Structural Transformation and the Transmission of Monetary Policy

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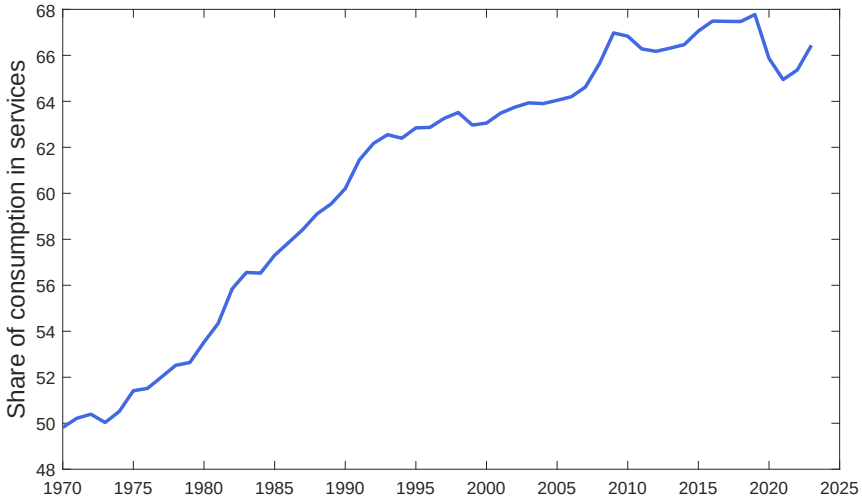
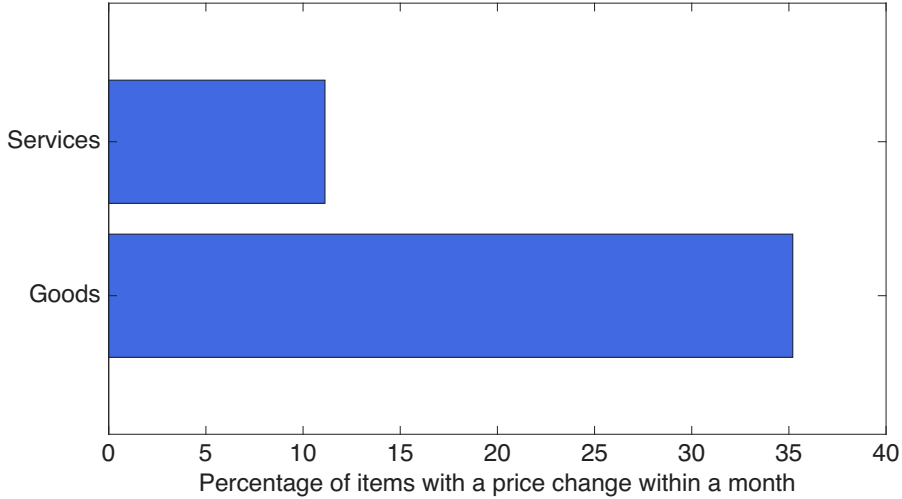
Copenhagen Business School

Modern Economic Growth $\Longrightarrow$ Structural Transformation



Source: U.S. B.E.A. Table 2.3.5

Prices of Services Adjust Less Frequently



Data from BLS compiled by Nakamura and Steinsson (2008)

This Paper

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  - How do changes in the services share shape consumption responses to interest rates?

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     - economies have different services shares
  3. Policy experiment: Increase in the nominal interest rate
     - compare monetary policy transmission across economies with different services shares

Preview of the Quantitative Model Results

1. **Structural Transformation and Monetary Policy Transmission:**
   - over the past 50 years, the rise in services made **monetary policy 21% more powerful**
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3. **Supply Shocks:**
   - structural transformation dampens supply-shock effects by shifting toward less volatile sectors

Related Literature and Contribution

1. **Long-run trends and monetary policy transmission**
   e.g. Boivin and Giannoni (2006), Galesi and Rachedi (2019), Pancrazi and Vukotić (2019), Leahy and Thapar (2022), Mangiante (2025)

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3. **Non-homotheticities for business cycle analysis**
   e.g. Jaimovich et al. (2019), Andreolli et al. (2024), Olivi et al. (2024), Boehnert et al. (2025), Orchard (2025), Becker (2024), Bernardino et al. (2025)

   $\Rightarrow$ HANK with non-homothetic preferences

Plan of the Talk

1. Empirical Analysis
2. Model
3. Taking the Model to the Data
4. Structural Transformation and the Transmission of Monetary Policy
5. Conclusion

Empirical Analysis

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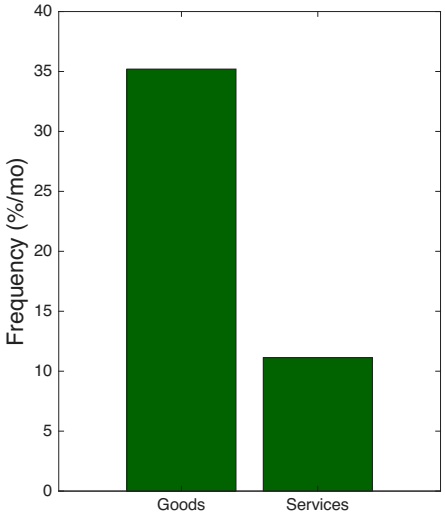

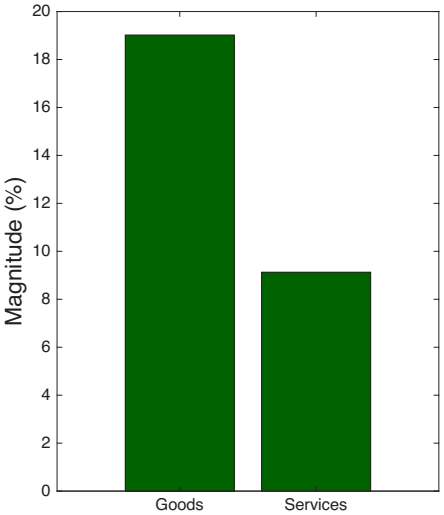

Details about data | Robust to Sales | Robust to dataset | Robust to time period and geography

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Real short-run responses to monetary policy have increased over time

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$$\Delta \log C_{t+h|t-1} = \alpha_h + \beta_h \epsilon_t^M + \gamma_h X_t + \varepsilon_{t+h}, \text{ for } h = \{0, 1, ..., 12\}$$

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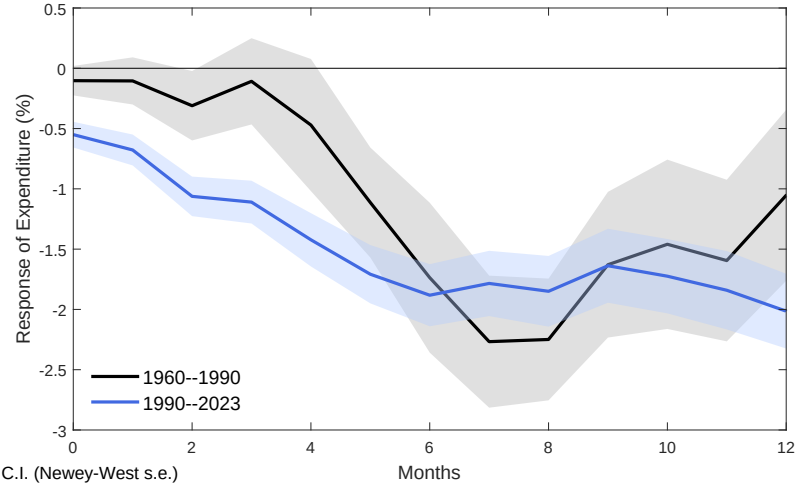

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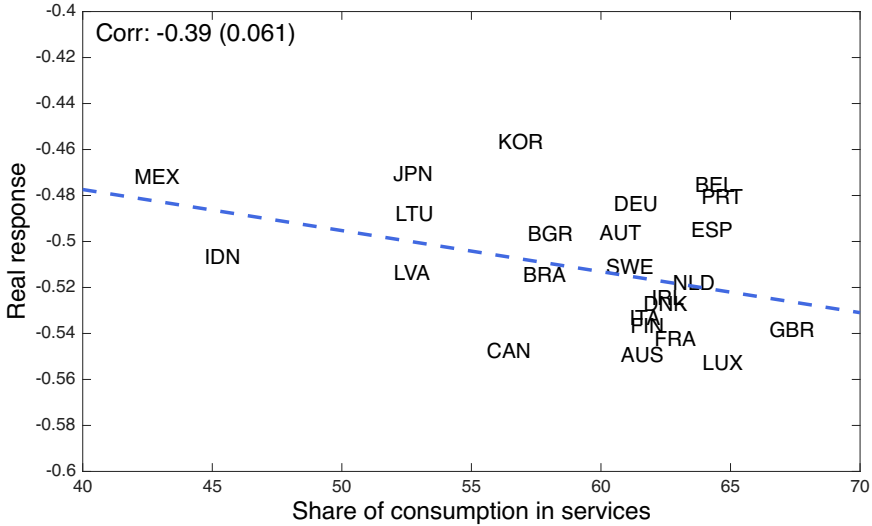

