Pricing Inequality

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The views expressed herein are those of the authors and not those of the Federal Reserve System.

Firm pricing and household inequality

1. **Two facts about households**
   - Poor households are more price elastic (Auer Burstein Lein Vogel, 2024)
   - Poor households buy low price varieties of same good (Jaimovich et al, 2019; Bils Klenow, 2001)

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  Result 1 - Household elasticity heterogeneity rationalizes wide body of empirical facts

  Result 2 - Large firms have higher markups mostly (**60%**) due to household heterogeneity

  Result 3 - A fiscal transfer of 1% of GDP to h'holds increases aggregate markup **0.3 ppt**

Firms - Markups depend on customers' demand elasticities

- Firm - Selling variety $j \in \{1, \ldots, J\}$ of good $g \in \mathcal{G}$.

$$\pi_{jg} = \max_{p_{jg}} p_{jg} q_{jg} - W n_{jg} \quad \text{subject to} \quad \underbrace{q_{jg} = \int \rho^i_{jg} \, q^i_{jg} \, di}_{\text{Demand}} \quad , \quad \underbrace{q_{jg} = n^{\alpha}_{jg}}_{\text{Technology}}$$

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- Optimal price

$$p^*_{jg} = \frac{\varepsilon_{jg}}{\varepsilon_{jg} - 1} \, mc_{jg} \quad , \quad \varepsilon_{jg} = \int \underbrace{\left[\varepsilon^{i,\rho}_{jg} + \varepsilon^{i,q}_{jg} \right]}_{\text{Elasticities}} \underbrace{\left(\frac{\rho^i_{jg} q^i_{jg}}{q_{jg}} \right)}_{\text{Sorting}} di$$

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- What do firms want to know?
  - Elasticities - What are the elasticities of demand of different customers?
  - Sorting - What is the sorting of high and low elasticity customers across firms?

Households - Elasticities and sorting depend on wealth and income

- Today, conditional on choosing a single good-variety jg to consume

$$
\begin{aligned}
V\left(a, e, p_{jg}\right) &= \max_{a', c_{jg}} u\left(c_{jg}\right) + \beta \int \overline{V}\left(a', e'\right) d\Gamma_e\left(e'|e\right) \\
p_{jg} c_{jg} + a' &= (1-\tau) We + (1+r) a + \Pi + T \quad , \quad \left[\lambda_{jg}(a, e)\right] \\
a' &\geq \underline{a}
\end{aligned}
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- Tomorrow, draw preferences over good-varieties ζ'_{jg} and choose jg to consume

$$
\overline{V}\left(a', e'\right) = \int \max_{j,g} \left\{ V\left(a', e', p_{jg}\right) + \underbrace{\frac{1}{\eta} \log \phi_{jg}}_{\text{Quality - } \phi_{jg}} + \zeta'_{jg} \right\} d\Gamma_\zeta\left(\boldsymbol{\zeta}'; \theta, \eta\right)
$$

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$$
\log \Gamma_\zeta\left(\zeta^i\right) = \sum_{g \in \mathcal{G}} \left(- \sum_{j \in g} e^{-\eta \zeta^i_{jg}} \right)^{\theta/\eta}
$$

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- Demand

- Elasticities

- Sorting

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- Demand

$$\rho^i_{jg} = \underbrace{\phi_{jg}\left(\frac{v\left(a^i, e^i, p_{jg}\right)}{\widetilde{v}\left(a^i, e^i, \boldsymbol{p}_g\right)}\right)^{\eta}}_{\rho^i_{j|g}} \underbrace{\left(\frac{\widetilde{v}\left(a^i, e^i, \boldsymbol{p}_g\right)}{\overline{v}\left(a^i, e^i\right)}\right)^{\theta}}_{\rho^i_g} \quad , \quad \widetilde{v}\left(a^i, e^i, \boldsymbol{p}_g\right) = \left[\sum_{j \in g} \phi_{jg}\, v\left(a^i, e^i, p_{jg}\right)^{\eta}\right]^{1/\eta}$$

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- Elasticities

$$\varepsilon^{i,\rho}_{jg} = \underbrace{\left[\theta\, \rho^i_{j|g} + \eta\left(1 - \rho^i_{j|g}\right)\right]}_{\text{Size-based market power}} \times \underbrace{\frac{\partial \log v\left(a^i, e^i, p_{jg}\right)}{\partial \log p_{jg}}}_{\text{Consumer heterogeneity}}$$

