,h} + \gamma_h D^O_{i,t} + \beta^O_h D^O_{i,t} MP_t + \theta_{i,h} X_{i,t-1} + \epsilon_{i,t+h},$$

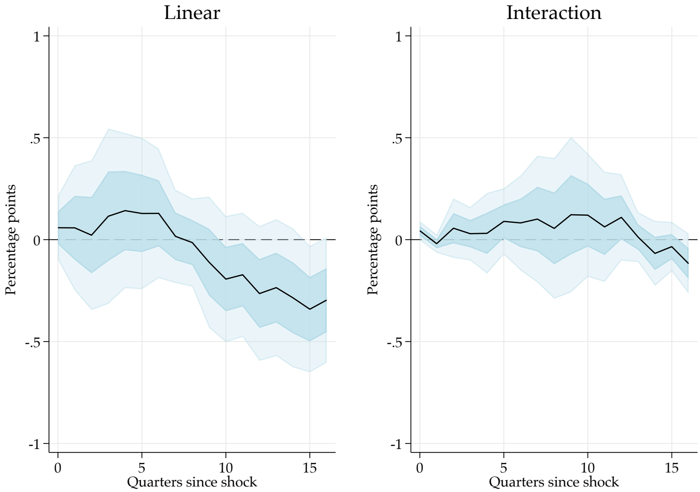
IRF real GDP, 68% and 95% CI



Economic activity in "*older*" U.S. states is more responsive

▸ Service contribution

IRF Inflation rate, 68% and 95% CI

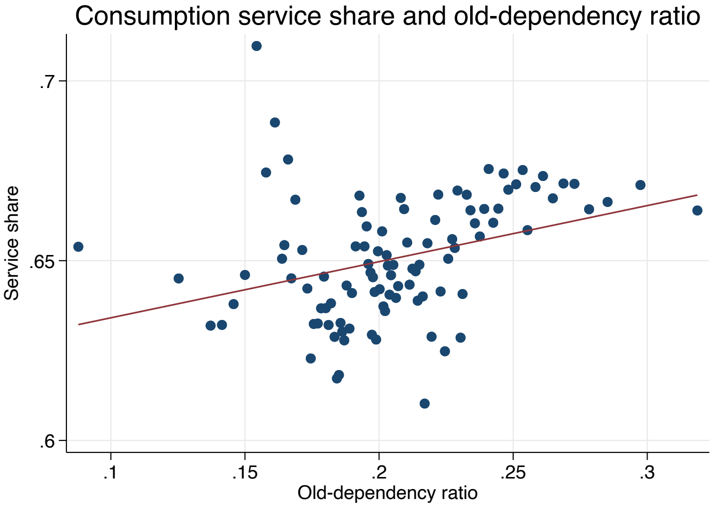


No significant differences for inflation rate

Robustness checks

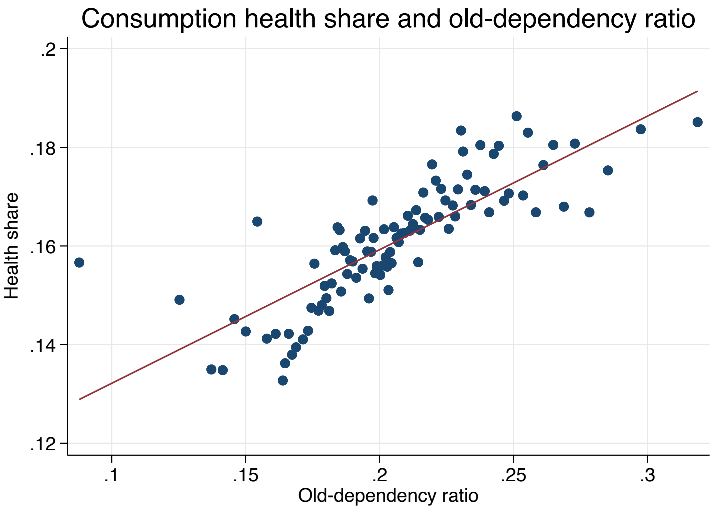
- Above/below median ▸ Go
- Top/bottom 10 % ▸ Go
- Share of working population ▸ Go
- No financial crisis ▸ Go
- Controlling for income ▸ Go
- Excluding small states ▸ Go
- High-frequency identification with IV-LP ▸ Go
- Services ▸ Go

Service share and old-age dependency ratio ▸ Back



Health share and old-age dependency ratio

▸ Back



Firms

The firms side has two sectors:

- **services** and **goods**
- Each sector has competitive final goods firm and a continuum of monopolistically competitive intermediate goods firms (standard NK model)
- Different frequency of price adjustment
- Only the output of the goods-sector can be used for capital investment

Price stickiness: Each period a fraction θ^s of intermediate producers cannot reset their price, $\theta^S > \theta^G$.

▸ Market clearing ▸ Back

Market clearing

Both aggregate labor and capital markets clear:

$$L_t = L_t^S + L_t^G = \sum_{j=1}^{jw} N_j h_j n_{t,j}, \qquad K_t = K_t^S + K_t^G = \sum_{j=1}^{J} N_{j-1} a_{t,j}$$

$$beq_t = \sum_{j=1}^{J} (N_{j-1} - N_j) a_{t,j} R_t^a$$

The markets of goods and services clear:

$$Y_t^S = (K_t^S)^\alpha (L_t^S)^{1-\alpha} = C_t^S$$

$$Y_t^G = (K_t^G)^\alpha (L_t^G)^{1-\alpha} = C_t^G + I_t$$

and bonds are in zero net supply, $B_t = 0$.

Back

Investment funds

The FOCs of the representative investment fund are:

$$K_{t+1} = (1-\delta)K_t + \Big[1 - \frac{S}{2}(\frac{I_t}{I_{t-1}} - 1)^2\Big] I_t$$

$$A_{t+1} = q_t(1-\delta)K_t + I_t + p^d_t$$

$$\frac{R^a_t}{\pi_t} A_t = \Big[r^k_t + q_t(1-\delta)\Big] K_t + f_t + p^d_t$$

$$R_t q_t = \mathbb{E}_t\Big[\Big(r^k_{t+1} + q_{t+1}(1-\delta)\Big)\pi_{t+1}\Big]$$

$$R_t p^d_t = \mathbb{E}_t\Big[\Big(p^d_{t+1} + f_{t+1}\Big)\pi_{t+1}\Big]$$

$$1 = q_t\Big[1 - \frac{S}{2}(\frac{I_t}{I_{t-1}} - 1)^2 - S(\frac{I_t}{I_{t-1}} - 1)\frac{I_t}{I_{t-1}}\Big] + \mathbb{E}_t\Big[\frac{\pi_{t+1}}{R_t} q_{t+1} S(\frac{I_{t+1}}{I_t} - 1)(\frac{I_{t+1}}{I_t})^2\Big]$$

▸ Back

Government and Monetary Authority

The government funds a **pay-as-you-go social security system**. The tax rate on labor income τ_t is set such that the budget is balanced in each period.

$$pen_t = \bar{d}(1-\tau_t)w_t \sum_{j=0}^{jw} N_j h_j$$

$$\tau_t w_t \sum_{j=0}^{jw} N_j h_j = pen_t \sum_{j=jw+1}^{J} N_j$$

with d_t the amount of pension benefit and $\bar{d}$ the replacement rate.

The central bank follows the following simple **Taylor-type rule**:

$$\frac{R_t}{R} = \left(\frac{\Pi_t}{\Pi}\right)^{\phi_\pi} \left(\frac{Y_t}{Y}\right)^{\phi_y} e^{\nu_t^r}$$

Back

Phillips Curve

The **sectoral Phillips Curve**:

$$\hat{\pi}_t^S = \beta \mathbb{E}_t \hat{\pi}_{t+1}^S + \kappa^S \hat{mc}_t^S$$

$$\hat{\pi}_t^G = \beta \mathbb{E}_t \hat{\pi}_{t+1}^G + \kappa^G \hat{mc}_t^G$$

with

$$\kappa^S = \frac{(1-\theta^S)(1-\theta^S\beta)}{\theta^S}, \qquad \kappa^G = \frac{(1-\theta^G)(1-\theta^G\beta)}{\theta^G}$$

Since $\theta^S > \theta^G$, it follows that $\kappa^S < \kappa^G$.