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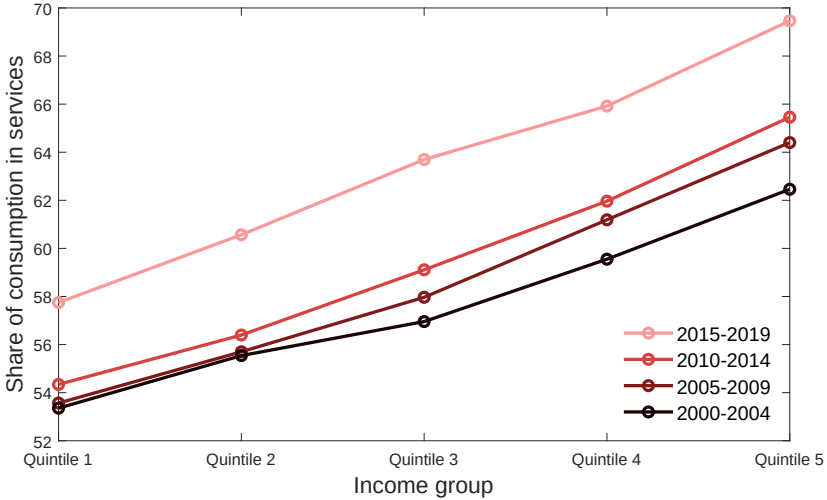
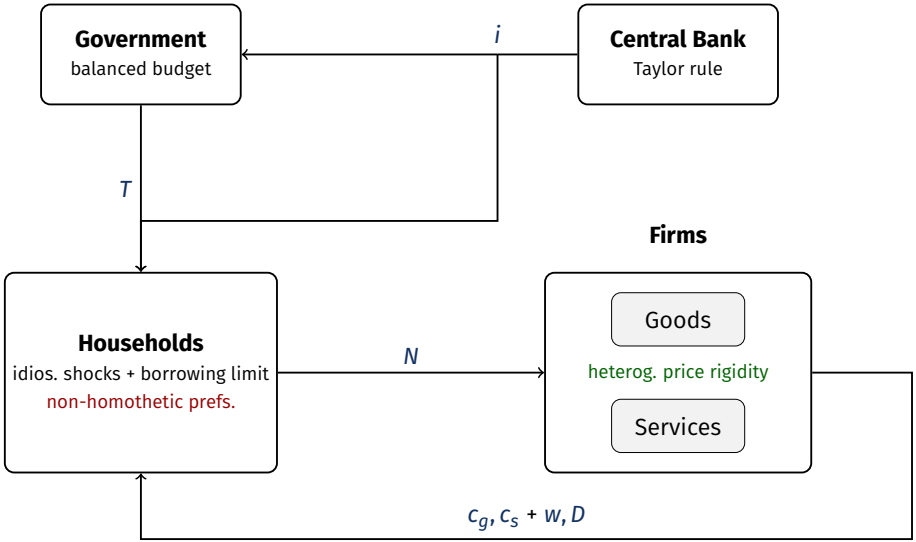


Details about data | Details about methodology | Robust to age | Robust to income extremes

Model

Model Overview

A two-sector HANK model with non-homothetic preferences



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$$\mathcal{U} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, h_t)$$

  - c is implicitly defined through a non-homothetic CES aggregator (Comin et al., 2021):

$$1 = (\Omega c^{\epsilon})^{\frac{1}{\sigma}} c_s^{\frac{\sigma-1}{\sigma}} + (c)^{\frac{1}{\sigma}} c_g^{\frac{\sigma-1}{\sigma}}$$

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- **Two-stage budgeting:**
  - Intertemporal consumption-savings decision with static labor supply choice
  - Intratemporal consumption allocation between goods and services

I. Households

The intratemporal sectoral expenditure allocation

- Given $\{p_m\}_{m\in\{g,s\}}$ and c, households solve the following **expenditure minimization problem**:

$$\min_{\{c_s,c_g\}} E\left(c_s, c_g; p_s, p_g\right) = p_g c_g + p_s c_s$$

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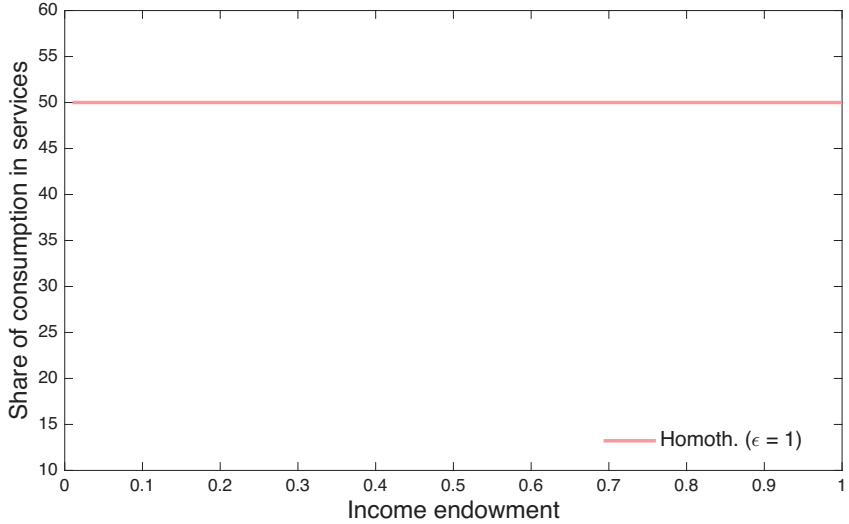
- Solution: (Hicksian) **demands**

$$c_g = \left(\frac{p_g}{E}\right)^{-\sigma} c^{1-\sigma} \text{ and } c_s = \left(\Omega\frac{p_s}{E}\right)^{-\sigma} c^{\epsilon(1-\sigma)}$$

I. Households

Static non-homothetic CES illustration



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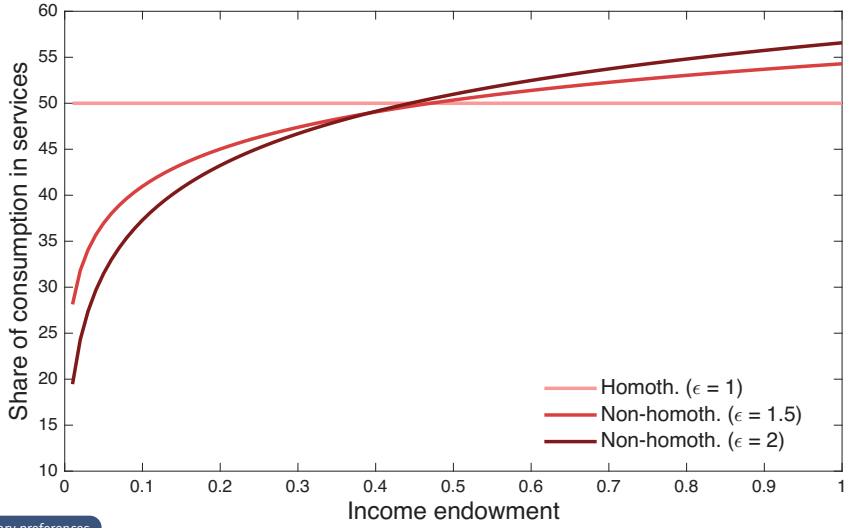

Compare with Stone-Geary preferences

I. Households

The intertemporal consumption-savings decision problem

The intertemporal recursive representation of the household problem:

$$
\begin{aligned}
V(\omega, b; \Xi) = \max_{\{c, b', h\}} \quad & u(c, h) + \beta \mathbb{E}\left[V(\omega', b'; \Xi')\right] \\
\text{s.t.} \quad & E + p_b b' = w\omega h + (p_b + i)b + T + D \\
& E = \left[(p_g c)^{1-\sigma} + \Omega\,(p_s c^{\epsilon})^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \\
& \Xi' = \Psi(\Xi) \\
& c \geq 0,\ b' \geq 0,\ h \in (0, 1),
\end{aligned}
$$

with $u(c, h) = \frac{c^{1-\gamma}-1}{1-\gamma} - \chi \frac{h^{1+\eta}}{1+\eta}$ and $\omega \sim$ log-AR(1)