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$$\rho_{jg}^{i} = \underbrace{\phi_{jg}\left(\frac{v\left(a^{i}, e^{i}, p_{jg}\right)}{\widetilde{v}\left(a^{i}, e^{i}, \boldsymbol{p}_{g}\right)}\right)^{\eta}}_{\rho_{j|g}^{i}} \underbrace{\left(\frac{\widetilde{v}\left(a^{i}, e^{i}, \boldsymbol{p}_{g}\right)}{\overline{v}\left(a^{i}, e^{i}\right)}\right)^{\theta}}_{\rho_{g}^{i}} \quad , \quad \widetilde{v}\left(a^{i}, e^{i}, \boldsymbol{p}_{g}\right) = \left[\sum_{j \in g} \phi_{jg}\, v\left(a^{i}, e^{i}, p_{jg}\right)^{\eta}\right]^{1/\eta}$$

- Elasticities

$$\varepsilon_{jg}^{i,\rho} = \underbrace{\left[\theta\, \rho_{j|g}^{i} + \eta\left(1 - \rho_{j|g}^{i}\right)\right]}_{\text{Size-based market power}} \times \underbrace{\frac{\partial \log v\left(a^{i}, e^{i}, p_{jg}\right)}{\partial \log p_{jg}}}_{\text{Consumer heterogeneity}}$$

- Sorting

$$\log\left(\frac{\rho_{1}^{H}/\rho_{2}^{H}}{\rho_{1}^{L}/\rho_{2}^{L}}\right) = \eta \int_{\log p_{2}}^{\log p_{1}} \left\langle -\frac{\partial \log v^{L}(p)}{\partial \log p} \right\rangle - \left\langle -\frac{\partial \log v^{H}(p)}{\partial \log p} \right\rangle d \log p$$

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- Elasticities

$$\varepsilon^{i,q}_{jg} = \frac{1}{\sigma}\left(\frac{\partial \log \lambda^i_{jg}}{\partial \log p_{jg}} + 1\right) \in \left[\frac{1}{\sigma}\,,\ 1\right]$$

- Sorting

$$\log\left(\frac{\rho^H_1/\rho^H_2}{\rho^L_1/\rho^L_2}\right) = \eta \int_{\log p_2}^{\log p_1} \left\langle -\frac{\partial \log v^L(p)}{\partial \log p} \right\rangle - \left\langle -\frac{\partial \log v^H(p)}{\partial \log p} \right\rangle d \log p$$

Contrast with alternative approaches

1. Macro

Interpreted empirical size-markup relationship as causal - $\varepsilon_j = \varepsilon(s_j)$

EMX (2015, 2023), De Loecker Eeckhout Mongey (2022), Baqaee Farhi Sangani (2024, 2024), Boar Midrigan (2023)

New - Household heterogeneity also determines markups

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2. Industrial Organization

Individual elasticities are parametric functions of income - $\varepsilon^i = \varepsilon(e^i)$

BLP (1995), Nevo (2000), Nakamura Zerom (2010), ...

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3. Public / Spatial / Micro / Trade / Search

Parameterize elasticities or search costs $\varepsilon(e^i)$ and / or tastes $\phi_j^i(e^i)$

Handbury (2021), Auer et al (2024), Faber Fally (2022), Olivi et al (2024), Sangani (2024), Nord (2024)

New - Preferences separated from income

Calibration

1. Off-the-shelf Bewley model parameters / structure
   - Income process, borrowing constraint, tax, transfer, r, β follow Kaplan, Violante (2024)

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   - Firms-per-market $\mathbf{J}$, Pareto tail of quality ξ, Preference dispersion η, θ

Parameter		Moment		Data	Model
$\mathbf{J}$	25	Concentration	Sales share HHI	0.052	0.052
ξ	10.9	Concentration	Top 4 firms sales share	30.5	30.5
η	8.9	Markups - Level	Average cost-weighted	1.25	1.25
θ	0.04	Markups - Slope	EMX within-industry elasticity of markups to sales	0.03	0.03

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2. Follow Edmond Midrigan Xu (JPE, 2023)
   - Firms-per-market $\mathbf{J}$, Pareto tail of quality ξ, Preference dispersion η, θ
3. Use novel empirical evidence from Auer, Burstein, Lein, Vogel (ReStud, 2024)
   - CRRA parameter σ
   - Replicate their estimates of declining elasticities of demand by income