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Since $\theta^S > \theta^G$, it follows that $\kappa^S < \kappa^G$.
It can be shown that:

$$\hat{\pi}_t = \omega\hat{\pi}_t^S + (1-\omega)\hat{\pi}_t^G = \beta\mathbb{E}_t\hat{\pi}_{t+1} + \left[\omega\kappa^S + (1-\omega)\kappa^G\right](\hat{w}_t - \alpha(\hat{k}_t - \hat{l}_t)) - \lambda\hat{z}_t$$

where $\omega = \sum_j \alpha_j s_j \frac{P_j^{\eta-1}}{\sum_j s_j P_j^{\eta-1}}$, $s_j = \frac{N_j P_j C_j}{\sum_j N_j P_j C_j}$ and $\hat{z}_t = logP_t^G - logP_t^S$.

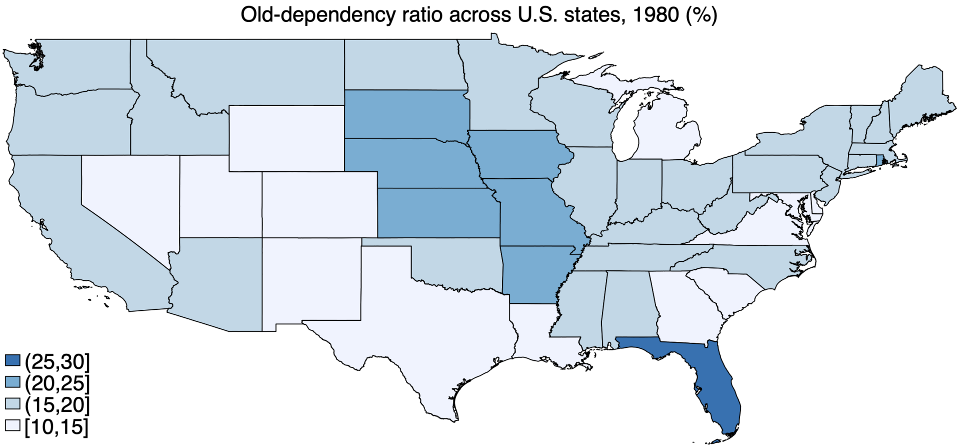
Phillips Curve

Effect of population aging on the slope of the Phillips Curve

	Baseline 1980	Dem+Pref 2010	Only Dem 2010
Service weight ω	0.4498	0.4953 (+10.11 %)	0.4542 (+0.97 %)
PC slope	1.2759	1.1773 (-7.72 %)	1.2665 (-0.74 %)