— Dividends are distributed according to households' productivity

II. Firms

Two-sector production and price setting

- The economy features two sectors: **goods** and **services**
- In each sector, a **final producer** aggregates a continuum of differentiated intermediate inputs

$$Q_m = \left(\int_0^1 q_m(j)^{\frac{\theta_m - 1}{\theta_m}} dj \right)^{\frac{\theta_m}{\theta_m - 1}}$$

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  - sector-specific costs of price adjustment, κ_m (Rotemberg, 1982)
- Optimal price setting implies the sectoral **New-Keynesian Phillips Curves**:

$$\log(1 + \pi_{m,t}) = \frac{\kappa_m}{\theta_m} \left(1 - \theta_m + \theta_m \frac{w_t}{Z_m P_{m,t}} \right) + \frac{1}{1 + i_t} (1 + \pi_{m,t+1}) \log(1 + \pi_{m,t+1}) \frac{Q_{m,t+1}}{Q_{m,t}}$$

III. Government and Monetary Authority

- There is a **government** that collects taxes to finance interest on public debt

$$p_{b,t}B = \int (p_{b,t} + i_t) b_t d\Xi + T_t$$

with B being a fixed amount of public debt

- The **monetary authority** sets nominal interest rate according to a **Taylor rule**

$$i_t = i_{SS} + \phi \pi_{t-1} + \varepsilon_t^M$$

with $\varepsilon^M \sim$ AR(1),
and π being the CPI inflation

Equilibrium definition

Taking the Model to the Data

Model Estimation

Strategy and Procedure

- Goal of the model: Represent the U.S economy...
  - **long-run:** economic activity shift towards services
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- ... to study how **structural transformation** changes **MP transmission**
  - compare dynamics around two steady-states: 1970 vs. 2019
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  - steady-states only differ in terms of sectoral productivity levels
- Start with the 2019 steady-state:
  1. **Demand estimation:** to obtain the price and income elasticities Estimation details
     - using price and consumption data, estimate the level of non-homotheticity
  2. **Pre-estimated parameters:** directly observed parameters in the data Params. details
     - including sectoral productivity growth rates and price rigidities
  3. **Simulated method of moments:** hours worked and the 2019 services share SMM details
     - match the values in 2019

Building Counterfactual Economies

- What I do:
  1. Start from 2019: services share = 67.3%
  2. Change **sectoral productivities** (Z_g, Z_s):
     - goods = 2.2%/year
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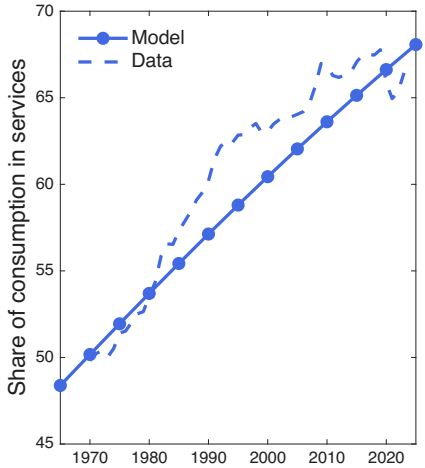
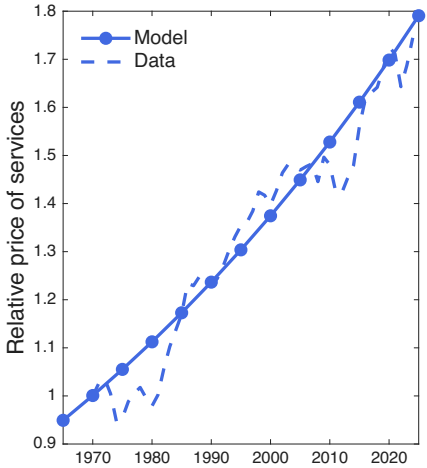
- My theory of structural transformation:
  1. **Cost-disease channel:** productivity growth differentials change the relative price
  2. **Non-homotheticity channel**: Creates an inc. effect that shifts consumption toward "luxuries"

Model Fit: Across Time





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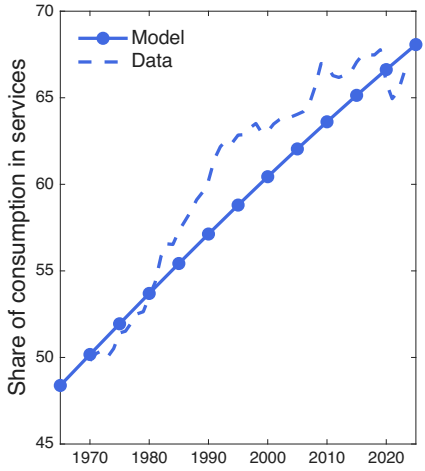
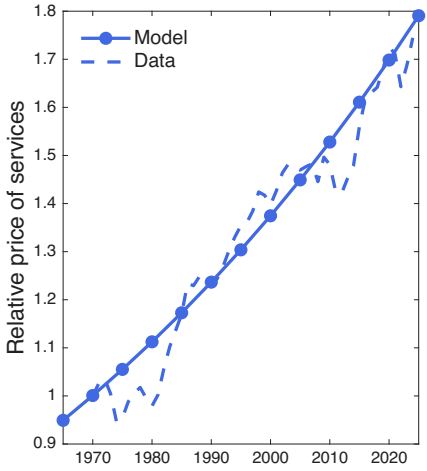
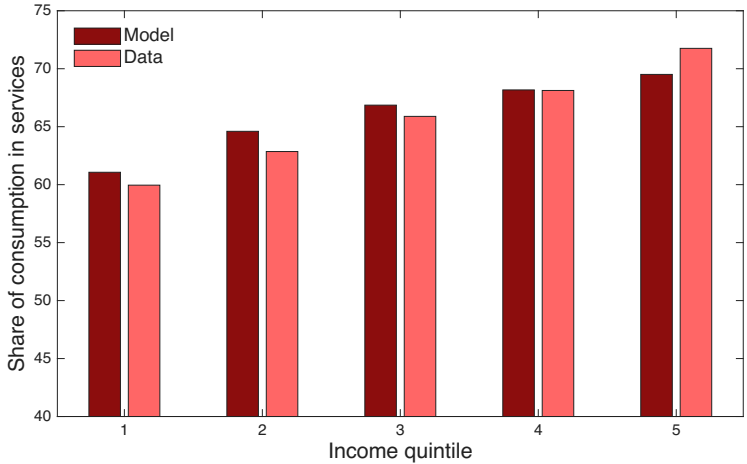




- **Hours worked:** decline 0.1%/year (data 1980–2023: -0.1%/year)

Model Fit: Cross-Section in 2019

Match of Engel curve in 2000



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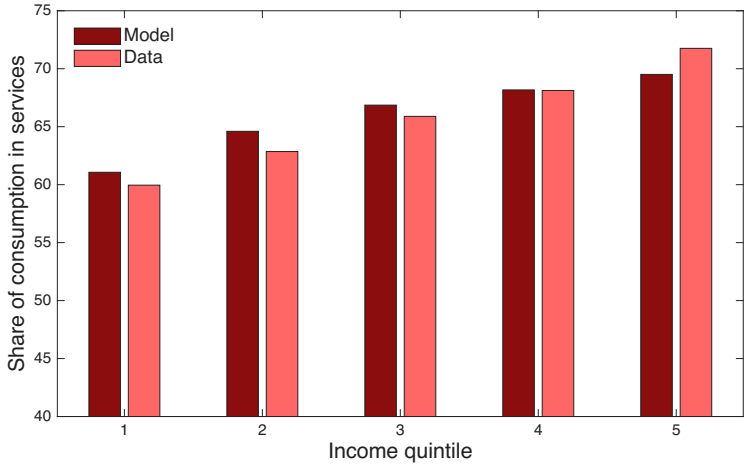

- **Average annual MPC**: 28% (data: 20 – 60%) MPC distribution
- **Share of Hand-to-Mouth**: 23.4% (data: 17.3%) Other wealth distribution moments

Structural Transformation & Monetary Policy Transmission

Monetary Policy Shock

- Economy is in the steady-state 1970 SS 2019 SS

- **Monetary shock:** the Central Bank increases the nominal interest rate by 100 bp
  - Unexpected and never-to-occur again (Boppart et al., 2018)
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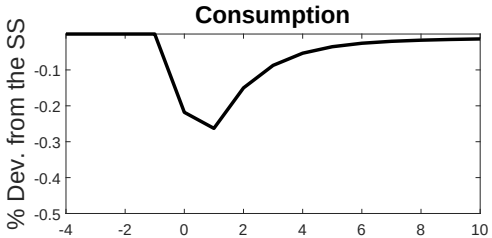
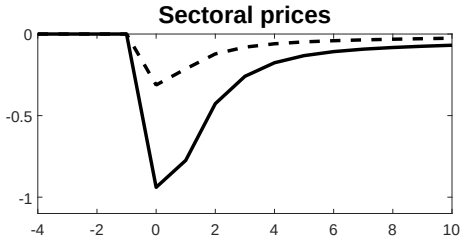
- Monetary policy shock operates through:
  - **Direct channel:** income and substitution effects
  - **Indirect channel:** GE effects through wages and taxes