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θ	0.04	Markups - Slope	EMX within-industry elasticity of markups to sales	0.03	0.03
σ	2.57	Elasticities-by-Income	$3\times$ higher income, X lower elasticity	2.42	2.42
α	0.63	Sorting	Top quintile of income households pay $X\%$ higher prices	14.4	14.4

Parameters - Disciplining σ

Auer et al (2024) - *Unequal Expenditure Switching: Evidence from Switzerland*

Data

$$\log\left(\frac{b^i_{Mt}}{b^i_{Dt}}\right) = \beta_0 - \beta_1 \log\left(\frac{p_{Mt}}{p_{Dt}}\right) + \beta_2 \log e^i \log\left(\frac{p_{Mt}}{p_{Dt}}\right) + \varepsilon_{it} \quad , \quad \widehat{\beta}_2 = 2.20$$

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Model

- Compare shares on goods $\{M, D\} \in g$ across low / high income $i \in \{L, H\}$
- To a first order around p_{Dg} then e_L:

$$\log\left(\frac{b^H_{Mg}}{b^H_{Dg}}\right) - \log\left(\frac{b^L_{Mg}}{b^L_{Dg}}\right) = \underbrace{\varepsilon^L_{Dg}\left(\frac{\partial \log c^L_{Dg}}{\partial \log e^L}\right)\left(-\frac{\partial \log \varepsilon^L_{Mg}}{\partial \log c^L_{Mg}}\right)}_{\text{Coefficient estimated in ABLV}} \underbrace{\log\left(\frac{e^H}{e^L}\right)\log\left(\frac{p_{Mg}}{p_{Dg}}\right)}_{\text{Interaction term}}$$

Parameters - Disciplining α

JRWZ (2019) - *Trading Up and the Skill Premium*

Data - Within-market-time, Across-household differences in prices paid

$$\log P^i_{mt} = \lambda_{mt} + \sum_{q=1}^{Q} \beta_q \mathbb{1}\left[q^i_{dt} = q\right] + \eta^i_{mt} \quad \text{, where} \quad \log P^i_{mt} = \sum_{u \in \{m,t\}} \omega^i_{umt} \log \overline{P}_{umt}.$$

Refine their approach

- Define markets m as *Module* $\times$ *DMA*
- Compute average unit prices $\overline{P}_{umt}$ of UPC's u within these markets
- Rank households by *total annual expenditure quantiles* q^i_{dt} within each *DMA* $\times$ *Year*
- Result - $\widehat{\beta}_5 - \widehat{\beta}_1 = 0.144$

Result 1 - Integrate wide body of empirical facts

- Extensive margin* - ↑ Sales mostly due to ↑ Customers, not ↑ Quantity per customer
  Afrouzi Drenik Kim (2024), Einav Klenow Levin Murciano-Goroff (2021)
- Firm sales - Higher due to quality, lower due to higher marginal cost and higher markups
  Hottman Redding Weinstein (2016)
- Sorting* - Higher income households buy from larger firms
  Faber Fally (2022)
- Income and markups* - Higher income households pay higher markups
  Sangani (2024)
- Wealth and markups* - An increase in local wealth increases local markups
  Stroebel Vavra (2019)

* Quantitatively replicate these statistics in the paper

Result 2 - Household heterogeneity accounts for markup differences

1. What is responsible for markup differences across firms?

2. What data informs this result?

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1. What is responsible for markup differences across firms?

	Relative size $\left[\rho^i_{j\|g}\theta + (1-\rho^i_{j\|g})\eta\right]$	Household heterogeneity $\lambda^i_{jg} p_{jg} c^i_{jg}$
Top vs. Bottom quintile sales firms	42.5	**58.5**
Largest vs. Smallest sales firms	45.5	54.5

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Top vs. Bottom quintile sales firms	42.5	**58.5**
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2. What data informs this result?

- Recalibrate model, match same concentration / markup moments, but under log ($\sigma = 1$)
- Role of household heterogeneity is **zero**
- But *Elasticities-by-Income* and *Sorting* moments are also **zero**
- New framework + New data $\implies$ New result

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1. What is responsible for markup differences across firms?

