Structural Transformation and the Transmission of Monetary Policy

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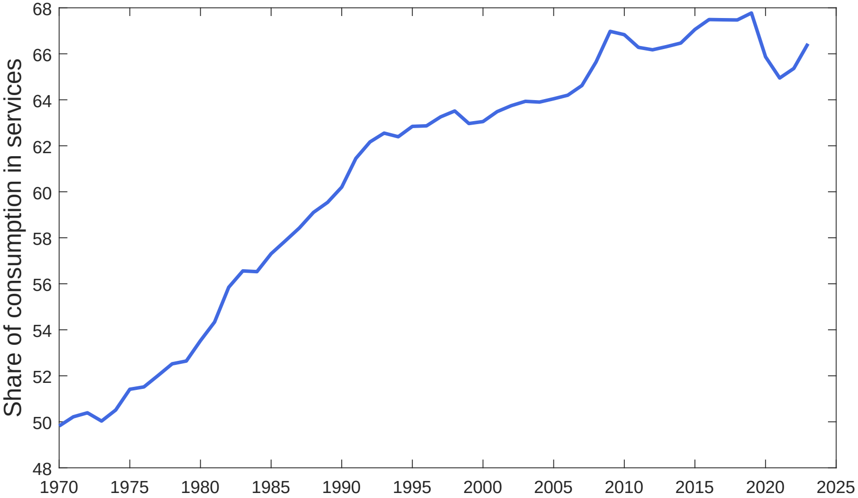
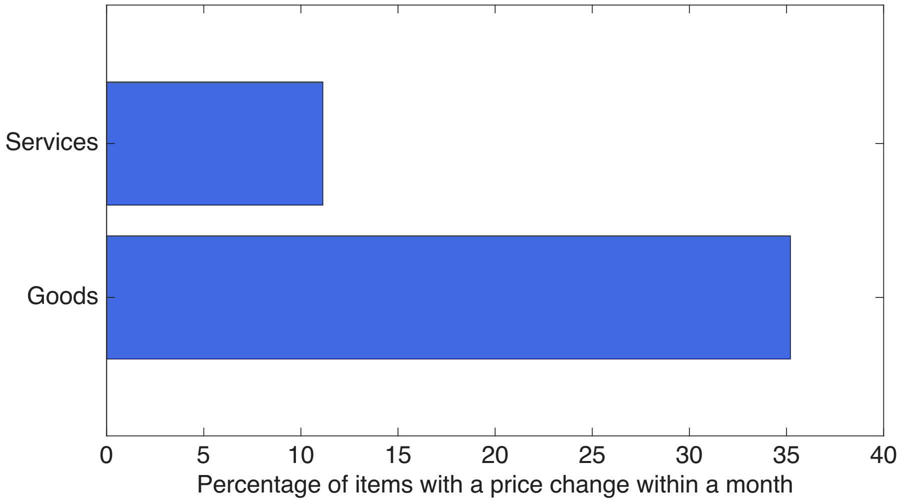
Modern Economic Growth $\Longrightarrow$ Structural Transformation



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)

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  - How does the services share impact the consumption responses to changes in the interest rate?

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     - generates the services share increase
  3. Policy experiment: increase in the nominal interest rate
     - compare monetary policy transmission across economies with different service shares

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4. **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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2. **Household heterogeneity and monetary policy transmission**
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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. Structural Transformation and Supply Shocks
6. Conclusion

Empirical Analysis

#1: Sectoral Price Rigidity

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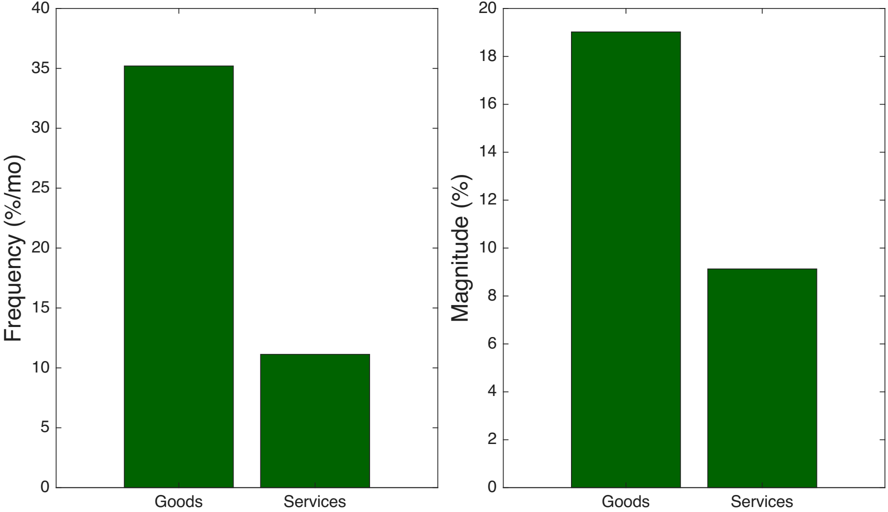
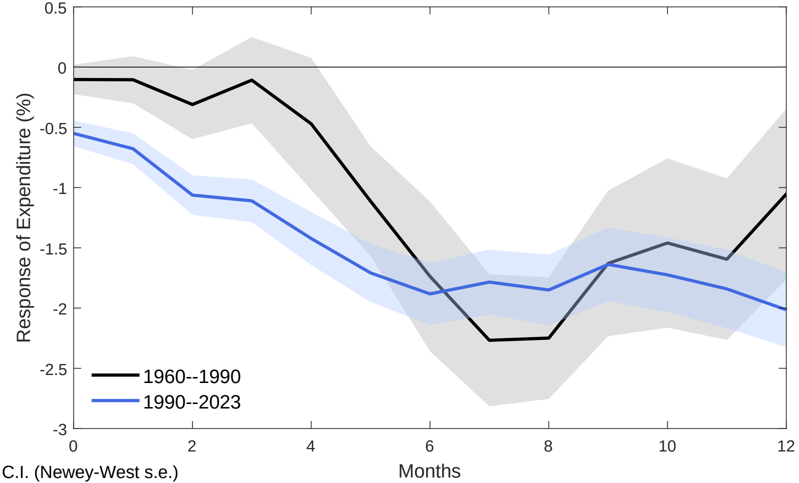


Data | Rob: Sales | Rob: Bils & Klenow (2004) | Rob: Gautier et al. (2022)

#2: The Slope of the Phillips Curve and the Services Share Data

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

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



68% C.I. (Newey-West s.e.)