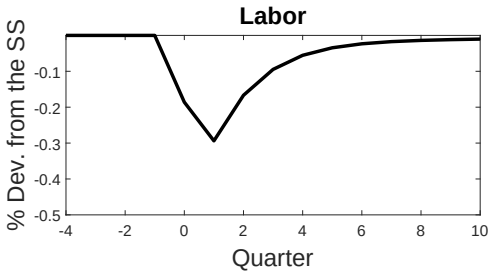
Response to Monetary Policy

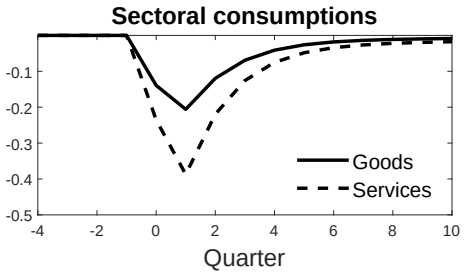
More: Demand Composition

Aggregate responses to a 100 bp contractionary shock: 1970 vs. 2019









Structural Transformation and Monetary Policy

More years

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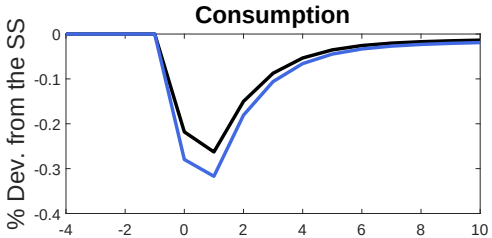

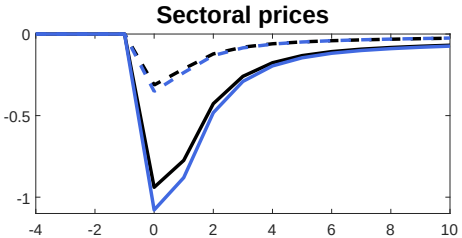

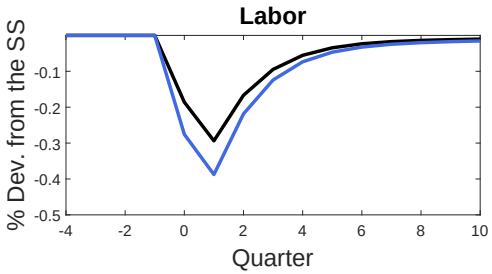

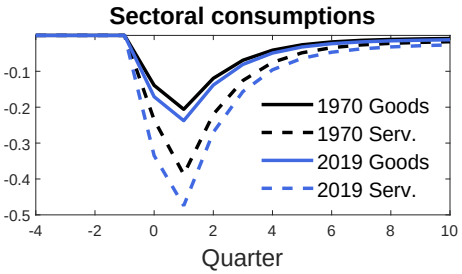

Structural Transformation and the Slope of the Phillips Curve

	(1) Baseline		(2) Homog. κ_m	(3) Homothetic
	1970	2019		
Service share	51.3	67.3		
MPC	8.1	7.6		
Consump. response (% change vs. 1970)	20.6			
Price of goods response (% change vs. 1970)	13.7			
Price of serv. response (% change vs. 1970)	10.7			

Structural transformation contributes to stronger real responses relative to price responses

Contribution of structural transformation channels

The Role of Heterogeneous Price Rigidities

Counterfactual: set $\kappa_g = \kappa_s$ (Hagedorn et al., 2019)

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Service share	51.3	67.3	51.3	67.3	
MPC	8.1	7.6	8.1	7.6	
Consump. response (% change vs. 1970)	20.6		3.5		
Price of goods response (% change vs. 1970)	13.7		5.9		
Price of serv. response (% change vs. 1970)	10.7		5.9		

Heterogeneous price rigidities explain 80% of the increase in the real effects of MP

The Role of Non-Homothetic Preferences

Counterfactual: set $\epsilon = 1$ and recalibrate to match services share in 1970 and 2019 using Ω

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	(1) Baseline		(2) Homog. κ_m		(3) Homothetic	
	1970	2019	1970	2019	1970	2019
Service share	51.3	67.3	51.3	67.3	51.0	67.2
MPC	8.1	7.6	8.1	7.6	8.6	8.4
Consump. response (% change vs. 1970)	20.6		3.5		24.1	
Price of goods response (% change vs. 1970)	13.7		5.9		6.3	
Price of serv. response (% change vs. 1970)	10.7		5.9		3.5	

Non-homotheticities $\Longrightarrow \uparrow$ precautionary saving motive $\Longrightarrow \downarrow$ MPC $\Longrightarrow \downarrow$ real effects

Taking Stock

- Structural transformation provides an explanation for the **flattening of the Phillips Curve**
  - Structural transformation increases the service share in the economy
  - Services are characterized by a high price rigidity

    $\Longrightarrow$ over the past 50 years, the rise in services made **monetary policy 21% more powerful**

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    - aggregate welfare cost of contractionary monetary policy increases
    - Inequality of welfare costs of contractionary monetary policy increases

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  - **Heterogeneity and Welfare:** Details
    - aggregate welfare cost of contractionary monetary policy increases
    - Inequality of welfare costs of contractionary monetary policy increases
  - **Supply Shocks:** Details
    - structural transformation dampens supply-shock effects
    - Why? Services are a less price-volatile sector

Conclusion

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- **This paper:** Sectoral composition matters for the transmission of monetary policy
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  - The **rise in the services share** from 1970 to 2019 **increased monetary non-neutrality by 21%**

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- **Policy implications:**
  - supply disruptions, aging $\Longrightarrow$ changes in services share $\Longrightarrow$ changes in MP effects
  - monetary policy in common currency areas (E.A., U.S.) with heterogeneous sectoral composition

Research Agenda: Fiscal and Monetary Policy Effectiveness

- **Monetary Policy:**
  - Structural Transformation and the Transmission of Monetary Policy

- **Fiscal Policy:**
  - The Full, Persistent, and Symmetric Pass-Through of a Temporary VAT Cut (J. of Public Economics) with R. D. Gabriel, J. Quelhas, and M. Silva-Pereira
  - The Heterogeneous Effects of Supply Shocks in Necessity Goods with P. Brinca, S. Darougheh, and M. Silva-Pereira
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Thank You!

Appendix

#1: Data and Methodology

Back

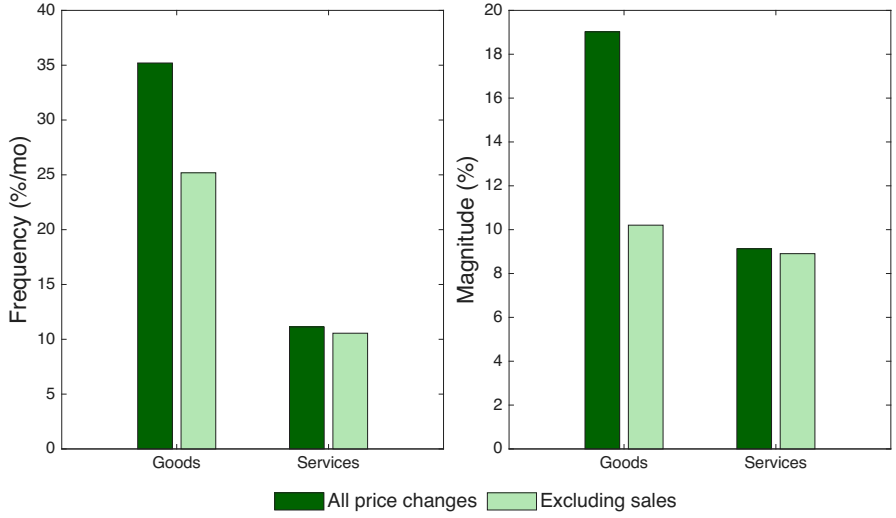
- **Data:** Summary statistics about price frequency assembled by Nakamura and Steinsson (2008)
  - Source: BLS monthly microdata that underlies the U.S. CPI, covering 70% of expenditures

Category	Weight	Freq. (Reg)	Freq. (All)	Magnitude (Reg)	Magnitude (All)
Processed food	8.2	10.5	25.9	13.2	26.5
Unprocessed food	5.9	25.0	37.3	14.2	27.1
Household furnishing	5.0	6.0	19.4	8.7	20.8
Apparel	6.5	3.6	31.0	11.5	30.2
Transportation goods	8.3	31.3	31.3	6.1	6.1
Recreation goods	3.6	6.0	11.9	10.1	18.9
Other goods	5.4	15.0	15.5	7.3	10.0
Utilities	5.3	38.1	38.1	6.3	6.3
Vehicle fuel	5.1	87.6	87.6	6.4	6.4
Travel	5.5	41.7	42.8	21.6	21.9
Services (excl. travel)	38.5	6.1	6.6	7.1	7.3
All sectors	100.0	8.7	19.4	8.5	10.7