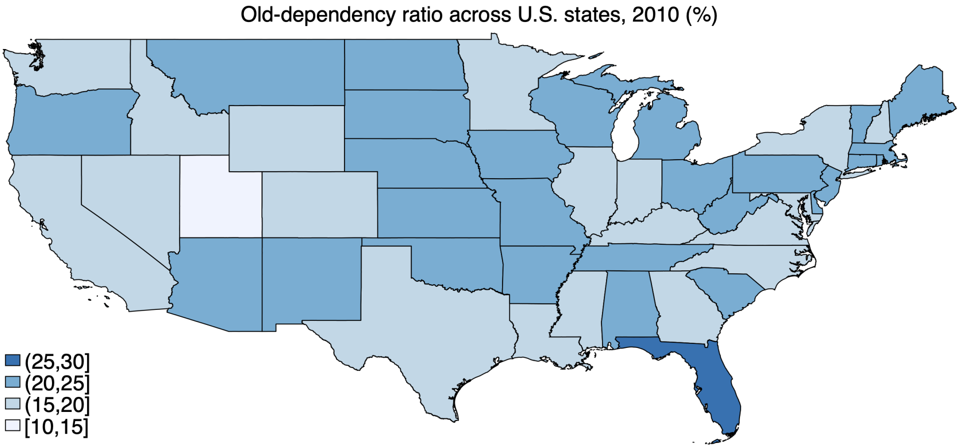
Back

old-age dependency ratio across states

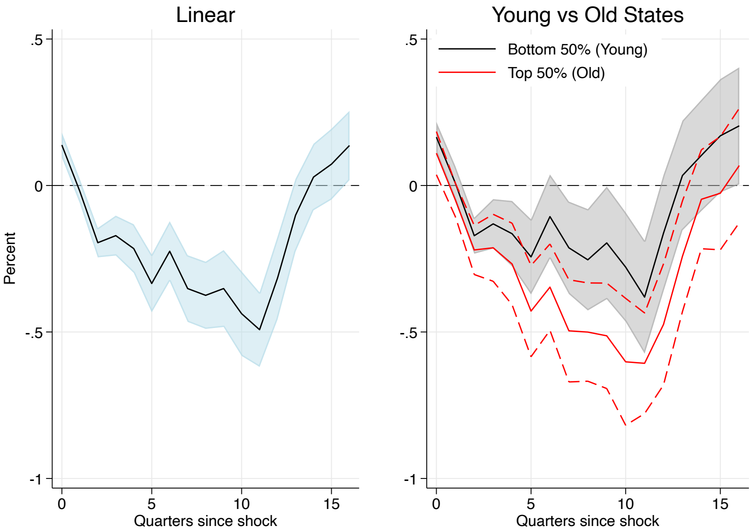


old-age dependency ratio across states

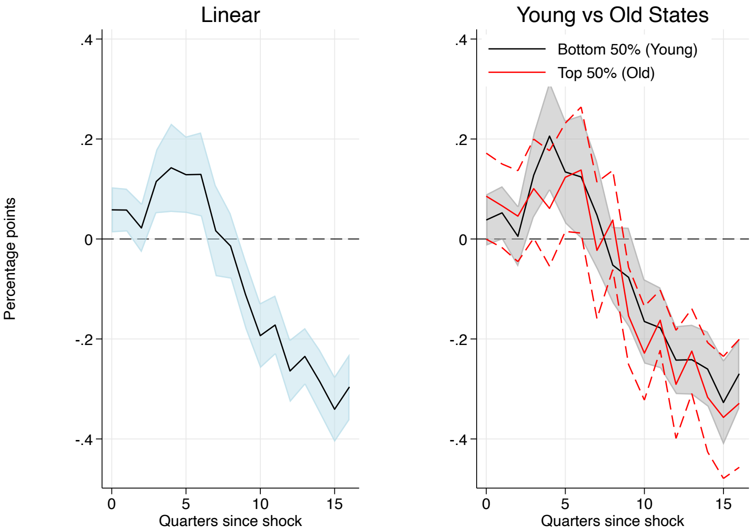
▸ Back



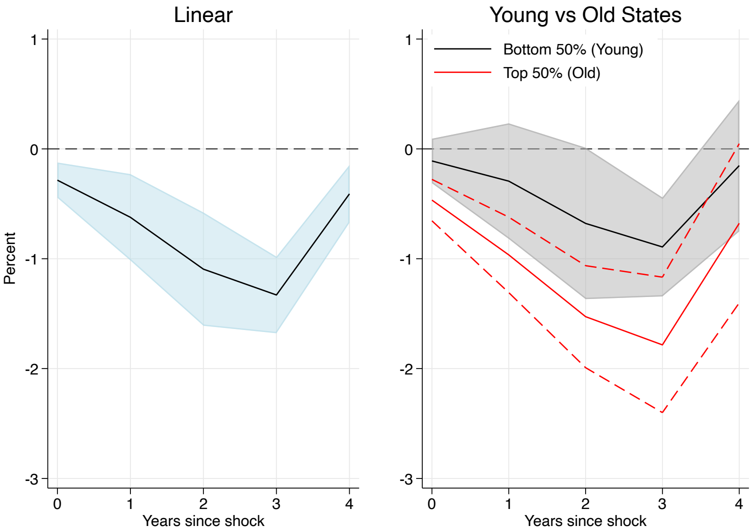
IRF Personal Income, Above/below median



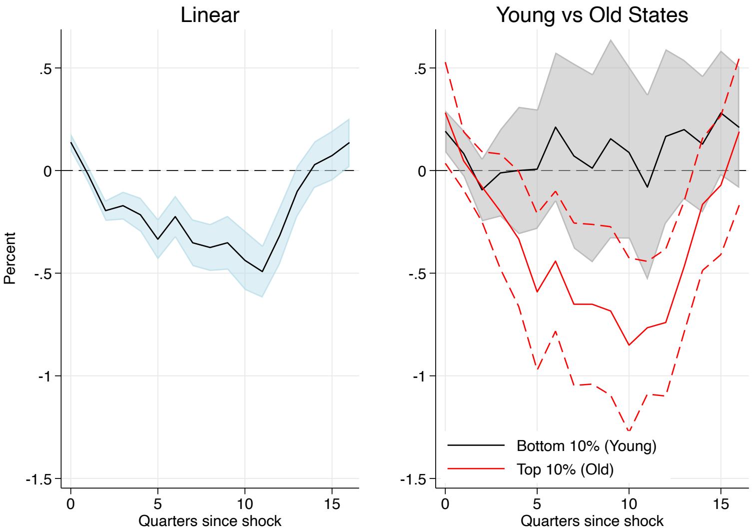
IRF Inflation rate, Above/below median



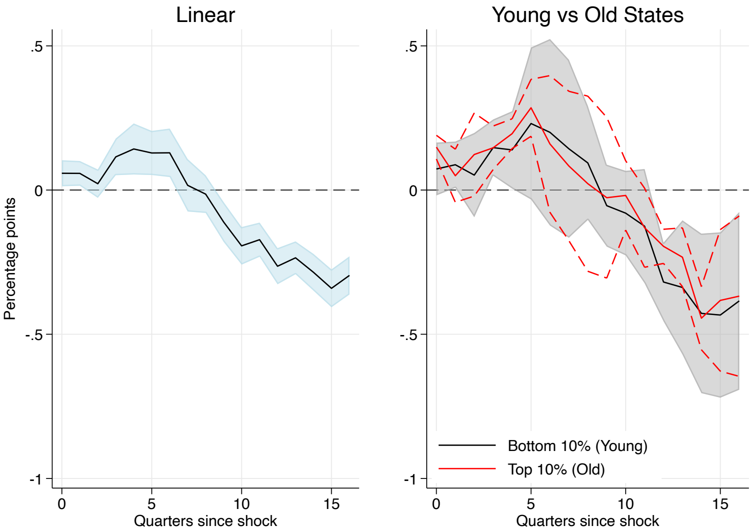
IRF Regional GDP, Above/below median ▸ Back



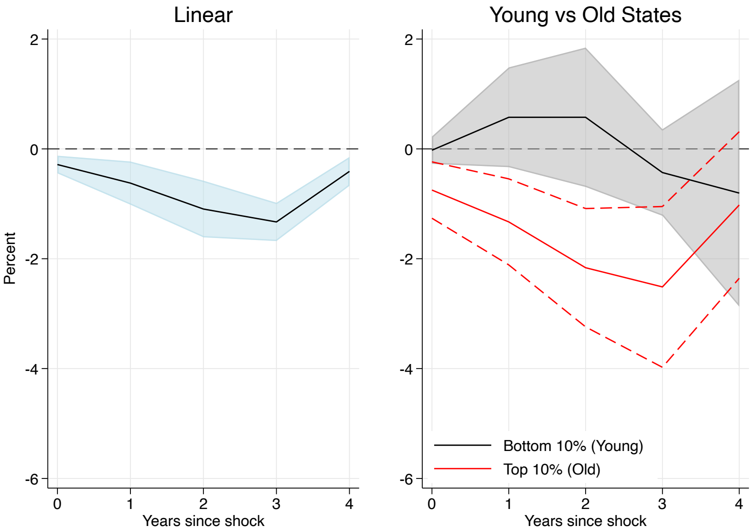
IRF Personal Income, Top/bottom 10 %



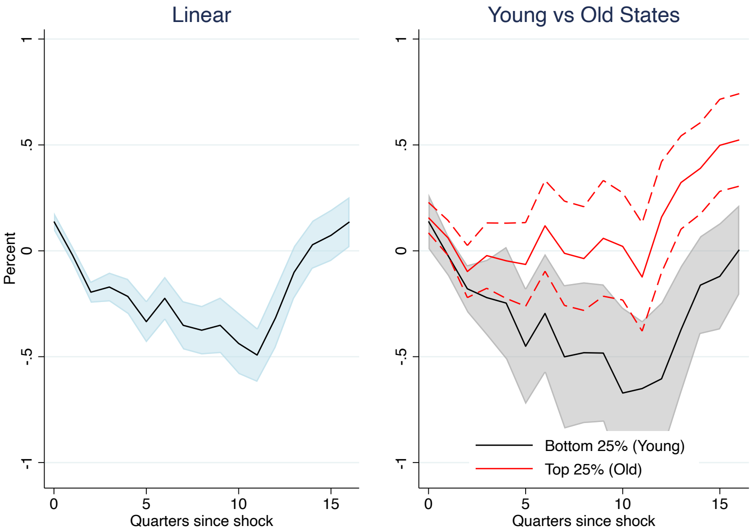
IRF Inflation rate, Top/bottom 10 %



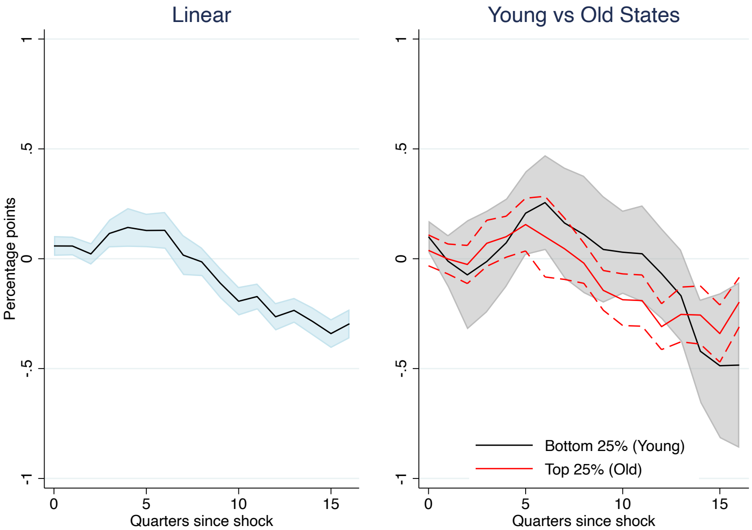
IRF Regional GDP, Top/bottom 10 % ▸ Back



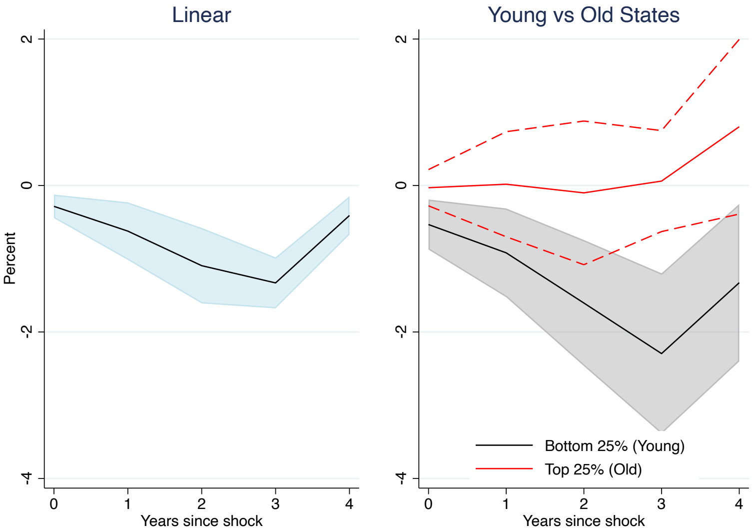
IRF Personal Income, share working population