#2: The Slope of the Phillips Curve and the Services Share Data

Economies with higher service share respond more to monetary policy

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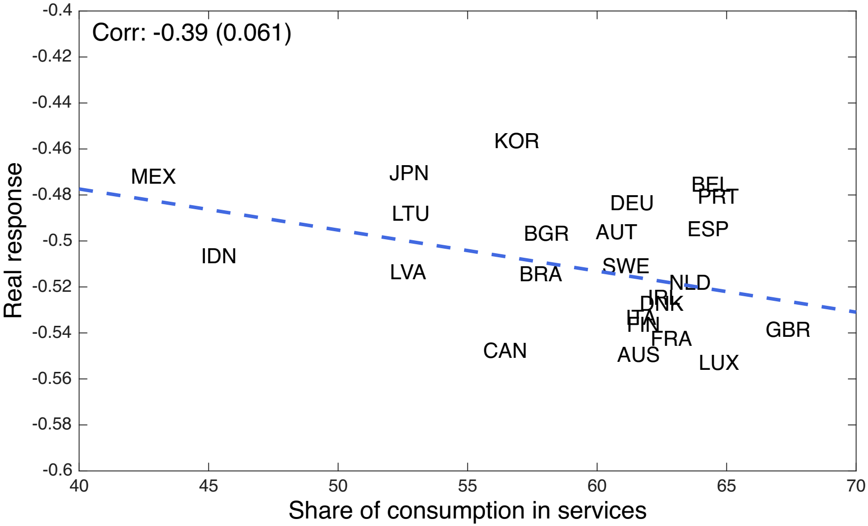

#3: Heterogeneous Demand Composition

The budget share of services rises with income

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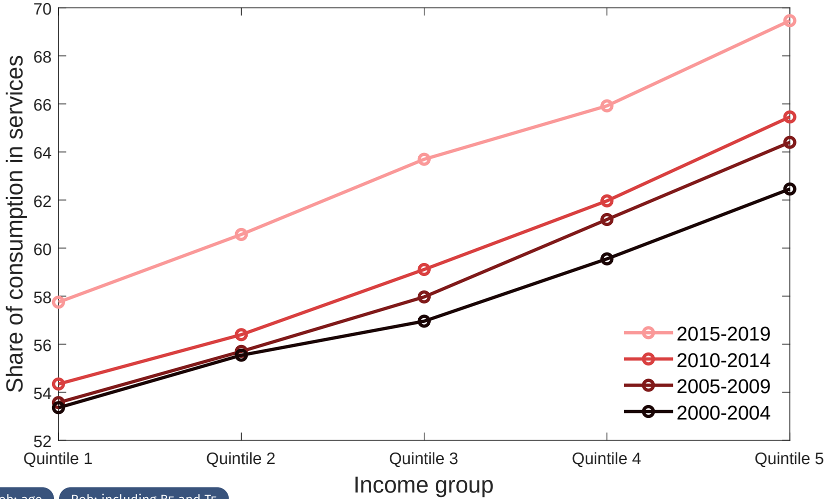
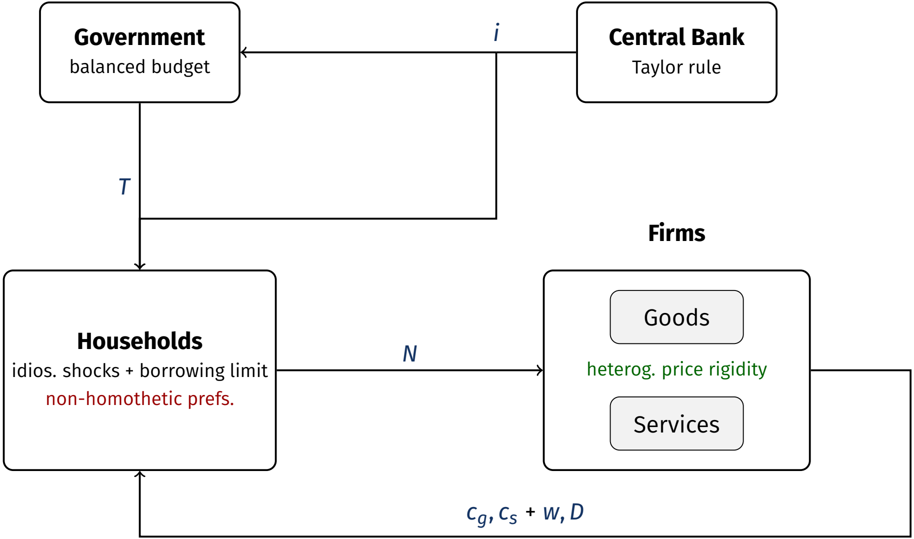


Data | Methodology | Rob: age | Rob: including B5 and T5

Model

Model Overview

A two-Sector HANK model with non-homothetic preferences



I. Households

Overview

- **Incomplete markets:** idiosyncratic productivity shocks and a borrowing constraint
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- **Preferences:** consumption (c_t), and labor (h_t):

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

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

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

  - Note: if $\epsilon = 1$, we recover the standard (homothetic) CES aggregator

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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**:

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

$$\text{s.t. } \left(\Omega c^{\epsilon}\right)^{\frac{1}{\sigma}} c_s^{\frac{\sigma-1}{\sigma}} + (c)^{\frac{1}{\sigma}} c_g^{\frac{\sigma-1}{\sigma}} = 1$$

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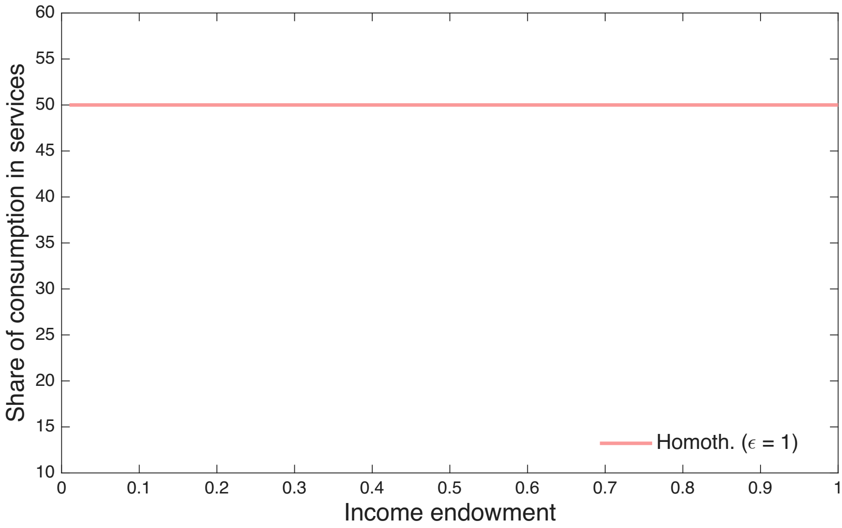
- Solution: (Hicksian) **demands**

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

I. Households

Static non-homothetic CES illustration



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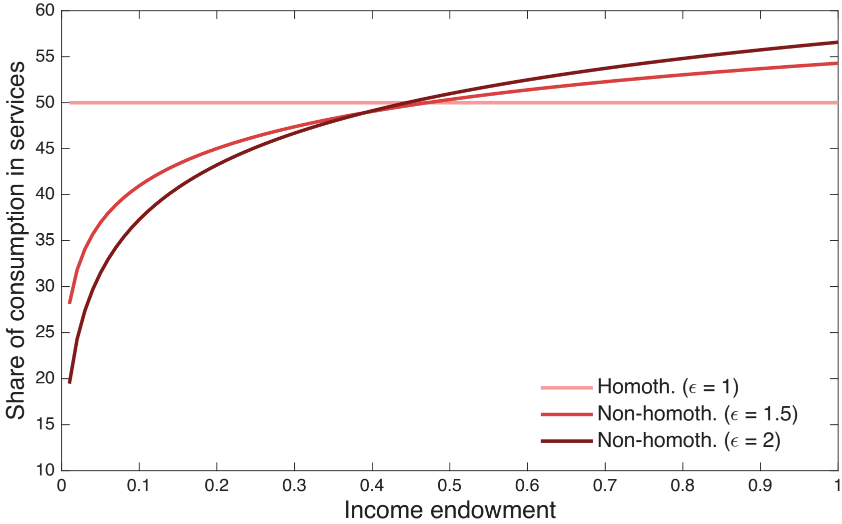