- **Methodology:** Aggregate by goods and services categories (BEA classification)

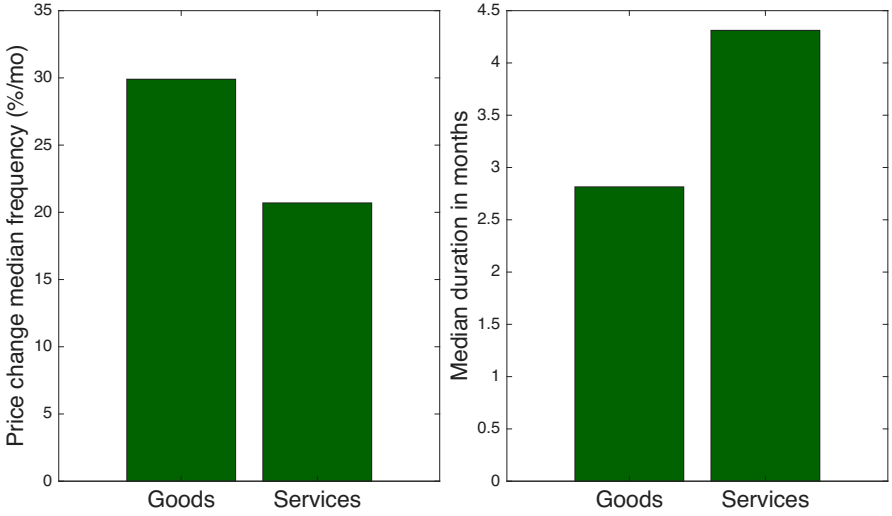
#1: Robustness Back

Excluding Sales



#1: Robustness Back

Using Bils and Klenow (2004) dataset



#1: Robustness

Back

Using Gautier et al. (2022)

- Data from Table 6 of Gautier et al. (2024)
- The data to compute the frequency for the period 1996–2001 comes from Dhyne et al. (2006)
- The representativeness of the consumer basket is relatively small (between 10–20%)

	Category	1996–2001	2011–2017
Frequency	Processed Food	13.6	15.6
	NEIG	9.4	13.1
	Services	5.0	6.2
Size increase	Processed Food	6.6	8.1
	NEIG	8.5	9.5
	Services	6.3	5.9
Size decrease	Processed Food	7.4	9.6
	NEIG	11.7	13.2
	Services	10.4	8.1

#2: Data Back

- **Local Projections Exercise:**
  - Total personal expenditure (BEA Tables)
  - Romer and Romer (2023) narrative MP shocks: October 1947 (-), August 1955 (-), September 1958 (-), December 1968 (-), January 1972 (+), April 1974 (-), August 1978 (-), October 1979 (-), May 1981 (-), December 1988 (-), and September 2022 (-)

- **Correlation Exercise:**
  - Galesi and Rachedi (2019) SVAR model (Y_t, π_t, i_t) estimates with sign restriction identification
  - 20-year average services share from national accounts

#3: Data Back

- **Consumer Expenditure Survey (CEX)**
  - curated by the U.S. B.L.S.
  - used to compute the relative importance of goods and services in the CPI basket
- **Coverage**
  - time frame: Between 2000 and 2022
  - each wave has between 5 000 – 8 000 households
- **Consumption and Expenditure data**
  - household expenditure by broad categories (e.g., food at home, education)
  - demographic variables (income, age, household composition, etc.)

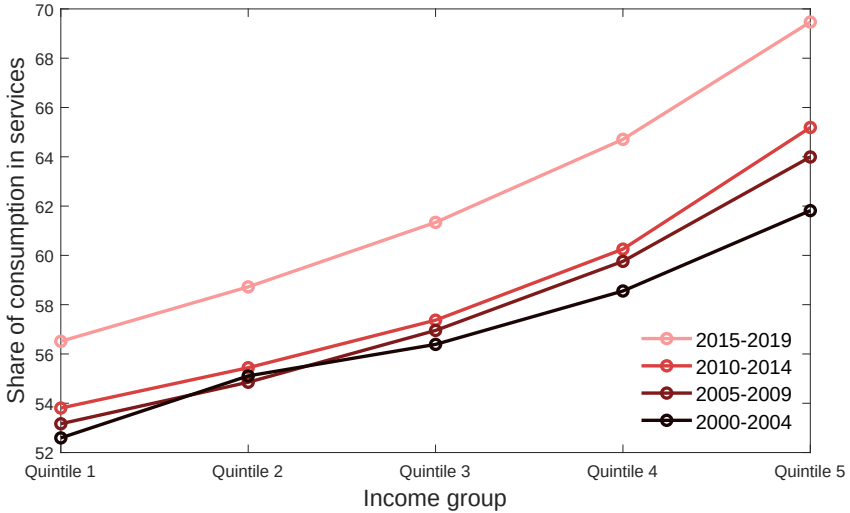
#3: Methodology Back

1. Household **sample selection**:
   - keep those who participate in the 4 waves
   - household head age between 25 and 64
2. Divide households into **5 income groups** (similar to Aguiar and Bils, 2015):
   - income = pre-tax income + alimony + gifts + gambling winnings + inheritance
   - regress income on household size, average age of household earners' head, and no income earners
   - from the regression residuals build 5 income groups
3. Classify non-durable expenditure by **economic activity**:
   - Services: Food Away, Education, Public Transportation, Health Care, Utilities, Personal Care, Entertainment, Other Vehicle Expenses
   - Goods: Food and Alcohol at Home, Apparel, Tobacco and Gasoline
4. Compute the **average share of consumption** in services along time

#3: Robustness

Back

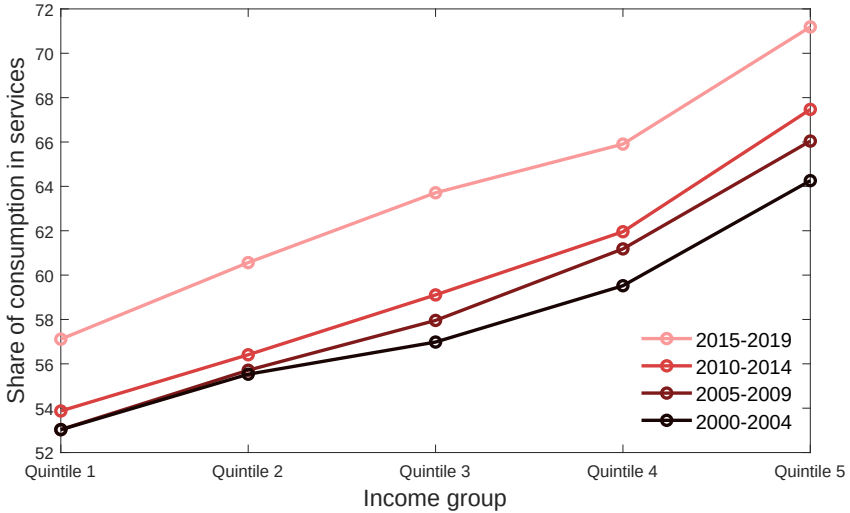
Excluding old households



#3: Robustness

Back

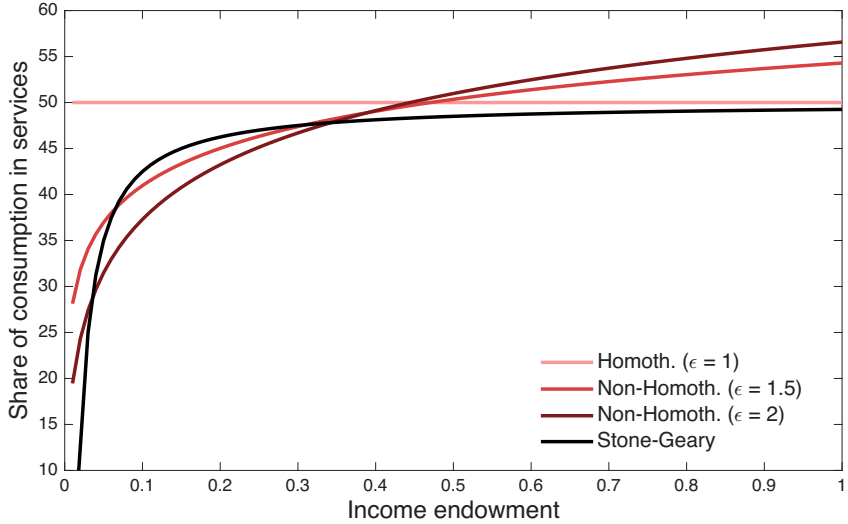
Including bottom and top 5%



Static non-homothetic CES illustration

Back

Comparison with Stone-Geary class



Competitive Equilibrium

Back

Definition: A competitive equilibrium is a sequence of lump-sum transfers T_t; interest rates i_t; value functions V_t with policy functions $\hat{c}_{g,t}, \hat{c}_{s,t}, \hat{h}_t$ and $\hat{b}_t$; prices p_t^b, p_t^g, p_t^s, and w_t; profits $\pi_{g,t}$ and $\pi_{s,t}$; and a law of motion Ψ, such that:

1. V_t satisfies the Bellman Equation, with the solution given by the policy functions $\hat{c}_{g,t}, \hat{c}_{s,t}, \hat{h}_t$ and $\hat{b}_t$ given sequences of lump-sum taxes, prices, interest rate and dividends.
2. Firms maximize profits, which are distributed in the form of dividends to households.
3. The government runs a balanced budget.
4. For all Ξ_t, the asset, labor, and goods markets clear.
5. The aggregate law of motion of the distribution, Ψ, is generated by the savings policy function.