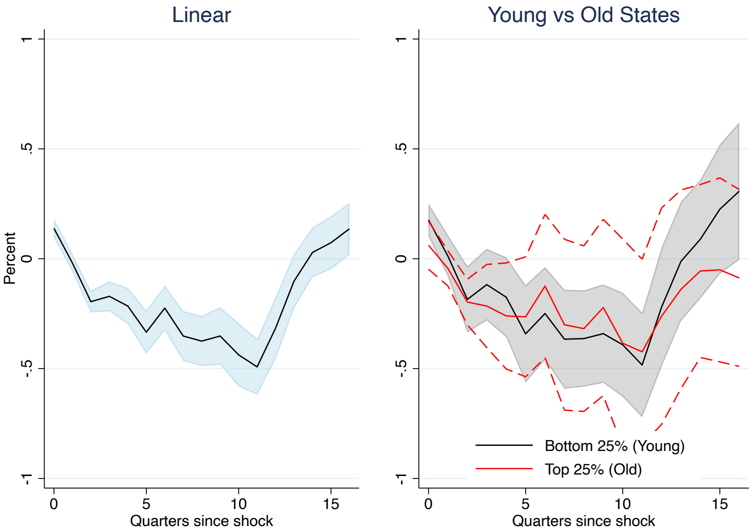
IRF Inflation rate, share working population



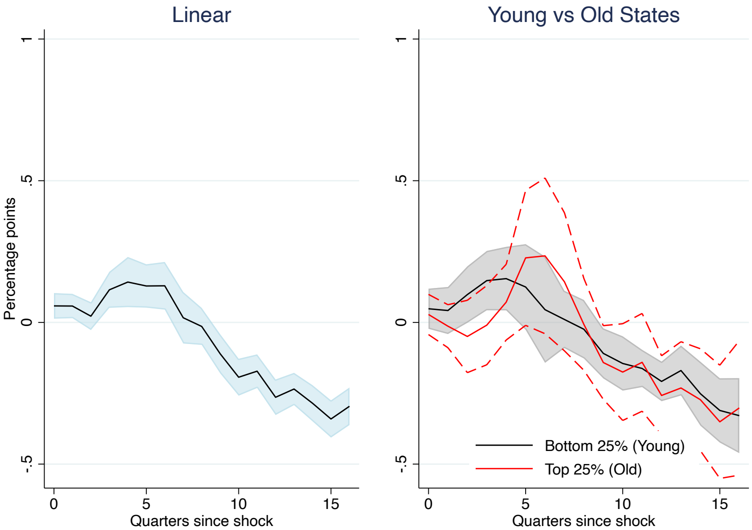
IRF Regional GDP, share working population ▸ Back