Stone-Geary

I. Households

The intertemporal consumption-savings decision problem

The intertemporal recursive representation of the household problem:

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

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

The final producer

- Two representative final sector producers indexed by m: **goods** and **services**
- Each **final producer** aggregates a continuum of intermediate inputs, j:

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

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- Given sectoral demand Q_m and prices $p_m(j)$, the **demand for the intermediate input** j is

$$q_m(j) = \left(\frac{p_m(j)}{P_m} \right)^{-\theta_m} Q_m,$$

with $P_m = \left(\int_0^1 p_m(j)^{1-\theta_m} \right)^{\frac{1}{1-\theta_m}}$ being the price in sector m

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- Intermediate firms adjust prices subject to an **adjustment cost** as in Rotemberg (1982):

$$\Phi_m\left(p_{m,t}(j), p_{m,t-1}(j)\right) = \frac{\theta_m}{2\kappa_m}\left[\log\left(\frac{p_{m,t}(j)}{p_{m,t-1}(j)}\right)\right]^2 Q_{m,t}P_{m,t}$$

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- The solution of the firm's problem yields the **New-Keynesian Phillips Curve**:

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

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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  - 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
     - using price and consumption data, estimate the level of non-homotheticity
  2. **Pre-estimated parameters:** directed observed parameters in the data
     - including sectoral productivity growth rates and price rigidities
  3. **Simulated method of moments:** hours worked and service share
     - match the values in 2019

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

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

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- 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
- Estimation results: $\epsilon = 1.73$ and $\sigma = 0.234$ Details

2. Externally Calibrated Parameters

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

- Parameters with SMM: χ, and Ω
- Use them to match 2 moments: average hours worked and agg. service 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

Building Counterfactual Economies

- What I do:
  1. Start from 2019: service share = 67.3%
  2. Change **sectoral productivities** (Z_g, Z_s):
     - goods = 2.2%/year
     - services = 1.1%/year

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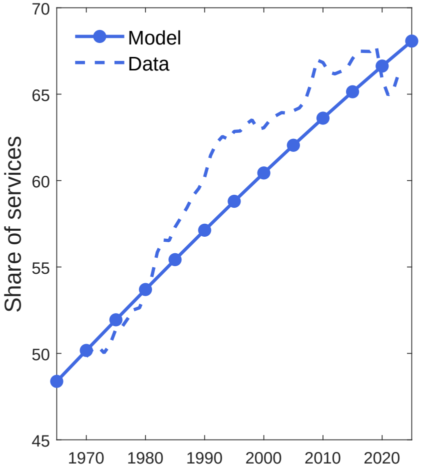
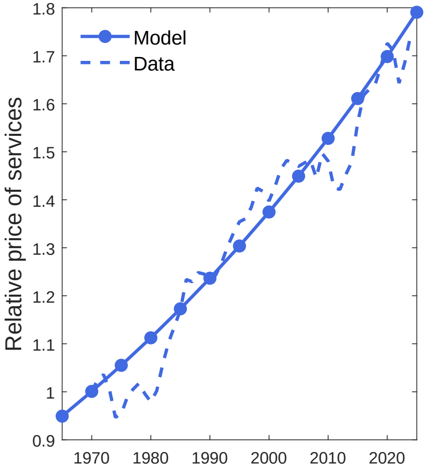
- My theory of structural transformation:
  1. **Cost-disease channel:** productivity growth differentials change the relative price
  2. **Non-homotheticity channel**: creates an inc. effect that shifts consumption toward "luxuries"

Model Fit

Across time





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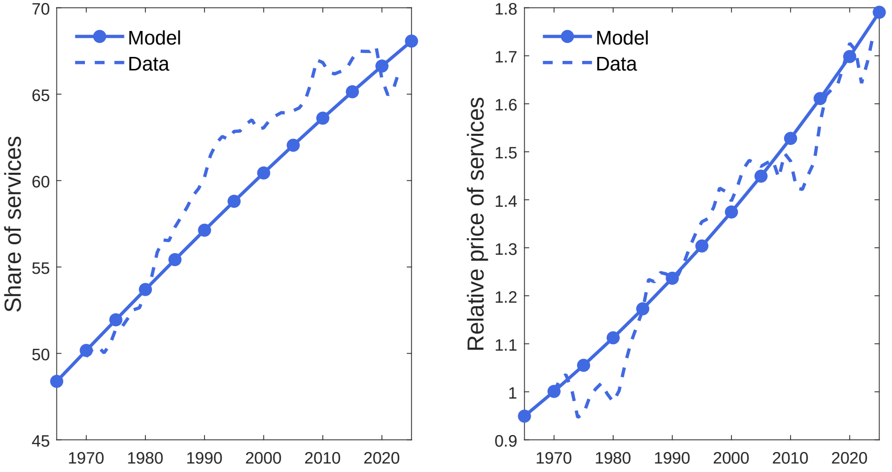
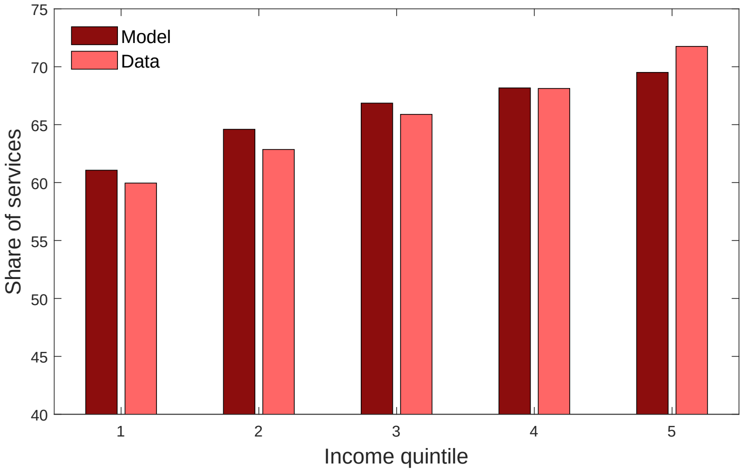


- **Hours worked:** decline 0.1%/year (data 1980–2023: -0.1%/year)

Model Fit
Engel curve 2000

Cross-Section



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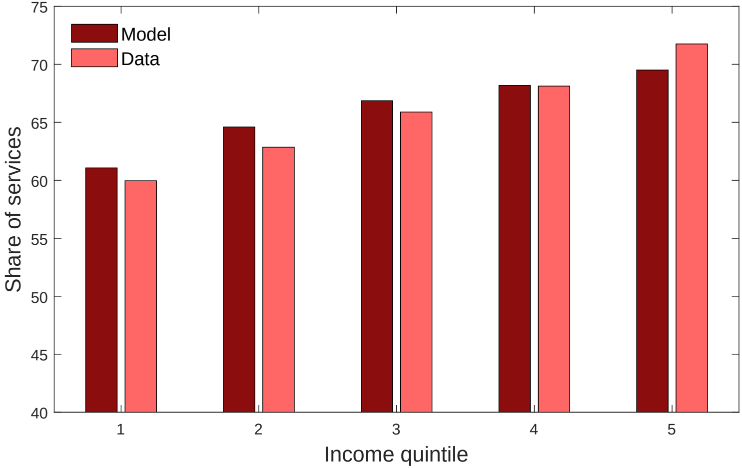

- **Average annual MPC**: 28% (data: 20 – 60%) MPC distribution
- **Share of Hand-to-Mouth**: 23.4% (data: 17.3%) Wealth Dist.