	Relative size $\left[\rho^i_{j\|g}\theta + (1-\rho^i_{j\|g})\eta\right]$	Household heterogeneity $\lambda^i_{jg} p_{jg} c^i_{jg}$
Top vs. Bottom quintile sales firms	100	0
Largest vs. Smallest sales firms	100	0

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Result 2 - Household heterogeneity accounts for markup differences

		Baseline	Log model $(\sigma = 1)$	Monopolistic competition $(\eta = \theta)$
		(1)	(2)	(3)
A. Household parameters				
Curvature in consumption	σ	2.6	1	
Taste dispersion - Within markets	η	8.9	2.12	
- Across markets	θ	0	0	
B. Firm parameters				
Tail parameter of Pareto	ξ	10.9	4.1	
Decreasing returns	α	0.63	0.66	
C. Moments				
Firms - Top 4 sales share		**0.30**	**0.30**	
Firms - Average markup	$\mathbb{E}[\mu_j]$	**1.25**	**1.25**	
Firms - Markups and sales shares	β_{EMX}	**0.03**	**0.03**	
Households - Elasticities and income	β_{ABLV}	**2.20**	0	
Households & Firms - Sorting	$\beta^5_{JRWZ} - \beta^1_{JRWZ}$	**0.14**	0	
Price dispersion	Std.$[\log p_j]$	0.14	**0.14**	
Share of elasticity variation due to h'hold heterogeneity		58	0	

Note: All economies have the same interest rate (r), with other parameters recalibrated to match the same level of total differentiated goods expenditure $(\overline{Z})$, labor income taxes (τ) and transfers (T) to GDP, average assets to average income (β)

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A. Household parameters				
Curvature in consumption	σ	2.6	1	↑ 3.4
Taste dispersion - Within markets	η	8.9	2.12	11.7
- Across markets	θ	0	0	
B. Firm parameters				
Tail parameter of Pareto	ξ	10.9	4.1	14.7
Decreasing returns	α	0.63	0.66	0.64
C. Moments				
Firms - Top 4 sales share		**0.30**	**0.30**	**0.30**
Firms - Average markup	$\mathbb{E}[\mu_j]$	**1.25**	**1.25**	**1.25**
Firms - Markups and sales shares	β_{EMX}	**0.03**	**0.03**	**0.03**
Households - Elasticities and income	β_{ABLV}	**2.20**	0	↑ 2.62
Households & Firms - Sorting	$\beta^5_{JRWZ} - \beta^1_{JRWZ}$	**0.14**	0	↑ 0.17
Price dispersion	Std.$[\log p_j]$	0.14	**0.14**	**0.14**
Share of elasticity variation due to h'hold heterogeneity		58	0	100

Note: All economies have the same interest rate (r), with other parameters recalibrated to match the same level of total differentiated goods expenditure ($\overline{Z}$), labor income taxes (τ) and transfers (T) to GDP, average assets to average income (β)

Role of consumer heterogeneity - Welfare effects of markups

Who gains from competitive product markets?

- Follow exercise in Edmond, Midrigan, Xu (2023)
- Implement optimal quantity subsidy $S_j = s_j^* y_j$:

$$p_j^* = \frac{\varepsilon_j^*}{\varepsilon_j^* - 1}\left[mc_j^* - s_j^*\right] \quad , \quad s_j^* = \frac{mc_j^*}{\varepsilon_j^*}.$$

- Financed by lump-sum tax on households: $S = \sum_j S_j$

Role of consumer heterogeneity - Welfare effects of markups

Who gains from competitive product markets? **Poor households.**

		Baseline	Optimal Subsidy
A. Statistics	Interest rate	2.00%	1.67%
	Average markup	24%	25%
	EMX slope	0.034	0.078
B. Firms	**Total quantities**		
	Low quality goods		-1.66
	High quality goods		4.31
C. Households	**Average quality -** ϕ_j		
	Poor		2.2
	Rich		-0.9
	Average consumption		
	Poor		-7.9
	Rich		3.5
	Average welfare - $\overline{V}(a, e)$		
	Poor		46.2
	Rich		-21.9

Note: Firms split by top / bottom quintile of sales in baseline. Households split by top / bottom half of cash-on-hand in baseline. All values are log changes expressed in log points.

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A. Statistics	Interest rate	2.00%	2.00%
	Average markup	24%	25%
	EMX slope	0.034	0.077
B. Firms	**Total quantities**		
	Low quality goods		-1.30
	High quality goods		4.83
C. Households	**Average quality -** ϕ_j		
	Poor		2.3
	Rich		-0.6
	Average consumption		
	Poor		-8.0
	Rich		2.9
	Average welfare - $\overline{V}(a, e)$		
	Poor		46.1
	Rich		-23.0

Note: Firms split by top / bottom quintile of sales in baseline. Households split by top / bottom half of cash-on-hand in baseline. All values are log changes expressed in log points.