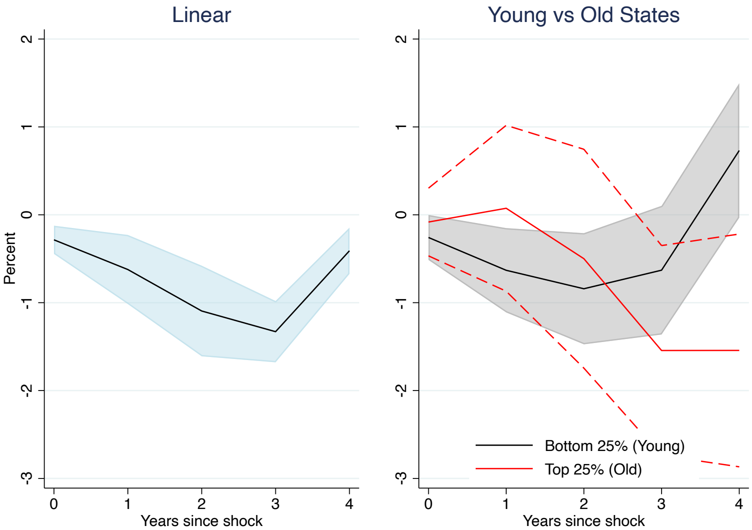
IRF Personal Income, share young



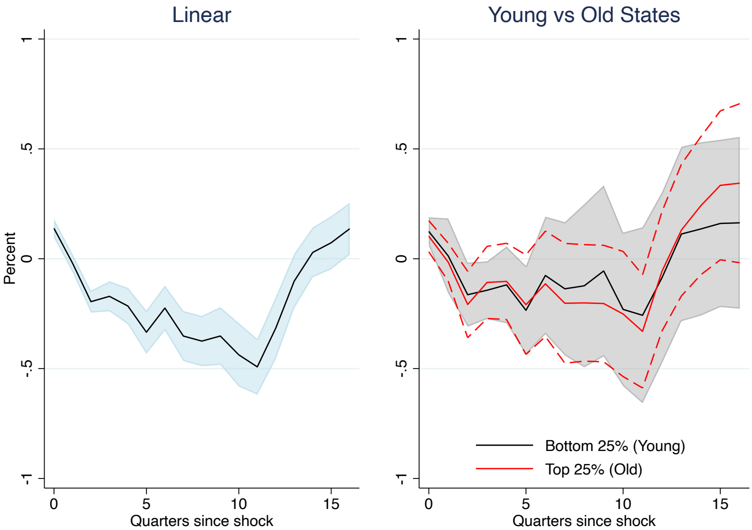
IRF Inflation rate, share young



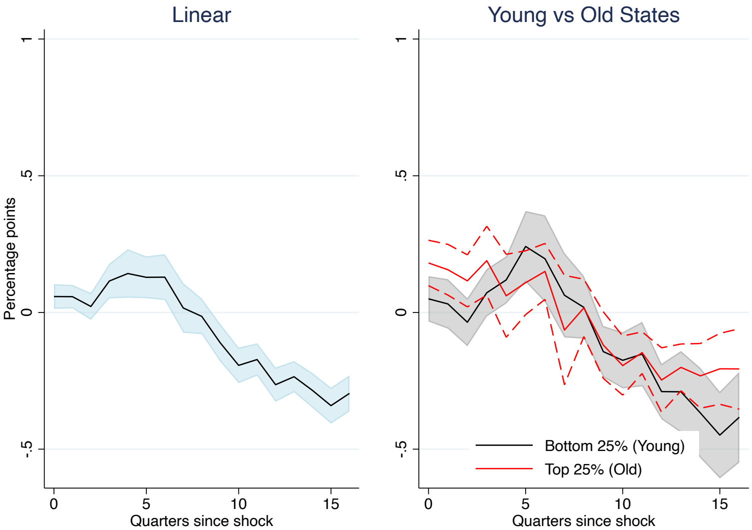
IRF Regional GDP, share young ▸ Back



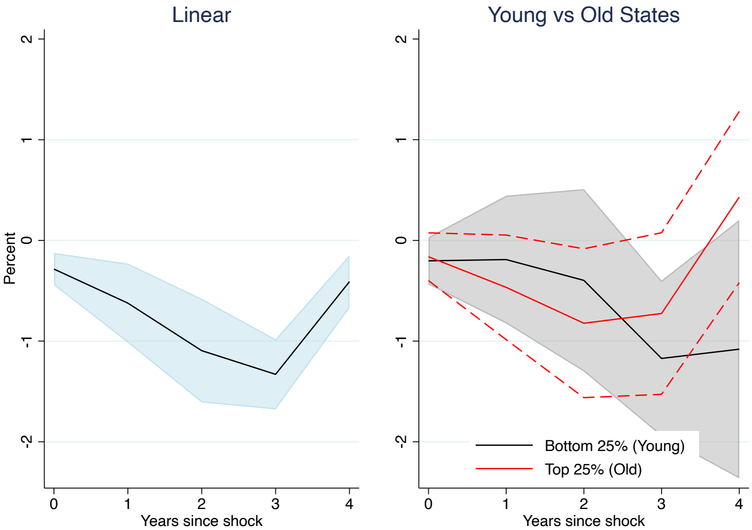
IRF Personal Income, share old



IRF Inflation rate, share old

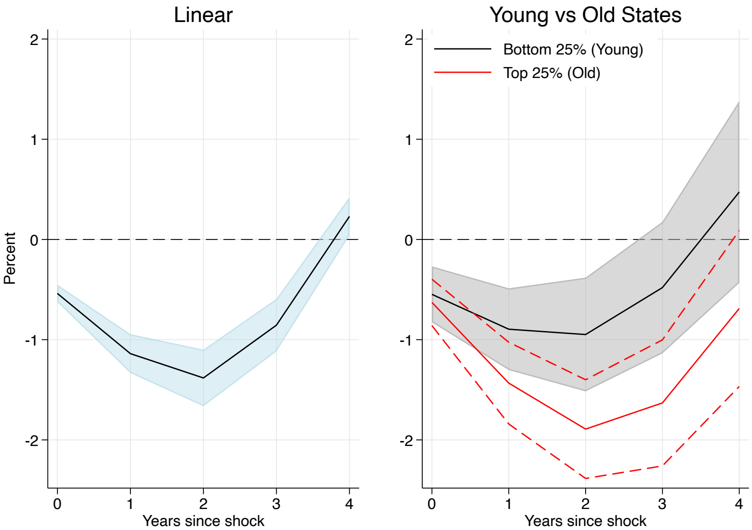


IRF Regional GDP, share old ‣ Back



IRF Regional GDP, services

Back



Lagged birth rates as IV

Baseline regression:

$$y_{i,t+8} = \alpha_i + \beta MP_t + \tau D_{i,t} + \delta MP_t x(D_{i,t} - \bar{D}) + \theta_{i,h} X_{i,t-1} + \gamma X_{t-1} + \epsilon_{i,t}$$

- $y_{i,t+8}$ is the 2 year ahead log of Personal Income
- $D_{i,t}$ share of working population

Regression table:

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS
MP_t	-0.545***	-0.473***	-0.385	
	(0.0905)	(0.0902)	(0.252)	
$D_{i,t}$	-0.000767*	-0.000710*	-0.00747***	-0.00697***
	(0.000434)	(0.000431)	(0.00239)	(0.00229)
$MP_t x(D_{i,t} - \bar{D})$		0.227***	0.649***	1.024*
		(0.0232)	(0.216)	(0.526)
Observations	7701	7701	7392	7392
Controls	YES	YES	YES	YES
State FE	YES	YES	YES	YES
Time FE	NO	NO	NO	NO
First stage F stat.			17.74	22.60

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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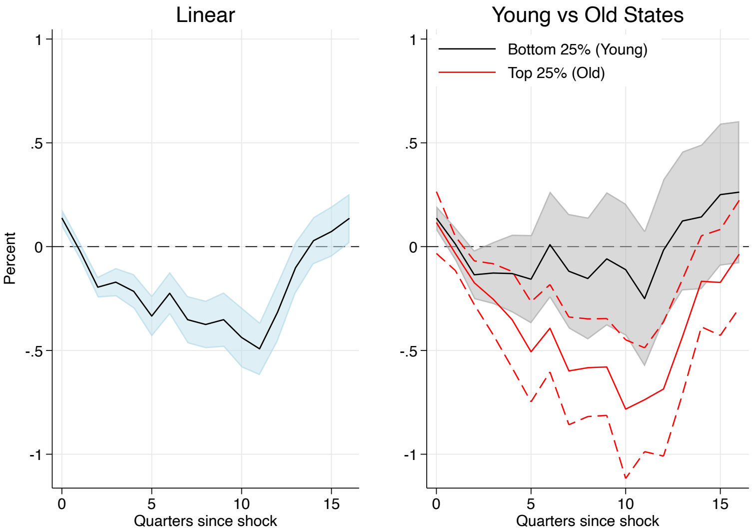
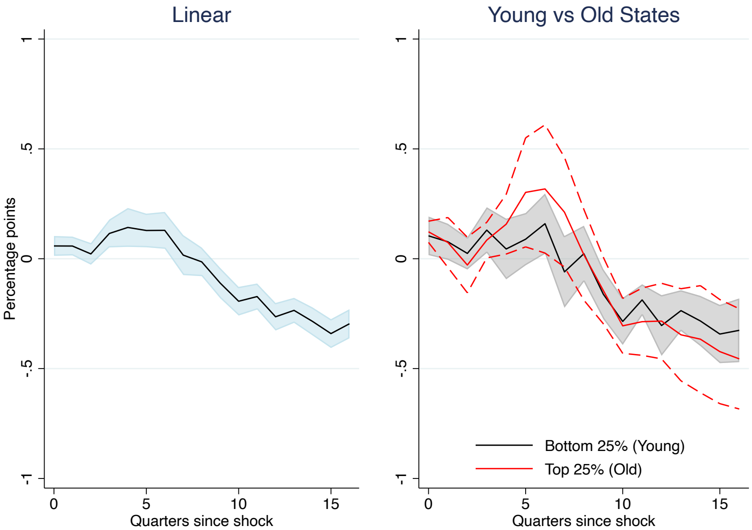
IRF Personal Income, IV