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)
  - Once it is realized, agents have full information about its path
  - Shock follows an AR(1) with persistent $\rho_M = 0.5$

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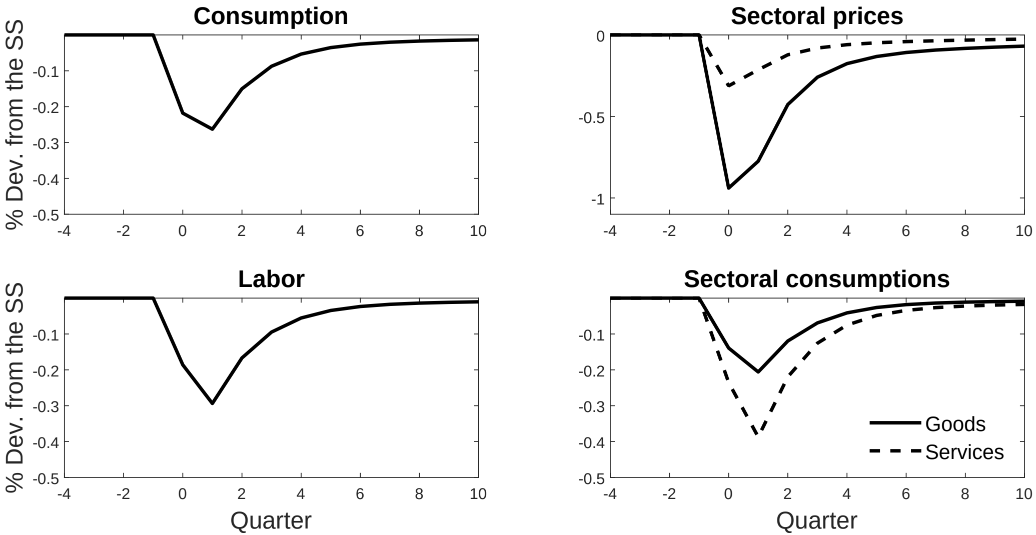
  - Shock follows an AR(1) with persistent $\rho_M = 0.5$
- Monetary policy shock operates through:
  - Direct channel: income and substitution effects
  - Indirect channel: GE effects through wages and taxes

Response to Monetary Policy
Demand Composition

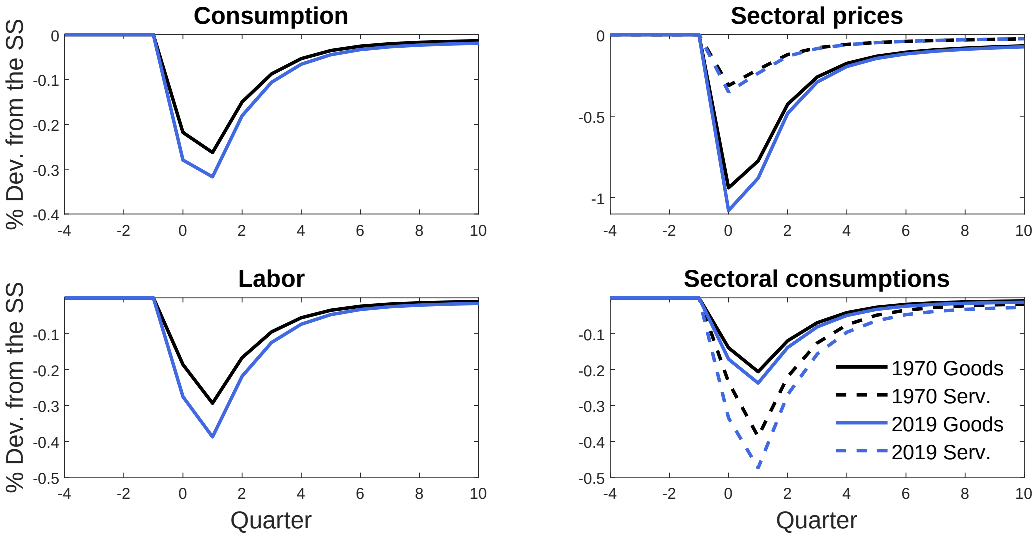
Aggregate Responses to a 100 bp Contractionary Shock: 1970 vs 2019



Structural Transformation and Monetary Policy

More years

Aggregate Responses to a 100 bp Contractionary Shock: 1970 vs 2019



Structural Transformation and the Slope of th 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

Inc. & Sub. effects

The Role of Heterogeneous Price Rigidities

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

The Role of Heterogeneous Price Rigidities

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

	(1) Baseline		(2) Homog. κ_m		(3) Homothetic
	1970	2019	1970	2019	
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 service 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

Structural Transformation and the Welfare Cost of Monetary Policy

- 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

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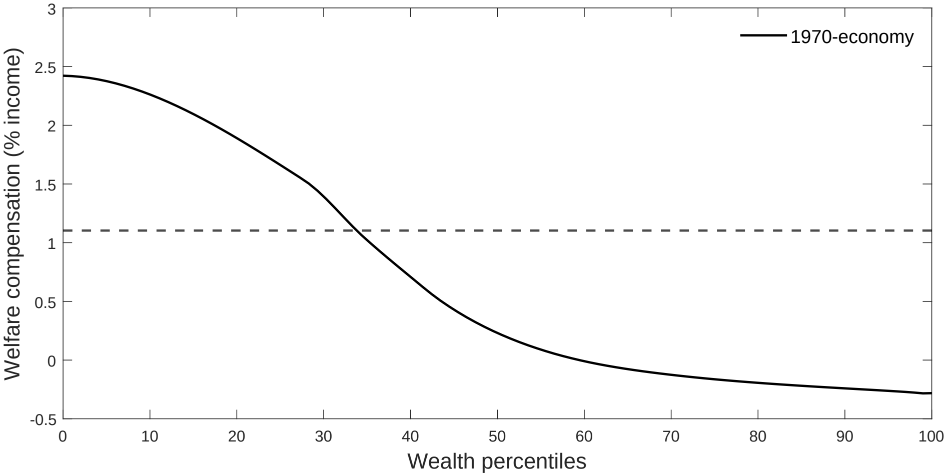
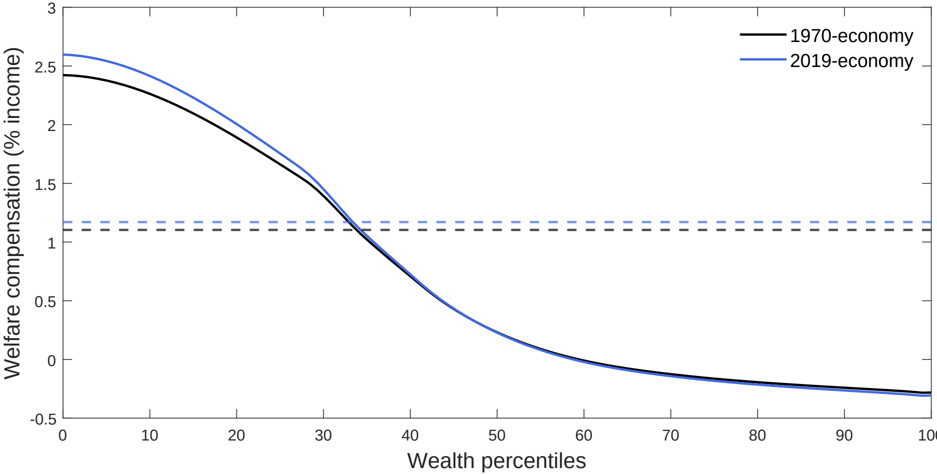
- Use **welfare** to summarize differences across households
- In practice, I find m such that:

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

Welfare Cost of Monetary Policy



Structural Transformation and the Welfare Costs of Monetary Policy



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

Structural Transformation & Negative Supply Shocks

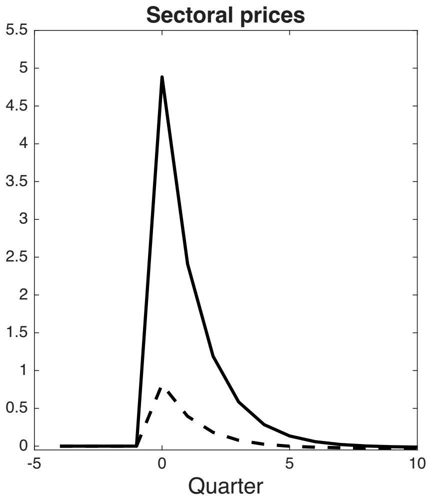
What is the Role of Services for Economic Resilience?

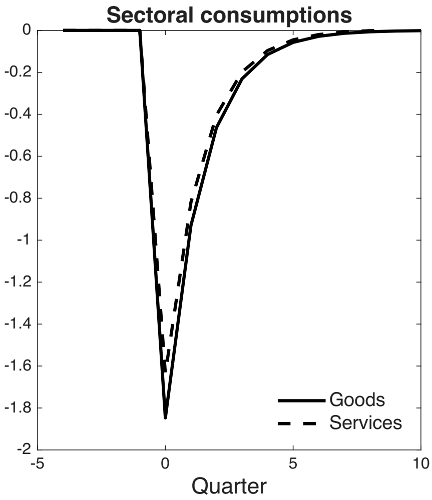
- **Goal:** Compare the effects of supply shocks with different demand compositions
  - compare the 1970-economy (50% services) and the 2019-economy (68% services).

- **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
     - Once it is realized, agents have full information about its path
     - Shock is persistent, but after one year is halfway to the SS value

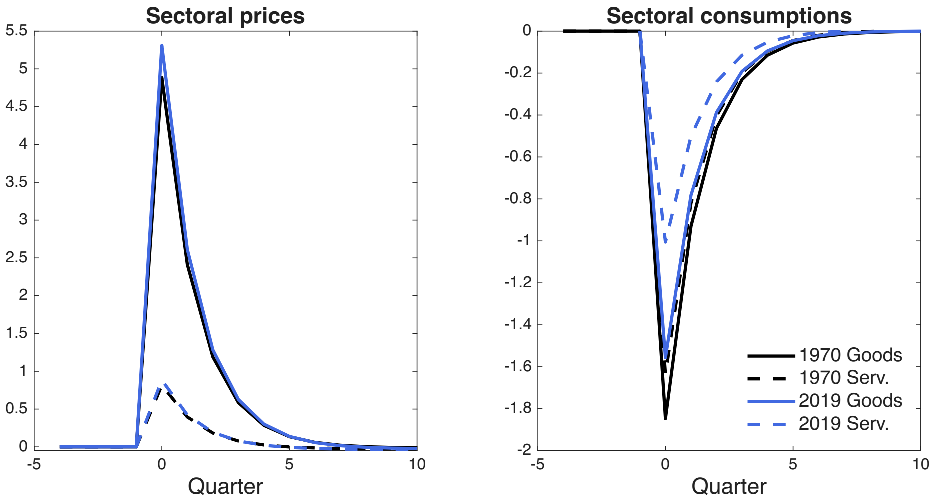
Structural Transformation and Supply Shocks

Aggregate responses to a negative 5% aggregate TFP shock





Structural Transformation and Supply Shocks Mechanisms



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

Conclusion

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- **This paper:** Sectoral composition matters for the transmission of monetary policy

- Using a quantitative dynamic model:
  - The **rise in the services share** from 1970 to 2019 **increased monetary non-neutrality by 21%**

Conclusion

- **This paper:** Sectoral composition matters for the transmission of monetary policy

- Using a quantitative dynamic model:
  - The **rise in the services share** from 1970 to 2019 **increased monetary non-neutrality by 21%**

- **Policy implications:**
  - supply disruptions, aging $\Longrightarrow$ changes in service share $\Longrightarrow$ changes in MP effects
  - monetary policy in common currency areas (EA, US) 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
  - The Costs of Building Walls: Immigration and the Fiscal Burden of Aging in Europe with F. Franco and L. T. Morais

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Thank You!

Appendix

#1: Data and Methodology Back

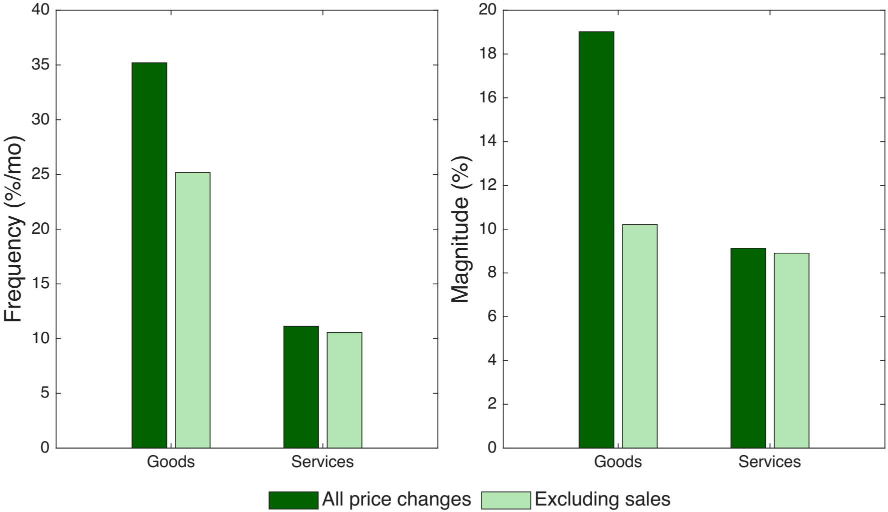
- **Data:** Summary statistics about price frequency assembled by Nakamura and Steinsson (2008)
  - Source: BLS monthly microdata that underlies the U.S. CPI, covering 70% of expenditures