1. Demand Estimation Back

- Preferences depend on the income elasticity, ϵ, and the price elasticity, σ

1. Demand Estimation

Back

- Preferences depend on the income elasticity, ϵ, and the price elasticity, σ
- The **relative demand** between the service sector and the goods sector is:

$$\log\left(\frac{\nu_{s,t}}{\nu_{g,t}}\right) = (1-\sigma)\log\left(\frac{p_{s,t}}{p_{g,t}}\right) + (1-\sigma)(\epsilon-1)\log\left(\frac{E_t}{p_{g,t}}\right) + (\epsilon-1)\log\nu_{g,t} + \log(\Omega),$$

where $\nu_{m,t}$ is the expenditure share in sector m at time t

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  where $\nu_{m,t}$ is the expenditure share in sector m at time t

- Using GMM, estimate σ and ϵ
  1. Use household-level consumption data 2000–2020 (CEX)
  2. Controls: dummies for age groups, number of earners, and family size
  3. IV Rel. Prices: average price across regions excluding the own region
  4. IV Expenditure: annual household income and the income quintile of the household

1. Demand Estimation

Back

Results

$$\log\left(\frac{\nu_{s,t}^n}{\nu_{g,t}^n}\right) = (1-\sigma)\log\left(\frac{p_{s,t}^n}{p_{g,t}^n}\right) + (1-\sigma)(\epsilon-1)\log\left(\frac{E_t^n}{p_{g,t}^n}\right) + (\epsilon-1)\log\nu_{g,t}^n + \zeta^n + \tilde{\zeta}_t^n,$$

	(1)	(2)	(3)
σ	0.209	0.176	0.234
	(0.044)	(0.039)	(0.051)
ϵ	1.619	1.667	1.731
	(0.061)	(0.058)	(0.080)
Region FE	N	Y	Y
Year $\times$ Quarter FE	N	N	Y

2. Externally Calibrated Parameters

Back

Parameter	Description	Value	Source
I. Household			
β	Discount factor	0.99	Standard (quarterly model)
γ	CRRA	1.20	Standard
η	Frisch elasticity	1.00	Chetty et al. (2011)
ρ_z	Persistence of idiosync. productivity	0.99	Krueger et al. (2016)
σ_z	Std. dev. of idiosync. productivity	0.10	Krueger et al. (2016)
II. Firm			
θ_g	Elasticity of substitution (goods)	5.8	Marto (2024)
θ_s	Elasticity of substitution (services)	4.7	Marto (2024)
κ_g	Price adjustment cost (goods)	8.5	Data
κ_s	Price adjustment cost (services)	89.2	Data
Z_g^{2019}	Goods productivity	1	standardized
Z_s^{2019}	Services productivity	0.6	match 2019 relative price

3. Simulated Method of Moments

Back

- Parameters calibrated with SMM: χ, and Ω
- Use them to match 2 moments: average hours worked and agg. services share in 2019
- I match the moments in the steady-state
- Goal: Minimize loss function

$$\min_{\chi,\Omega} \mathcal{L} = ||M_m - M_d||$$

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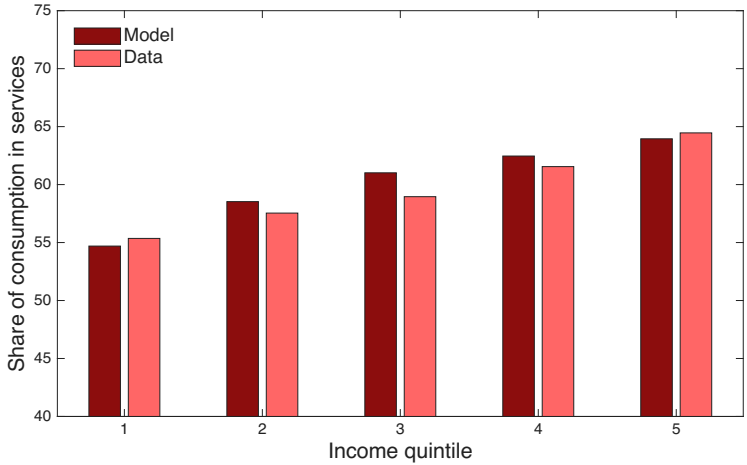
Moment	Model Mom.	Data Mom.	Data Source	Parameter	Param. Value
Average hours worked	0.217	0.212	OECD	χ	30.0
Average service share 2019	0.673	0.678	BEA	Ω	7.0

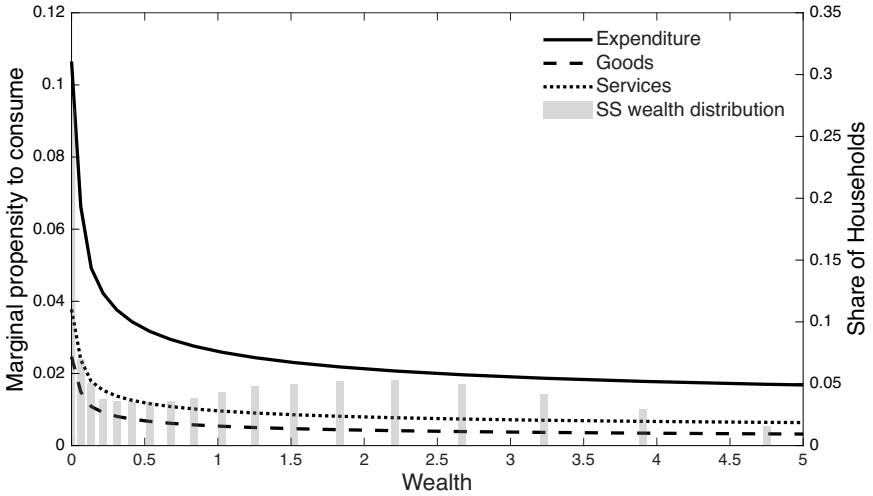
Model Fit: Engel Curve in 2000 Back



Model Fit

Back

Short-run household behavior: Quarterly marginal propensity to consume



Model Fit

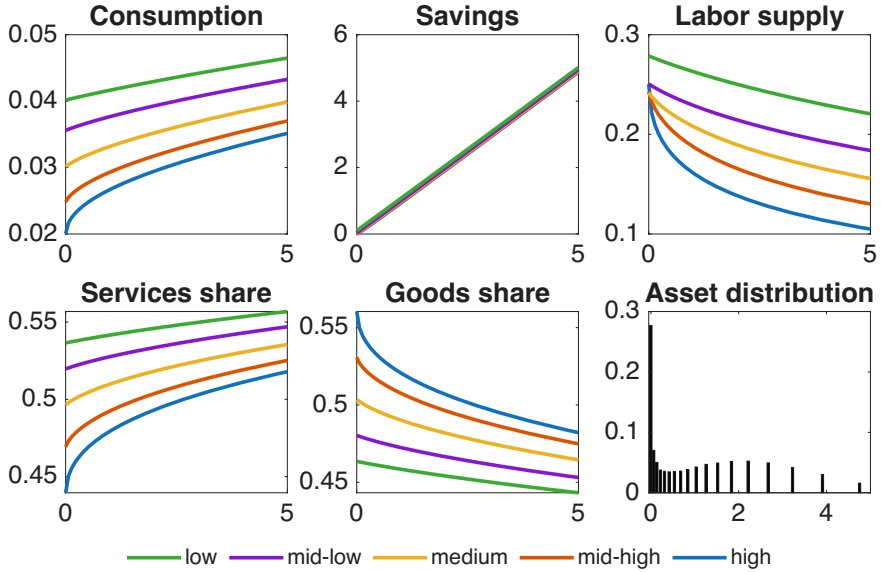
Back

Short-run household behavior: wealth distribution

Wealth Statistic	Data	Model
Mean wealth	4.1	4.4
Median wealth	1.5	1.8
Wealth, bottom 50%	2.5%	3.1%
Wealth, top 10%	49.9%	48.6%
HtM share	17.3%	23.4%