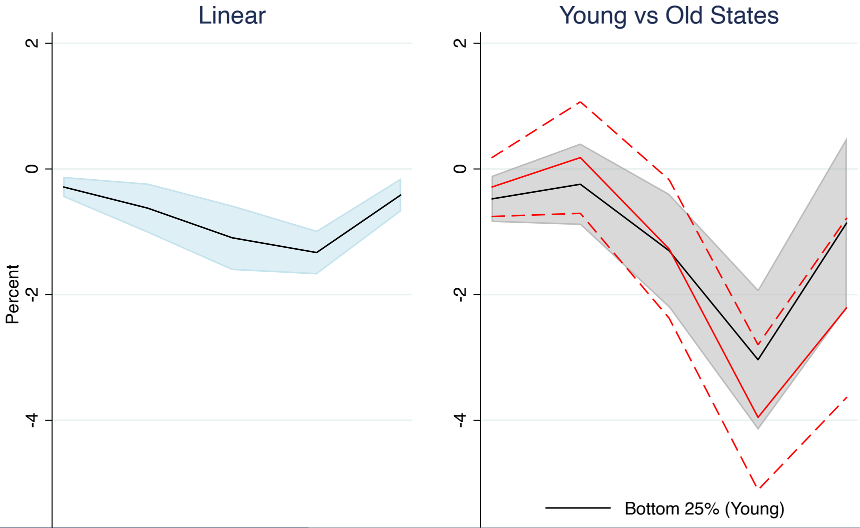


IRF Inflation rate, IV

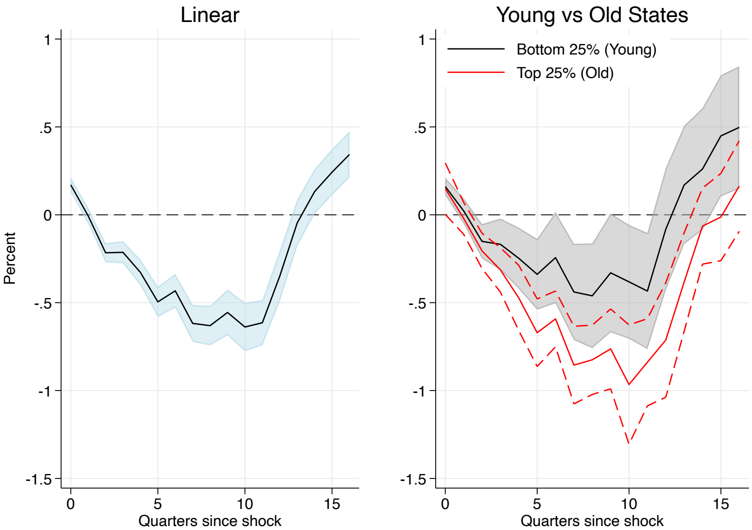


IRF Regional GDP, IV

Back

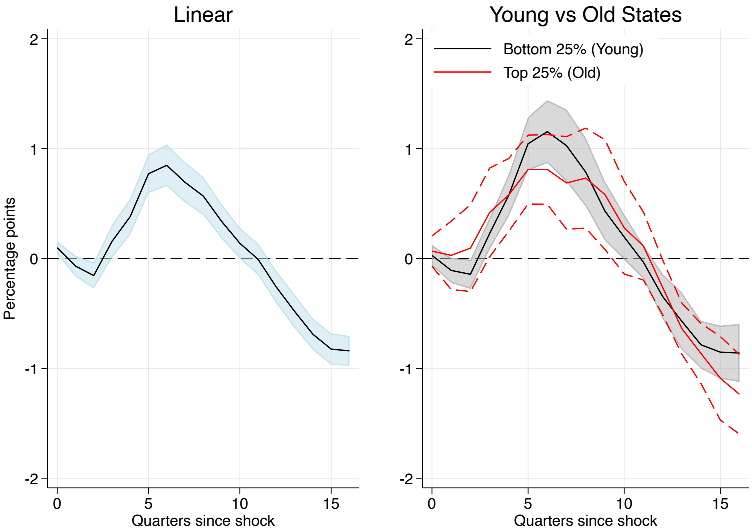


IRF Personal Income, No financial crisis

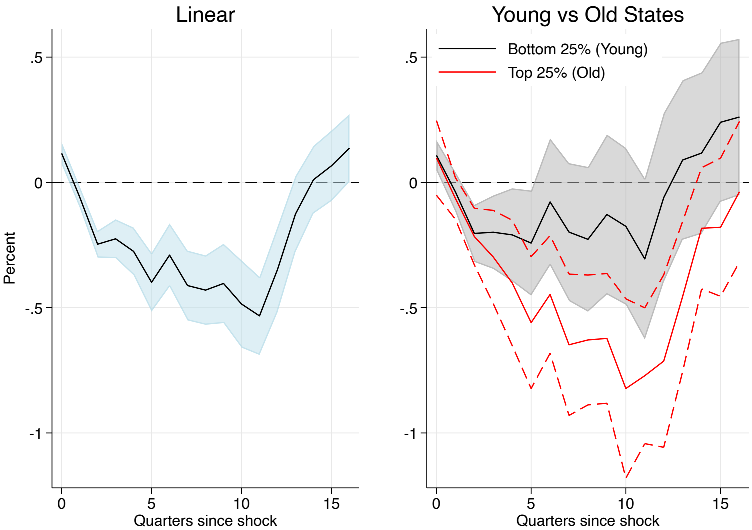


IRF Inflation rate, No financial crisis

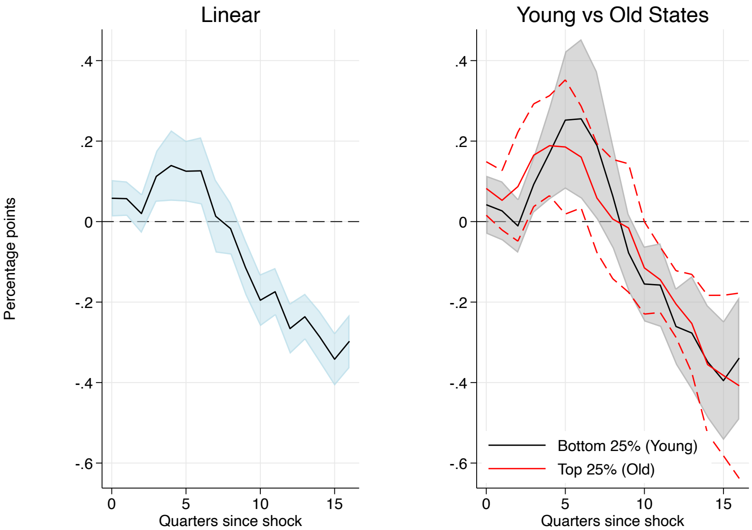
Back



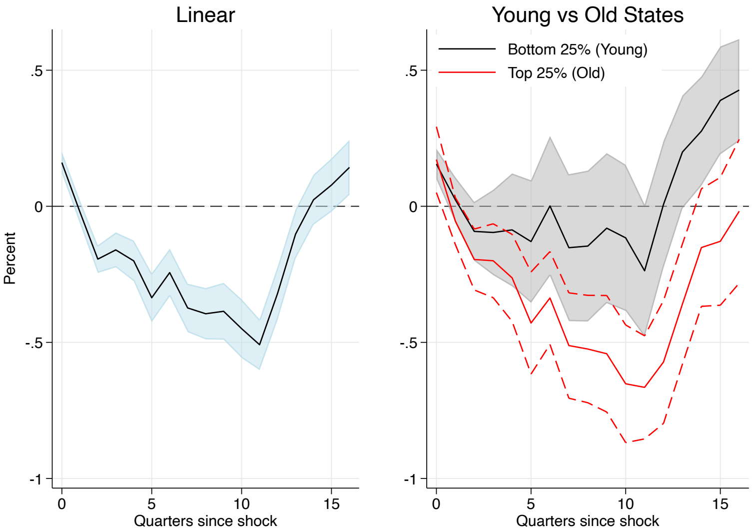
IRF Personal Income, Controlling for income