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)

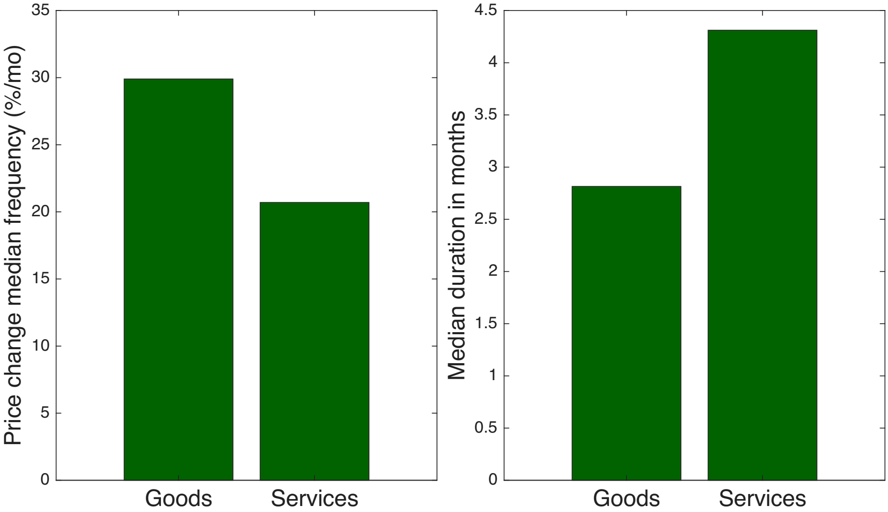
#1: Robustness Back

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%)

	1996–2001	2011–2017
Processed Food	13.6	15.6
NEIG	9.4	13.1
Services	5.0	6.2

#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 service share from national accounts

#3: Data Back

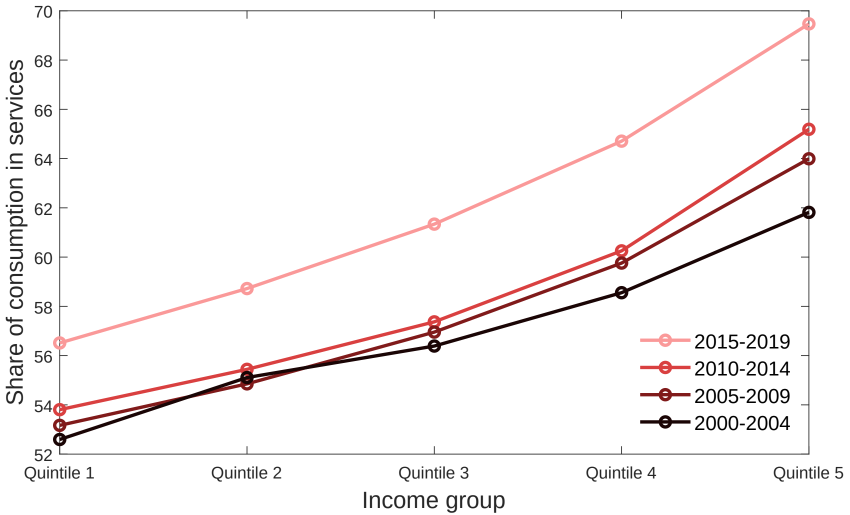
- **Consumer Expenditure Survey (CEX)**
  - curated by the US BLS
  - used to compute the relative importance of goods and services in the CPI basket
- **Coverage**
  - time frame: between 2000 and 2022
  - each wave has between 5 000 – 8 000 households
- **Consumption and Expenditure data**
  - household 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

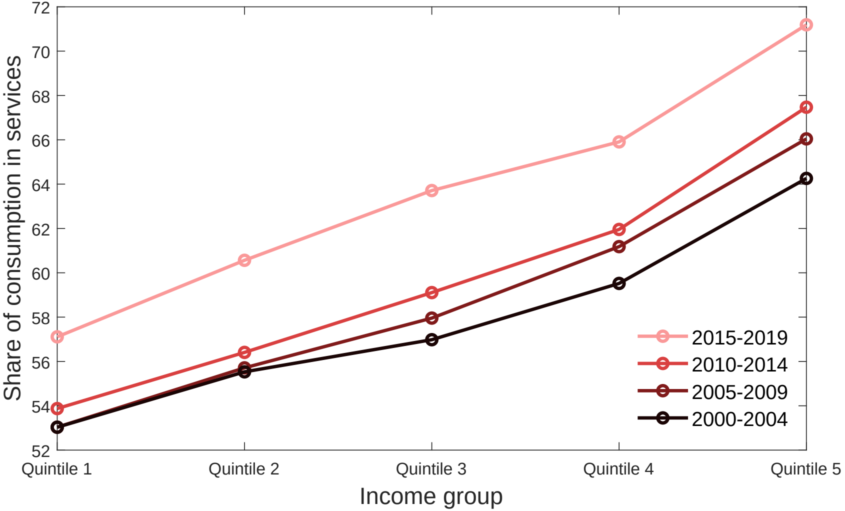
#3: Robustness Back

Excluding old households



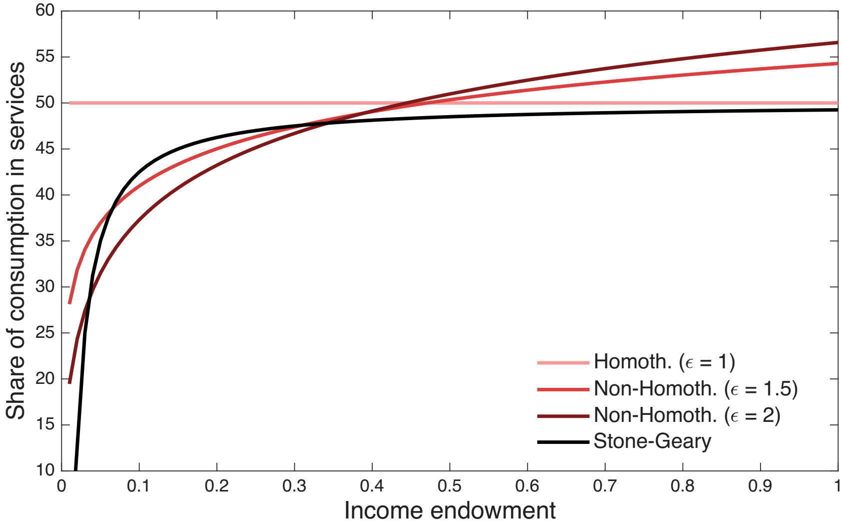
#3: Robustness Back

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

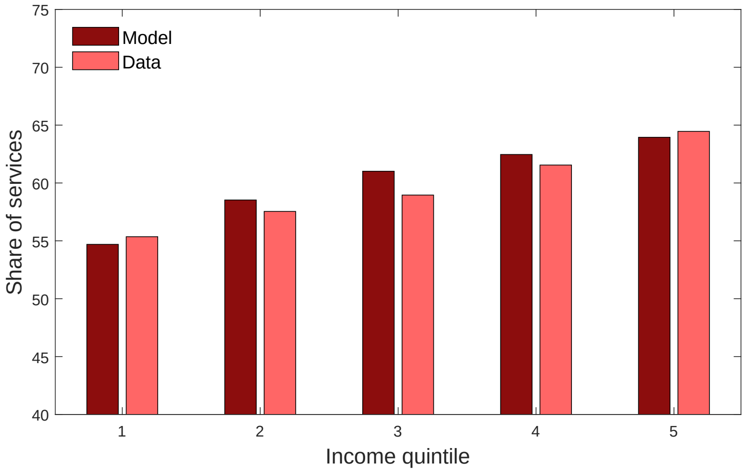
Results

$$\log\left(\frac{\nu^n_{s,t}}{\nu^n_{g,t}}\right) = (1-\sigma)\log\left(\frac{p^n_{s,t}}{p^n_{g,t}}\right) + (1-\sigma)(\epsilon-1)\log\left(\frac{E^n_t}{p^n_{g,t}}\right) + (\epsilon-1)\log\nu^n_{g,t} + \zeta^n + \xi^n_t,$$