Result 3 - Fiscal transfer increases the aggregate markup

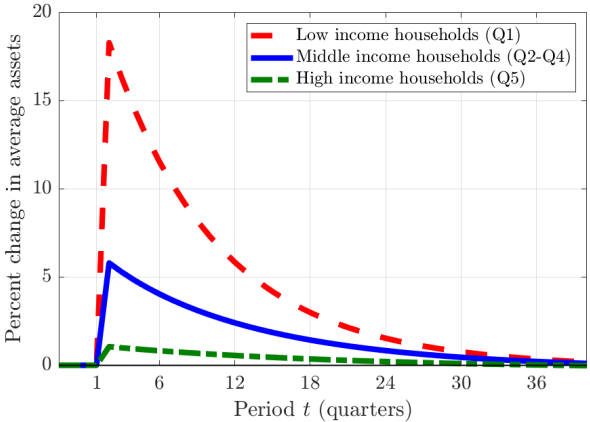
- Unanticipated increase in transfers T by 1% of GDP in one quarter
  - Excess savings peaked at 7.56% of GDP, 6 quarters into pandemic (SF Fed)
- Details
  - Government spending $\overline{G}$ fixed
  - Interest rate $\overline{r}$ fixed

    $\Longrightarrow$ Small-open economy in the *homogeneous good*.
    Allows labor producing $\overline{G}$ to flow to production of differentiated goods
  - Taxes gradually adjusted to finance increase in debt

$$\tau_t = \overline{\tau}\left(\frac{B_{t-1}}{\overline{B}}\right)^{\phi_\tau}$$

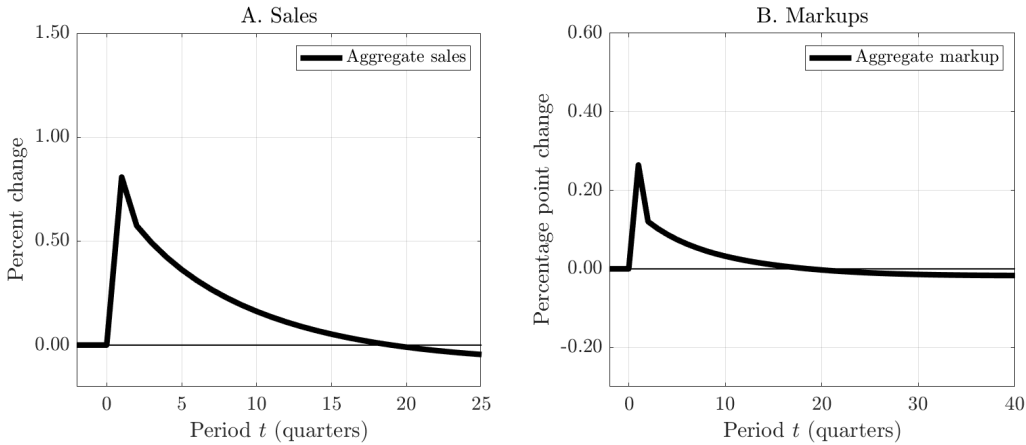
  - Set $\phi_\tau = 0.25$ for half-life of debt of 10 years

Result 3 - Fiscal transfer increases the aggregate markup



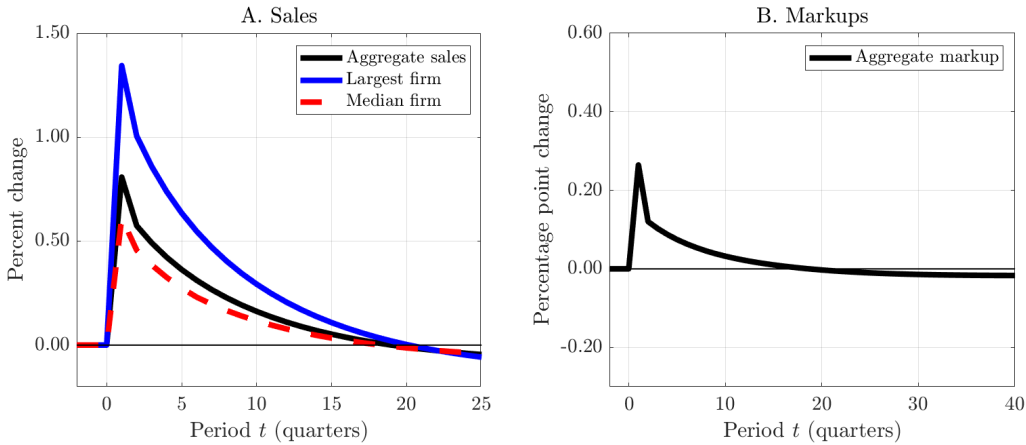
- One-time transfer of 1% of GDP to households

