Pricing Inequality

Simon Mongey   Michael E. Waugh
FRB Minneapolis and NBER

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Household Heterogeneity and Firm Pricing

Question:

Does household heterogeneity matter for firm price setting and aggregate price dynamics?

Two facts about households that motivate this question. . .

- Auer, Burstein, Lein, and Vogel (2022): poor households are more price elastic.
- Bils and Klenow (2001) and Jaimovich et al. (2020): poor households buy cheaper price varieties of the same good.

Suggest that household heterogeneity has implications for how firms set prices / markups.

- Who the firm sells to and how elastic they are determines markups.
- Government policies affecting income / wealth will affect aggregate markups and inflation.

Three Contributions: **1.** Extensive Margin Demand in GE

1. Tractable Theory: $\underbrace{\text{Incomplete markets}}_{\text{Bewley, Aiyagari, Hugget}} + \underbrace{\text{extensive margin demand}}_{\text{Multinomial logit + Oligopoly}}$ in general equilibrium.

We show how households' marginal utility of wealth shapes

- price elasticities of demand,
- sorting across varieties.

These forces affect markups, pricing, and pass-through.

Three Contributions: **2.** How much does HH matter for markup variation?

2. Calibration: Few, standard parameters $\Rightarrow$ broad set of empirical facts.

- **Poorer households** are
  (i) more price elastic (Auer et al. (2022)), (ii) buy cheaper varieties (Bils and Klenow (2001), Jaimovich et al. (2020))(iii) buy from smaller firms (Faber and Fally (2022)) (iv) pay lower markups Sangani (2022).
- **Larger firms**
  (i) have higher markups (Edmond et al. (2023)), (ii) lower pass-through (Amiti et al. (2019)),
  (iii) are large because they sell to more customers (Einav et al. (2021), Fitzgerald et al. (2023)), and (iv) because of higher quality, not lower costs (Hottman et al. (2016)).

Question: How much does household heterogeneity shape the distribution of markups?

Answer: 2/3 of elasticity / markup variation comes from household heterogeneity.

Three Contributions: **3.** How do markups and inflation respond to a fiscal transfer?

3. Policy experiment: Fiscal transfer to households similar to 2020-2021

- **Poorer households:**
  Sharp increase in savings ⇒ lower marginal utility of wealth ⇒ much less elastic, trade up from low price to high price varieties.
- **Firms:**
  Markups increase as their customer base becomes more inelastic, markups increase by more for firms facing poorer households.

Question: Does household heterogeneity matter for aggregate price dynamics?

Answer: Yes...inflation increases by 1.75 percentage points. Half as much when household heterogeneity is turned off.

Outline

1. Model

- Setup and illustrate how things work.

2. Calibration

- How we discipline things, why we find what we find.

3. Policy experiment

- Use the model to study a fiscal transfer to households similar to 2020-2021.

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Goods and Firms

Differentiated goods:

Markets $m \in \mathcal{M}$, each contain J firms $j \in \{1, \ldots, J\}$. Firm jm produces the variety jm with technology

$$y_{jmt} = z_{jm}\left(n_{jmt}\right)^{\alpha} \quad , \quad \left(\psi_{jm}, z_{jm}\right) \sim \Gamma_{\psi,z}\left(\psi, z\right).$$

- z_{jm} is firm productivity.
- n_{jmt} are efficiency units of labor supplied by households.
- α controls extent of DRS (or IRS) for the firm.
- ψ_{jm} is quality (next slide), $\Gamma_{\psi,z}$ is the joint distribution of quality and productivity.

Homogeneous good:

Continuum of identical firms, competitive

$$y_{ct} = \overline{z}_c n_{ct}.$$

used for government spending, may be valued by household, and is the numeraire.