	(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

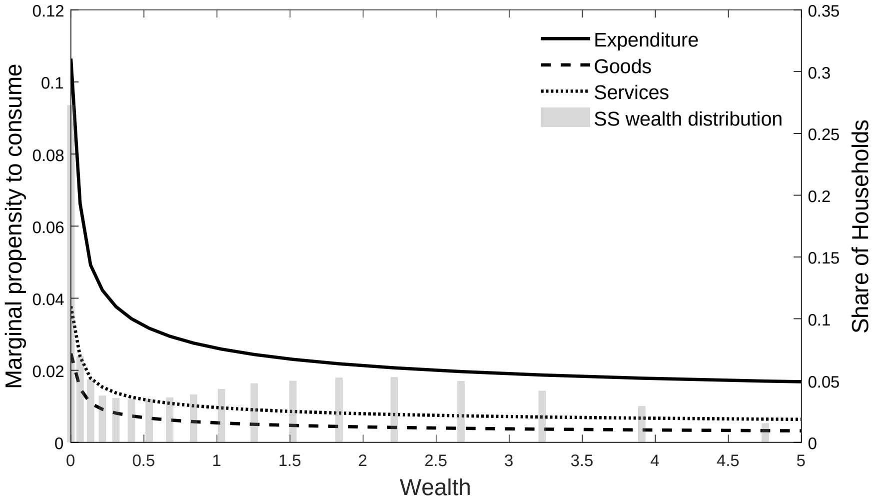
Model Fit Back

Engel curve 2000



Model Fit Back

Short-run household behavior: quarterly marginal propensity to consume



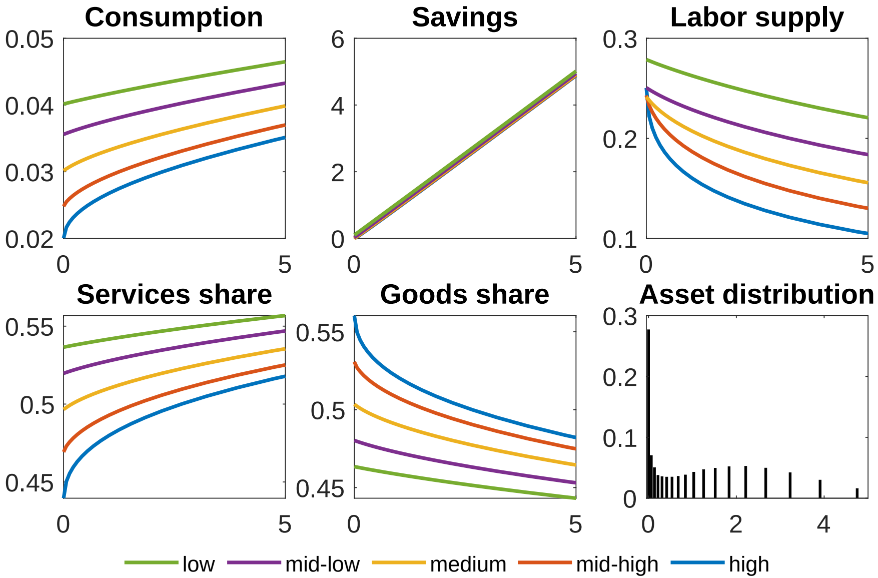
Model Fit Back

Short-run household behavior: wealth distribution

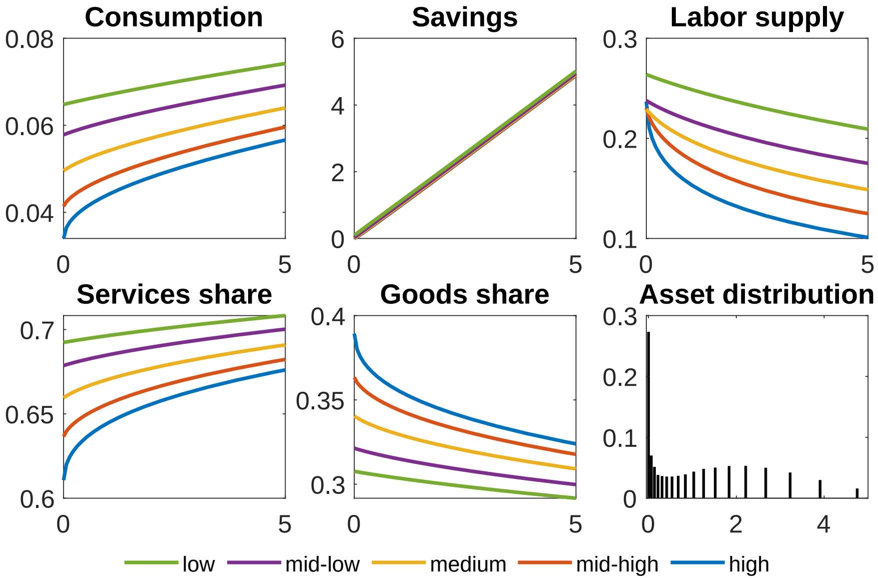
Wealth Statistic	Data	Model
Mean wealth	4.1	4.4
Median wealth	1.5	1.8
Wealth, bottom 50%	2.5%	3.1%
Wealth, top 10%	49.9%	48.6%
HtM share	17.3%	23.4%