IRF Inflation rate, Controlling for income ▸ Back

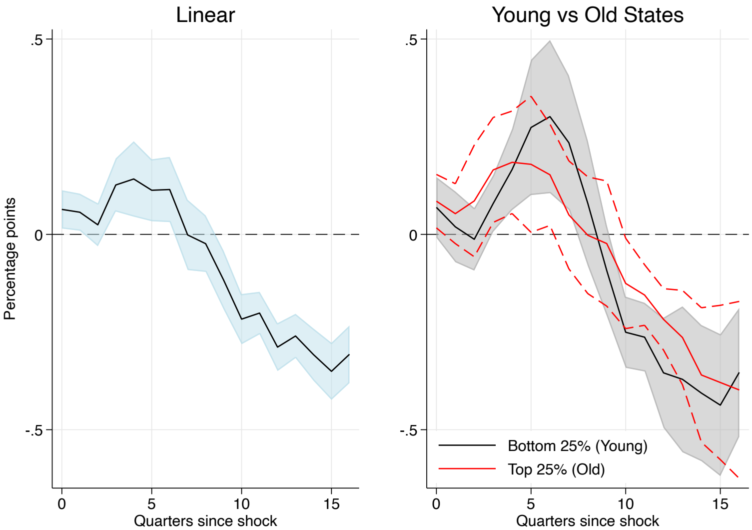


IRF Personal Income, no small states

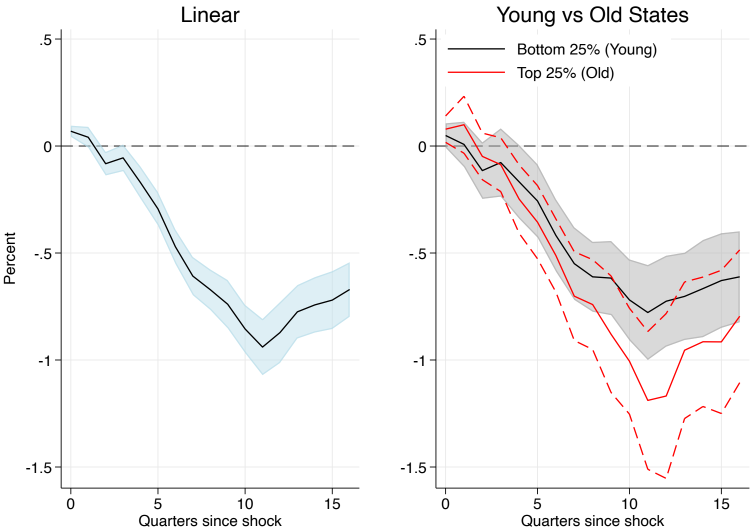


IRF Inflation rate, no small states

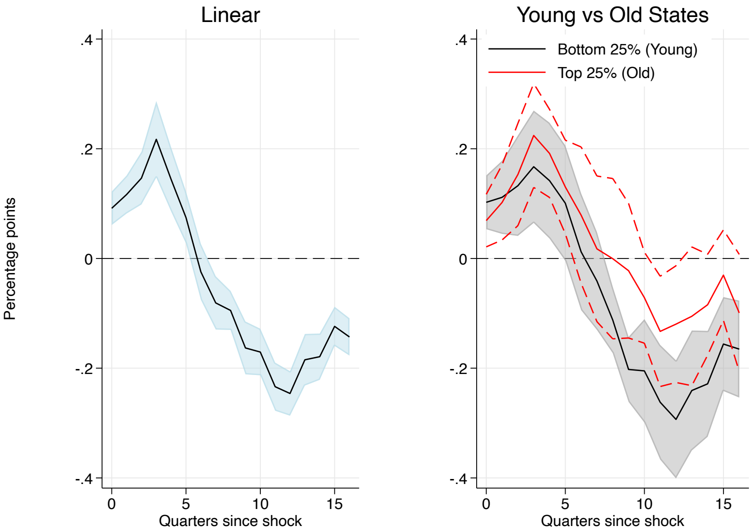
Back



IRF Personal Income, IV-LP

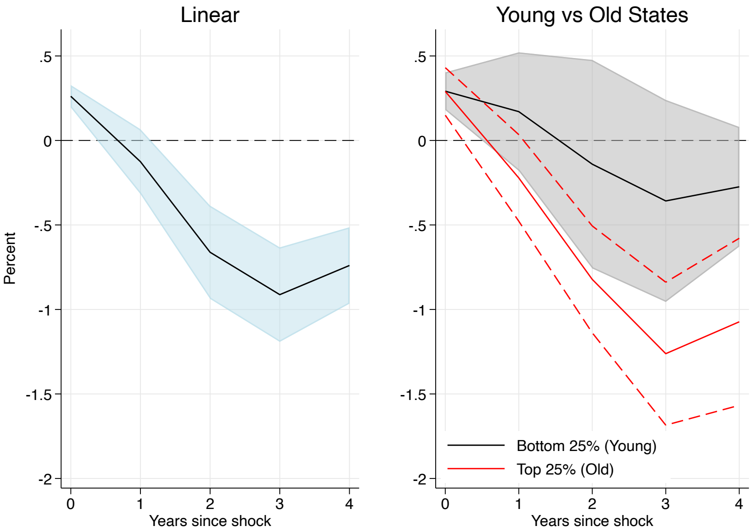


IRF Inflation rate, IV-LP

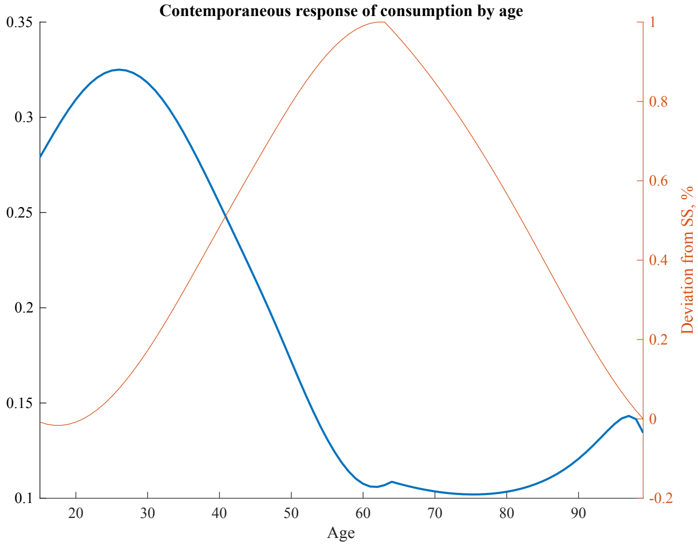


IRF Regional GDP, IV-LP

▸ Back



IRF by age, ▸ Back



Labor efficiency, *Source*: Fullerton (1999)

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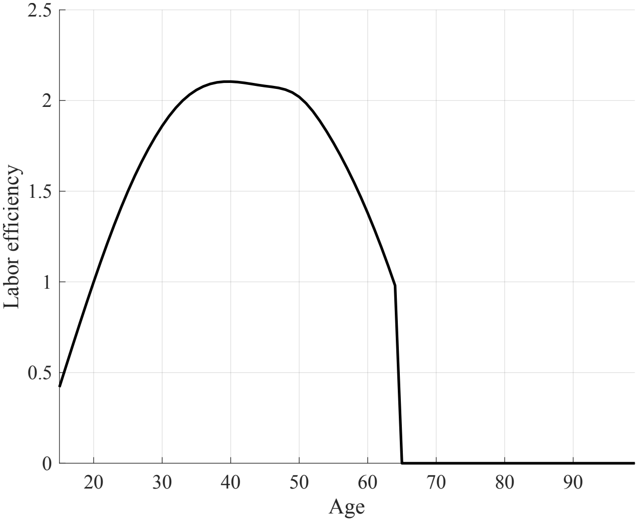
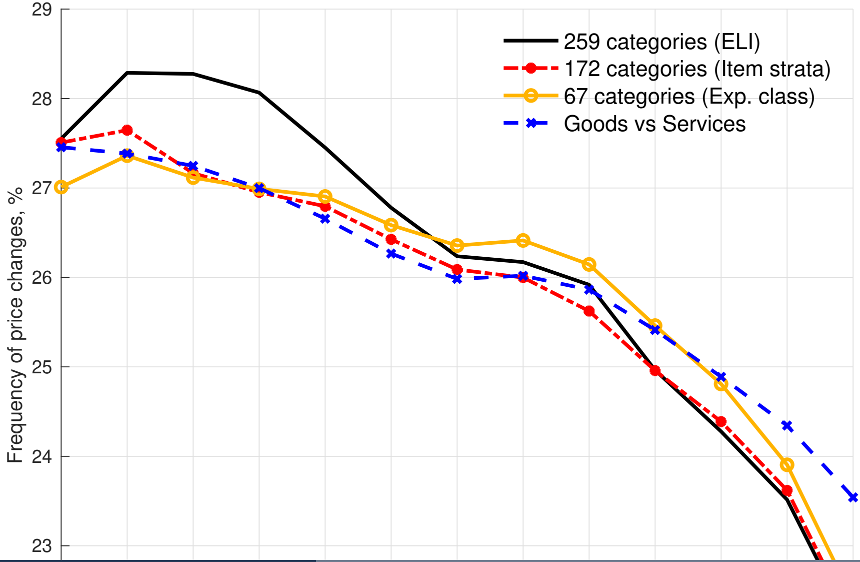