Steady-State Policy Functions

Back



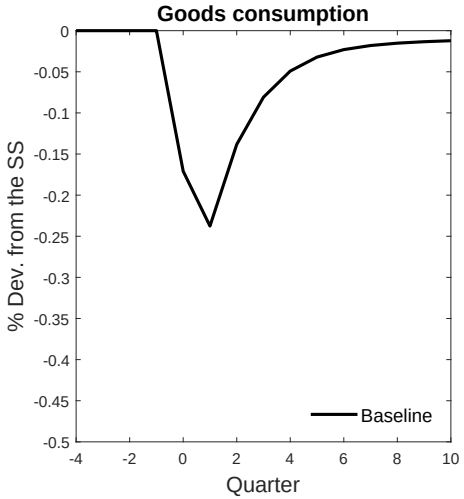
Steady-State Policy Functions

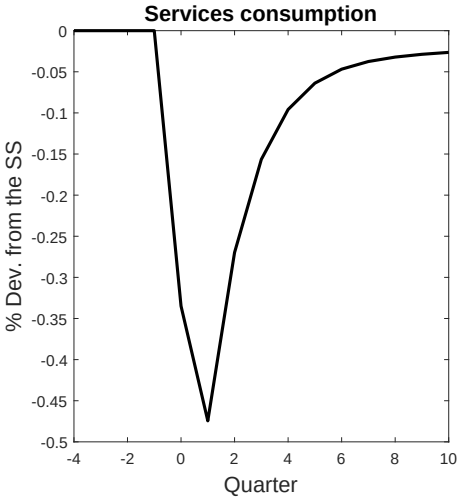
Back

Monetary Policy and Demand Composition

Back

MP contractions shift expenditure towards goods

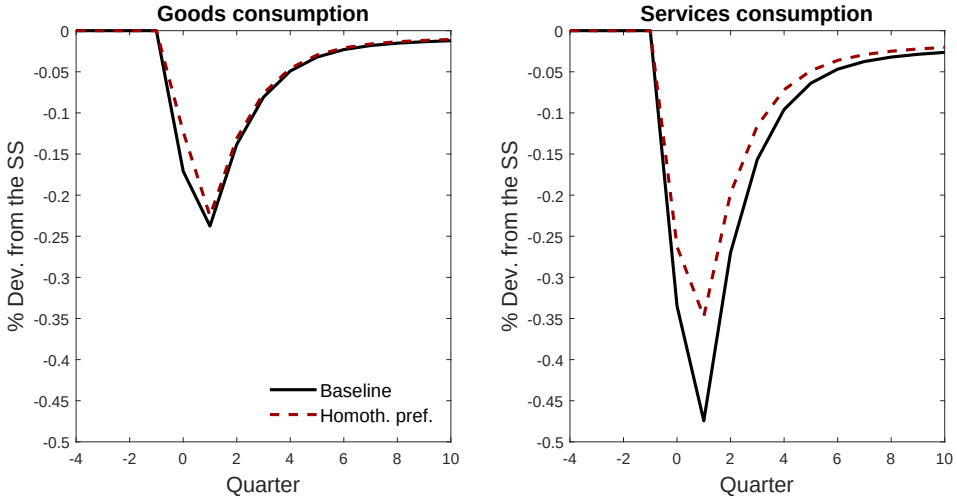




Demand Composition: Decomposition

Back

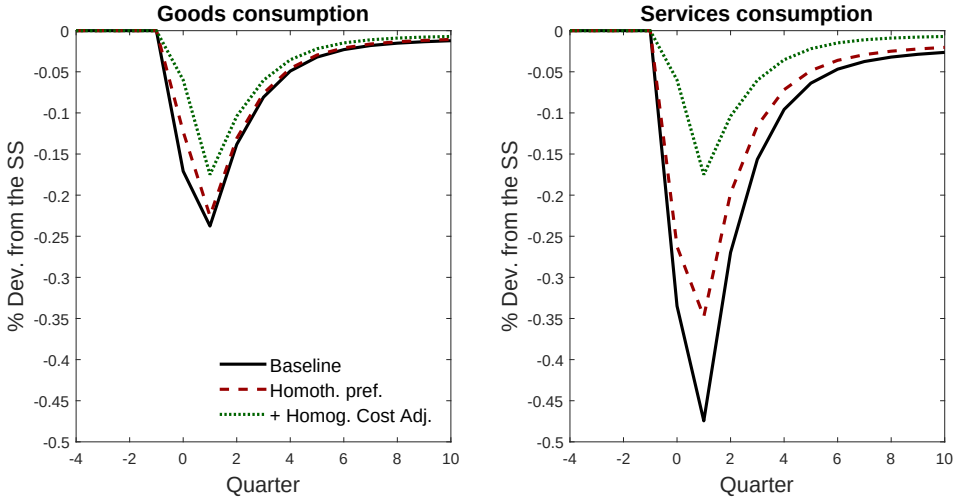
Non-homotheticity accounts for around half of the differences in the response



Demand Composition: Decomposition

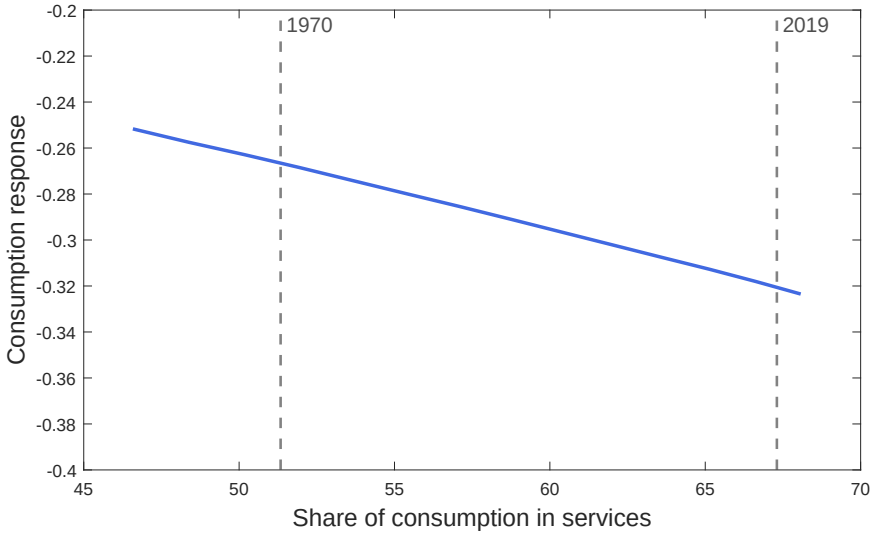
Back

Differences in the price rigidities account for the other half



Frontier: MP Response and Services Share

Back



Counterfactuals: Income vs Substitution effects

Back

Two forces that drive the increase in services:

1. Higher **income** makes consumption shift toward "luxuries"
2. changes in the **relative prices** change consumption composition

	(1) 1970 (bsl)	(1) 2019 (bsl)	(2) Income effect	(3) Substitution effect
Consump. response (vs. 1970)	–	20.64	11.52	14.02
Relative price	1.00	1.68	1.00	1.68
SS consumption	0.03	0.05	0.05	0.03
Service share	51.34	67.30	58.09	61.22

$\Rightarrow$ Income and price effect have the same relevance for the amplification of MP transmission

Structural Transformation and the Welfare Cost of Monetary Policy

Back

- Households' responses vary along sectoral consumptions and labor More
- Use **welfare** to summarize differences across households