Steady-State Policy Functions

Back



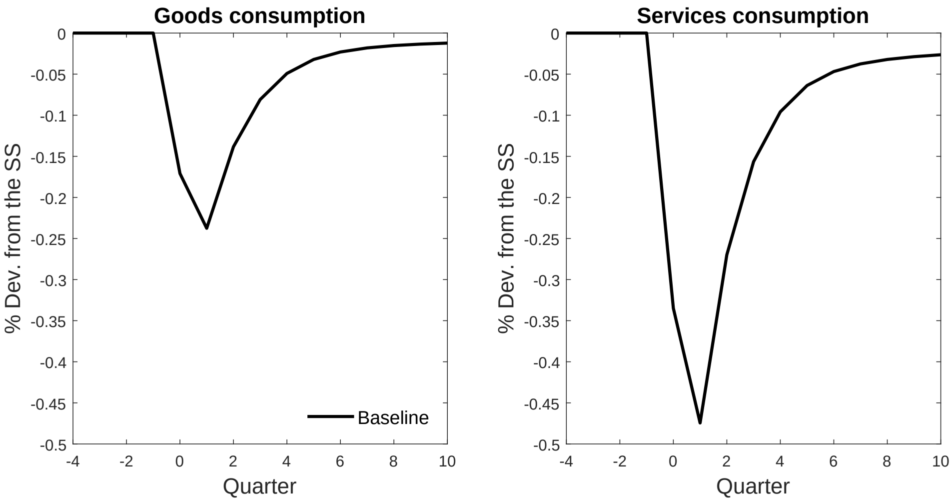
Steady-State Policy Functions Back



Monetary Policy and Demand Composition

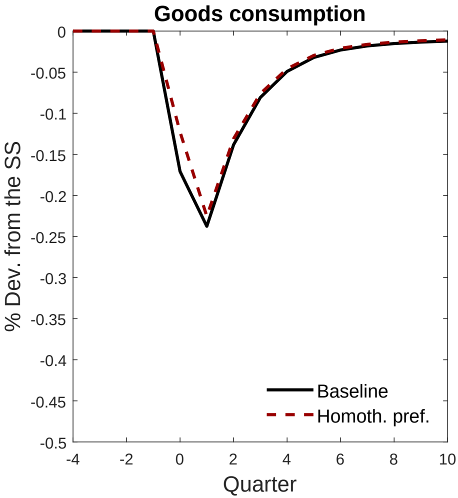
Back

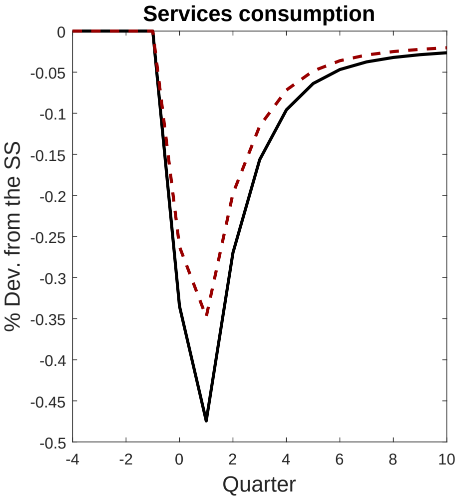
MP contractions shift expenditure towards goods



Demand Composition: Decomposition Back

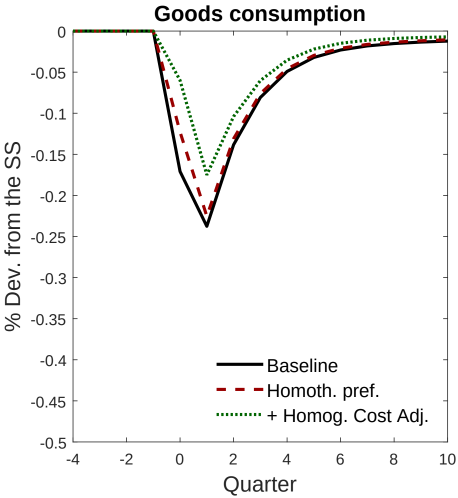
Non-homotheticity accounts for around half of the differences in the response

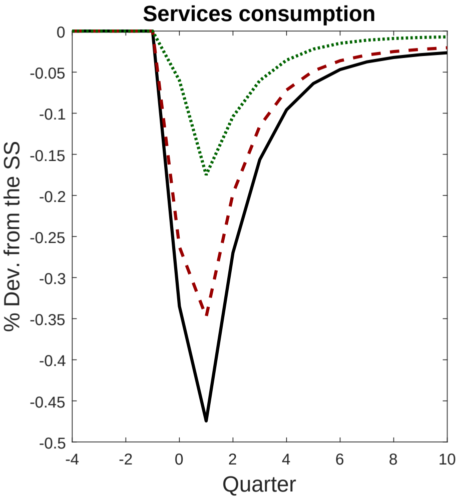




Demand Composition: Decomposition Back

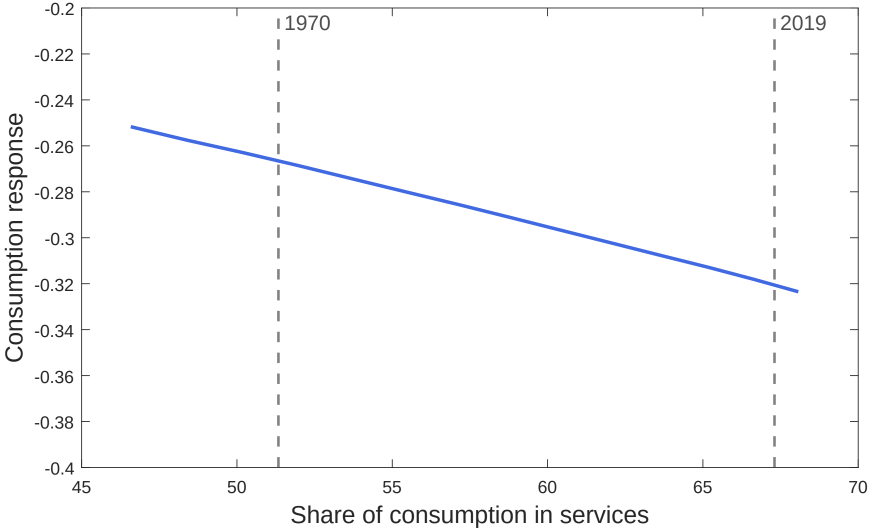
Differences in the price rigidities account for the other half





Frontier: MP Response and Services Share

Back



Counterfactuals: Income vs Substitution effects Back

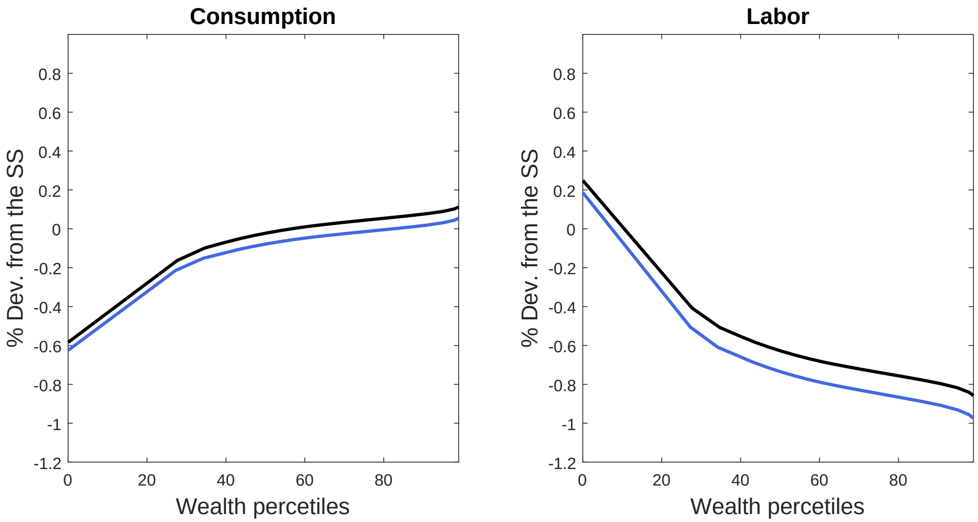
Two forces that drive the increase in services:

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

Heterogeneous Responses Back



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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