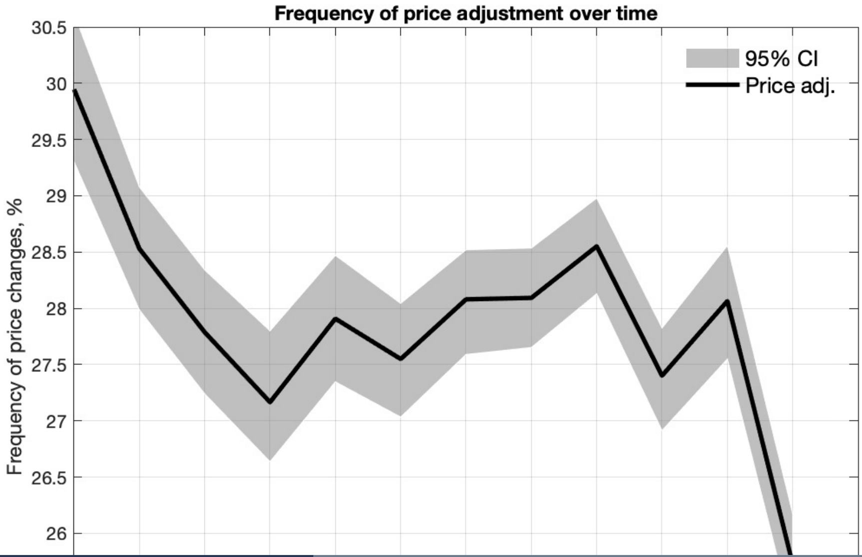
Summary results

Parameters	1980 $\to$ 2010	Parameters $\nearrow$	
		π^{IRF}	$Output^{IRF}$
Service preference α_j	$\nearrow$	$\searrow$	$\nearrow$
Survival probabilities s_j	$\nearrow$	$\nearrow$	$\searrow$
Retirement age jw	$\nearrow$	$\nearrow$	$\searrow$

Frequency of price adjustment across age groups

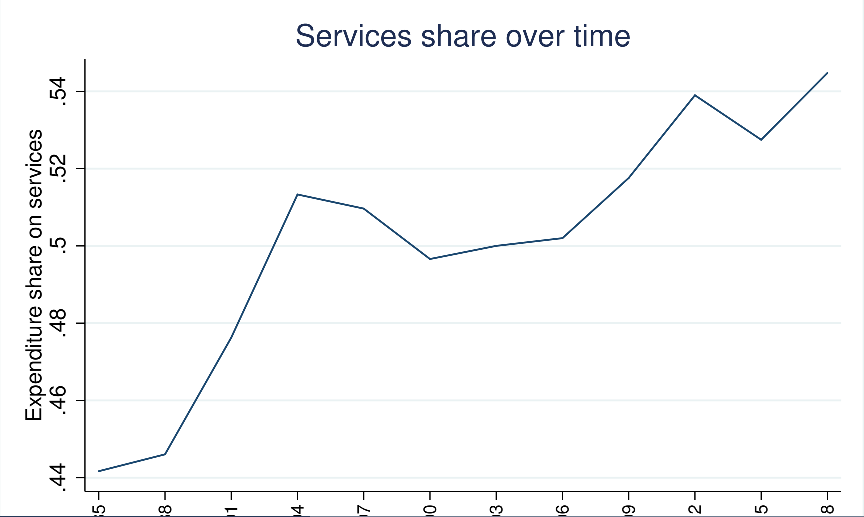


Freq year

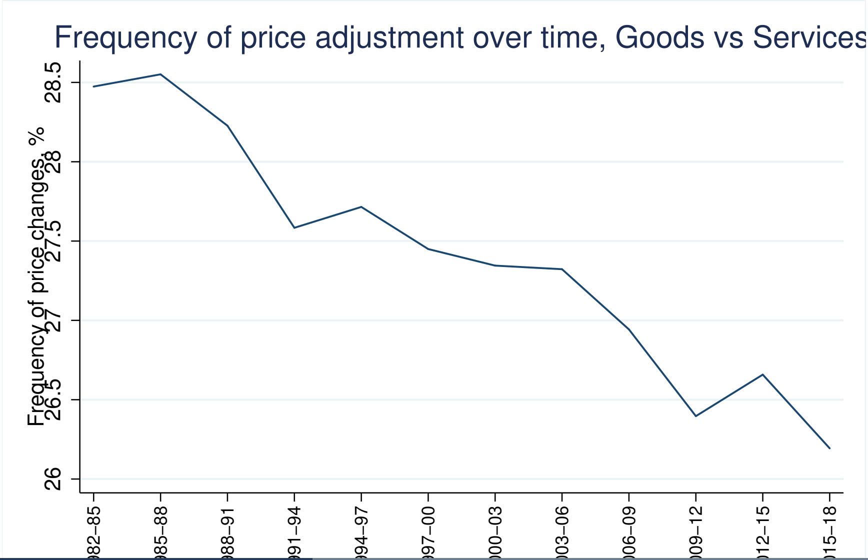

Frequency of price adjustment over time
95% CI
Price adj.
Frequency of price changes, %
30.5
30
29.5
29
28.5
28
27.5
27
26.5
26

Services vs Goods, share

$\theta_{Services}$: 14, θ_{Goods}: 39



Services vs Goods, price stickiness



Expenditure weights

	Age groups						
	25-	(30,35]	(40,45]	(50,55]	(60,65]	(70,75]	80+
Alcohol	2.1	1.4	1.2	1.2	1.2	1.1	0.6
Apparel	5.1	4.8	4.7	4.2	3.8	3.1	2.3
Education	6.7	1.5	2.4	3.9	1.0	0.6	0.4
Energy	3.8	5.0	5.4	5.5	6.0	6.7	7.9
Entertainment	5.9	7.0	7.5	6.9	6.8	6.0	4.4
Food Away	6.1	5.6	5.8	5.8	5.6	5.1	4.1
Food at Home	11.4	12.5	13.0	12.1	12.3	12.9	13.5
Medical	3.4	5.4	6.4	7.6	10.7	15.1	19.0
Household F&O	6.4	9.9	9.1	9.0	9.8	10.1	11.1
Other Lodging	1.2	1.0	1.4	2.0	1.8	2.0	0.9
Owned Dwellings	1.8	6.5	7.5	7.7	8.1	7.6	5.9
Other Expenses	0.9	1.1	1.3	1.4	1.6	1.8	2.4
Personal Care	1.9	1.9	2.0	1.9	1.9	2.0	2.1
Private Transportation	20.5	21.8	21.7	21.6	20.8	17.5	11.3
Public Transportation	1.2	1.3	1.4	1.5	1.8	1.7	1.1
Reading	0.3	0.4	0.4	0.5	0.6	0.7	0.7
Rented Dwellings	19.4	10.8	6.4	4.4	3.7	3.9	10.2
Tobacco	1.3	1.0	1.1	1.2	1.1	0.8	0.4
Water	0.6	1.1	1.2	1.2	1.3	1.5	1.7

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Change in the responsiveness of output

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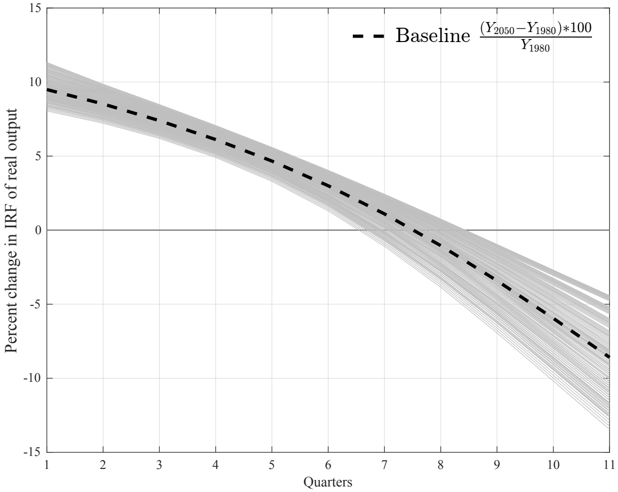

Change in IRFs of output from 1980 to 2050 under different price stickiness parameters