Structural Transformation and the Welfare Cost of Monetary Policy

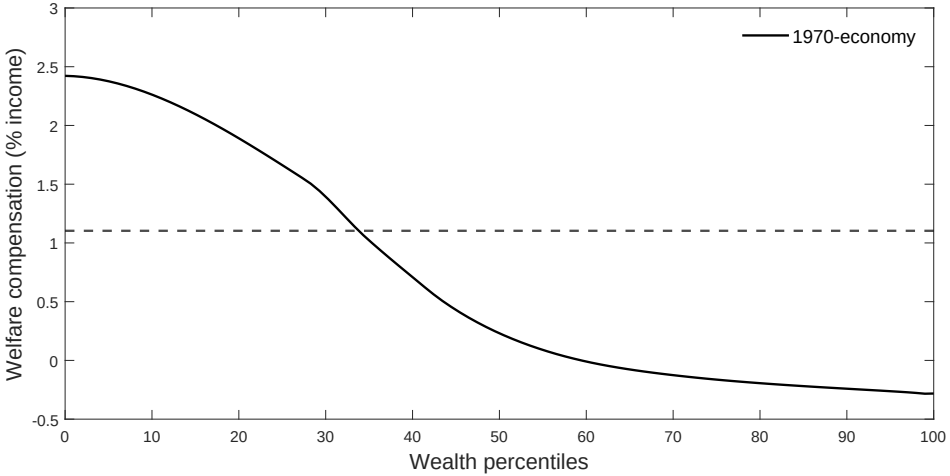
Back

- Households' responses vary along sectoral consumptions and labor More
- Use **welfare** to summarize differences across households
- In practice, I find m such that:

$$V^0(\omega, a) = V^1(\omega, a + m).$$

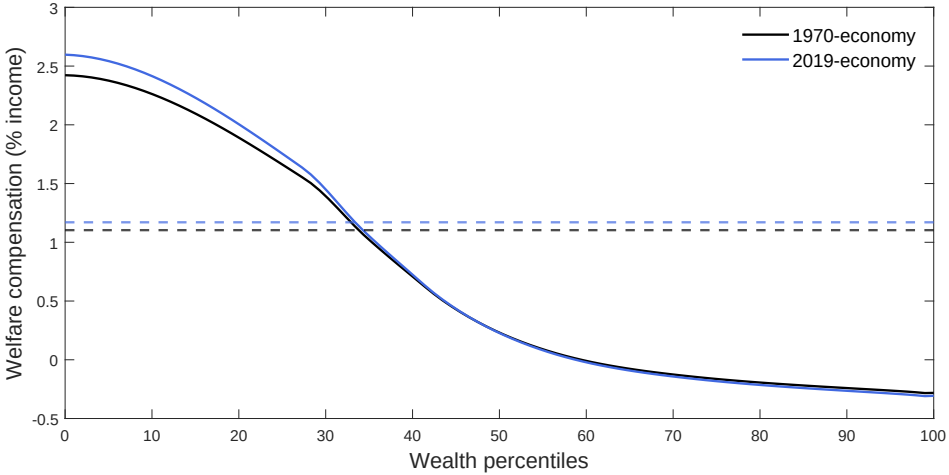
Welfare Cost of Monetary Policy

Back



Structural Transf. and the Welfare Costs of Monetary Policy

Back

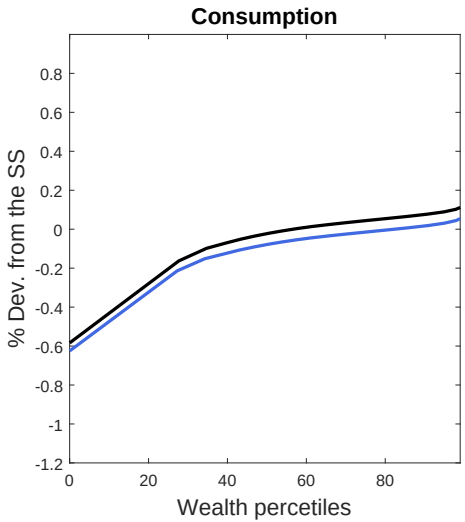


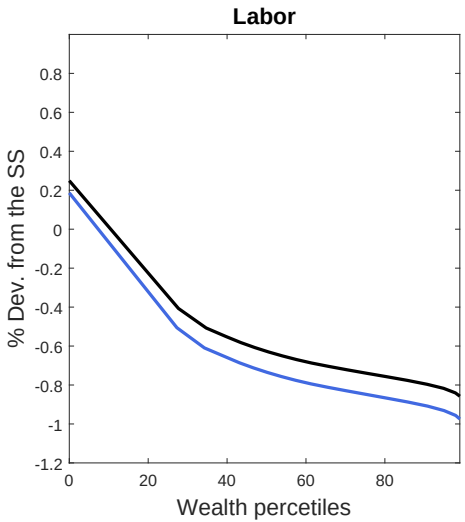
- **Aggregate welfare** cost of contractionary MP increases by 5%
- **Inequality** os costs of MP increase: For low-assets increases 7%, for high-assets unchanged

Heterogeneous Responses

Back

Responses to a 100 bp contractionary shock: 1970 vs. 2019





What is the Role of Services for Economic Resilience? Back

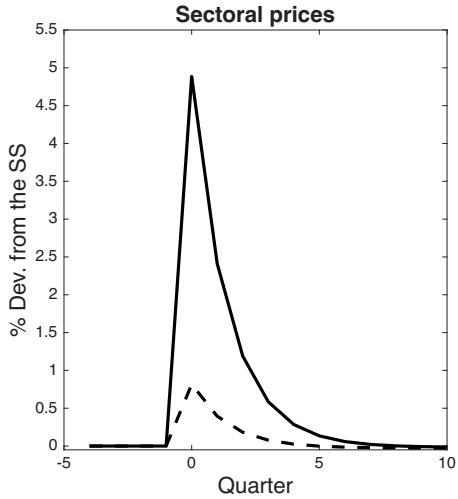
- **Goal:** compare the effects of supply shocks with different demand compositions
  - compare the 1970-economy (50% services) and the 2019-economy (68% services).

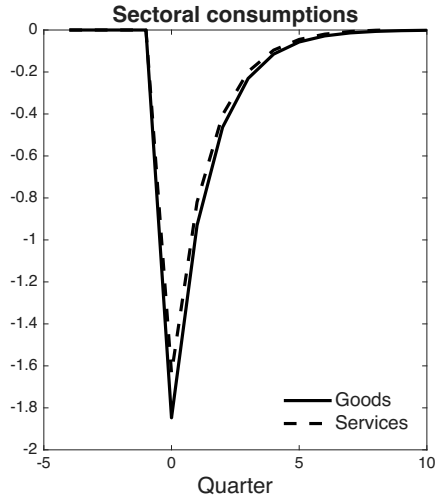
- **Setup:**
  1. Economy is at the Steady-State
  2. Unexpected shock in the sectoral productivity (same for both sectors: $\Delta Z_m / Z_m = -5\%$)
     - Unexpected and never to occur again (Boppart et al., 2018)
     - Once it is realized, agents have full information about its path
     - Shock is persistent, but after one year is halfway to the SS value

Structural Transformation and Supply Shocks

Back

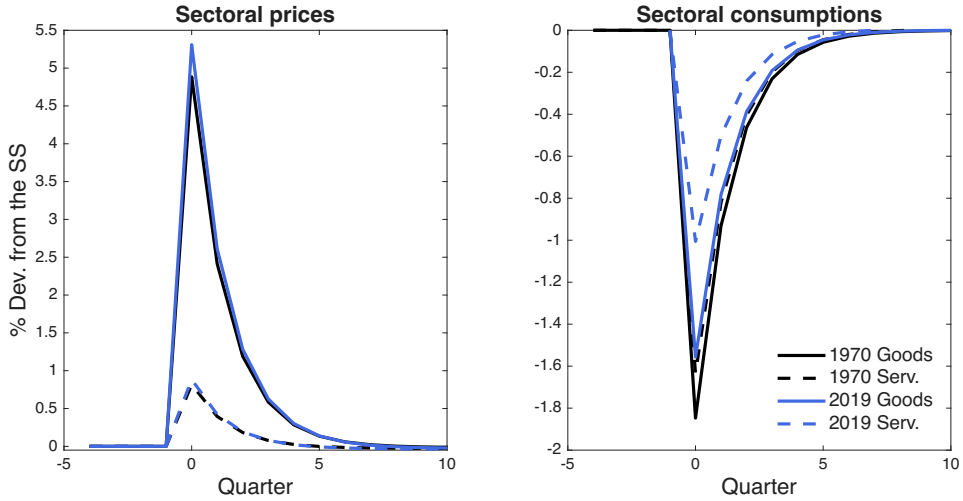
Aggregate responses to a negative 5% aggregate TFP shock





Structural Transformation and Supply Shocks

Mechanisms Back



- Structural transformation shifts the economic activity to a **less volatile** sector
- Real economic activity is **less responsive** to supply disruptions

The Role of Non-Homotheticity and Heterogeneous Price Rigidities

Back

	(1) Baseline		(2) Homog. κ_m		(3) Homothetic	
	1970	2019	1970	2019	1970	2019
Service share	51.3	67.3	51.3	67.3	51.0	67.2
MPC	8.1	7.6	8.1	7.6	8.6	8.4
Consump. response (% change vs. 1970)	-37.3		-9.2		-19.9	
Price of goods response (% change vs. 1970)	8.3		0.9		4.9	
Price of serv. response (% change vs. 1970)	6.9		0.9		4.1	

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