Result 3 - Fiscal transfer increases the aggregate markup



- **Result** - Aggregate markup increases **0.3 ppt**.Shaped by consumer heterogeneity effects.

Result 3 - Fiscal transfer increases the aggregate markup



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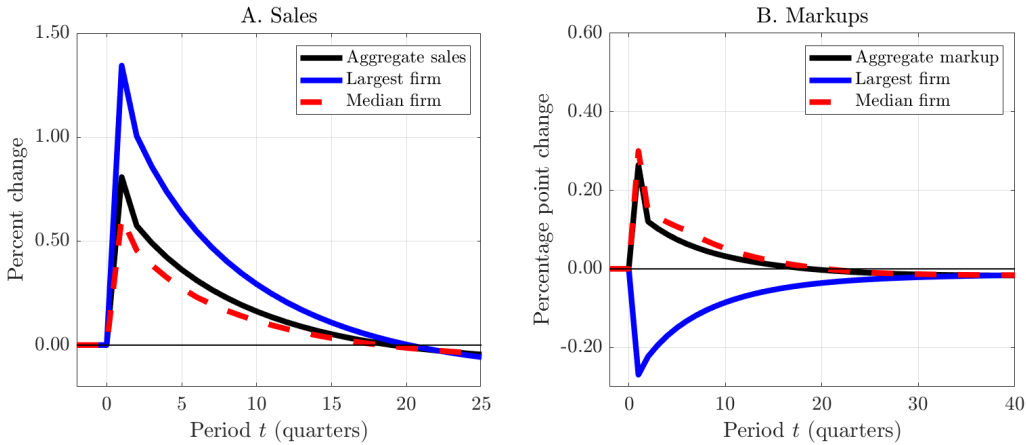

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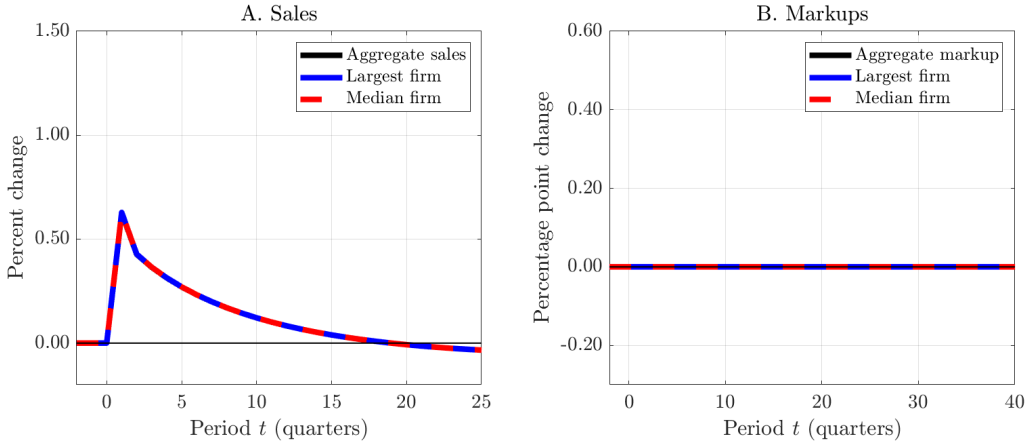

- **Result** - Heterogeneity accounts for 100% of markup response and 49% of inflation

Important questions

1. Is the restriction to a single good each period important?

2. Is the divisibility of the good important? What if $q^i_{jg} = 1$?

3. Why not have quality ϕ_j complementary to consumption $\phi_j u(c^i_j)$?

Important questions

1. Is the restriction to a single good each period important?

- Appendix has important variations that answer this:
  - Continuous time model - Shrink the period length. Keep the basket size
  - Shopping cart model - Keep the period length. Expand the basket size
- **Does not** change extensive margin elasticity and sorting results.

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- Appendix walks through this in context of Fajgelbaum Grossman Helpman (2011)
- Households very price sensitive to high quality goods. Large firms $\rightarrow$ Smaller markups ✗

Conclusion

New theory - Flexible framework that integrates IO and frontier heterogeneous agent macroeconomics. The key link is the endogenous marginal value of wealth. This avoids adding additional parameters to either model.

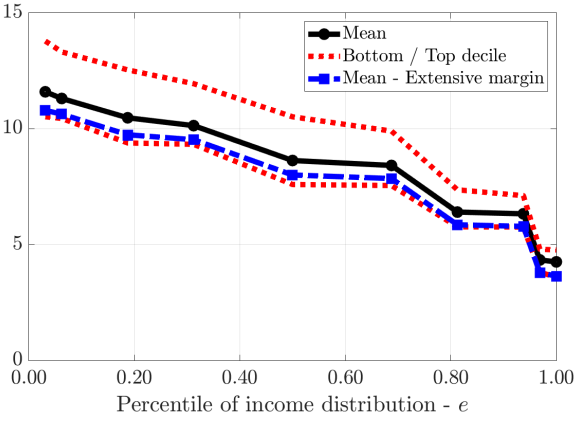
1. **New perspective on markups**
   - Lesson - *Household heterogeneity / incomplete markets are key*
   - *Counterfactuals* studied in incomplete markets settings have markup implications
   - Income inequality, Income shocks, Financial instruments ... all shape individuals' elasticities

2. **New perspective on policy**
   - Lesson - *Markup responses inhibit counter-cyclical policies that operate via 'high MPC' h'holds*
   - *Policies* studied in incomplete markets settings have markup implications
   - UBI, Medical insurance, Tax progressivity, Debt relief ... all shape individuals' elasticities

APPENDIX SLIDES

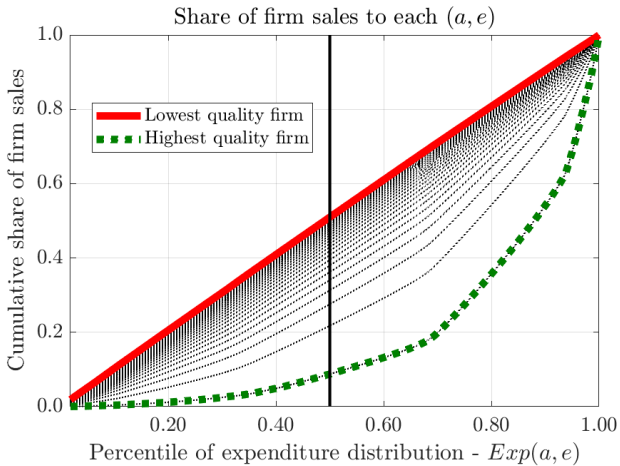
RESULTS - CROSS-SECTION

1. Elasticities



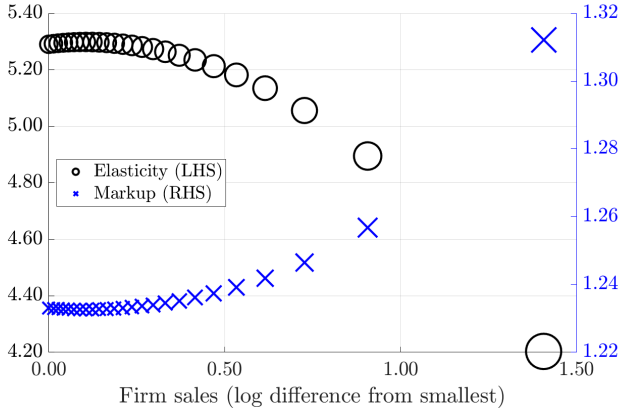
- Simple regression: $\mathbb{E}\left[\varepsilon^i | e\right] = \beta_0 - \beta_1 \log e, \quad \widehat{\beta}_1 = 2.19$
- Nakamura Zerom (2010) - 'Coffee paper' - *A household with an income 1 s.d. above the mean has a price elasticity about 20% [18.1%] below the price elasticity of the median consumer [8.34].*

2. Sorting



- At the low quality firm, >50 percent of sales to below median expenditure households
- At the high quality firm, <15 percent of sales to below median expenditure households

3. Markups



- High quality firms have: Higher sales, Higher prices, Lower elasticities, Higher markups