Households

Continuum of households with names $i \in [0,1]$

Household preferences:

$$\mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^t \sum_{m\in\mathcal{M}}\sum_{j=1}^{J}\widetilde{u}^i_{jmt}\right] \quad , \quad \widetilde{u}^i_{jmt} = \begin{cases} u\left(c^i_t, x^i_{jmt}\right) + \psi_{jm} + \zeta^i_{jmt} & \text{, if consume } jm \\ 0 & \text{, otherwise} \end{cases} \quad , \quad \underbrace{\zeta^i_t \sim \Gamma_\zeta\Big(\zeta\Big)}_{\text{iid each period}}.$$

Each period a household chooses:

- a single good from a market m and producer j, and quantity x^i_{jmt},
- consumption of the homogeneous good,
- save a^i_t in government debt with interest rate r, subject to borrowing constraint $\underline{a}$,
- earning we^i_t with e^i_t being stochastic productivity evolving according to a Markov chain,
- pays income taxes τwe^i_t, receives transfers T, and profits π.

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Taste shocks are distributed GEV:

$$\Gamma_\zeta\left(\zeta\right) = \prod_{m \in \mathcal{M}} \exp\left\{ -\left(\sum_{j \in J} e^{-\eta \zeta^i_{jm}} \right)^{\theta/\eta} \right\}.$$

- η controls dispersion across js within market m. θ controls dispersion across markets $\mathcal{M}$.
- Why? With $\theta \leq \eta$ allows us to think about an Atkeson and Burstein (2008) like setting; with $\theta = \eta$ collapses to monopolistic competition.

Households

Continuum of households with names $i \in [0,1]$

Household preferences:

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \sum_{m \in \mathcal{M}} \sum_{j=1}^{J} \widetilde{u}_{jmt}^i \right] \quad , \quad \widetilde{u}_{jmt}^i = \begin{cases} u\left(c_t^i, x_{jmt}^i\right) + \psi_{jm} + \zeta_{jmt}^i & \text{, if consume } jm \\ 0 & \text{, otherwise} \end{cases} \quad , \quad \underbrace{\zeta_t^i \sim \Gamma_\zeta\left(\zeta\right)}_{\text{iid each period}}.$$

For now, we will keep u general...

and summarize elasticities and sorting patterns in terms of the hh's multiplier on its budget constraint.

What Households Do

Focus on a stationary setting. A hh's state are its asset holdings a and shock e.

Work backwards...

2. Conditional on choosing firm jm, and given w, r, π, p_{jm}, their problem is

$$V\Big(a, e, p_{jm}\Big) = \max_{a', c, x} \; u\big(c, x\big) + \beta \int \overline{V}\Big(a', e'\Big) \, d\Gamma_e\big(e'|e\big),$$

$$\text{subject to:} \quad c + p_{jm}x_{jm} + a' = \Big(1 - \tau\Big)we + (1 + r)a + \pi + T \quad \text{and} \quad a' \geq \underline{a},$$

$$\text{an important object:} \quad \lambda(a, e, p_{jm}) = \text{multiplier on the budget constraint / shadow value of wealth}$$

1. Given preference shocks ζ_{jm}, choose a market m and producer j

$$\widetilde{V}\Big(a, e, \mathbf{p}_m\Big) = \log\left[\sum_{j \in m} \exp\left\{\psi_{jm} V\big(a, e, p_{jm}\big)\right\}^{\boldsymbol{\eta}}\right]^{1/\boldsymbol{\eta}}$$

$$\overline{V}\Big(a, e\Big) = \log\left[\sum_{m \in \mathcal{M}} \exp\left\{\widetilde{V}\big(a, e, \mathbf{p}_m\big)\right\}^{\boldsymbol{\theta}}\right]^{1/\boldsymbol{\theta}}$$

What Firms Do

Given competitors' prices $\mathbf{p}_m$ and aggregates $\mathbf{S}$, choose price p_{jm} to maximize profits.

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The equilibrium quantity sold is

$$x\Big(p_{jm}, \mathbf{p}_m, \mathbf{S}\Big) = \int_{A\times E} \rho\Big(a, e, p_{jm}, \mathbf{p}_m, \mathbf{S}\Big) x\Big(a, e, p_{jm}, \mathbf{p}_m, \mathbf{S}\Big)\, \mathrm{d}\,\Gamma(a, e)$$

$$\rho\Big(a, e, p_{jm}, \mathbf{p}_m, \mathbf{S}\Big) = \left(\frac{\exp\left\{\psi_{jm} V\left(a, e, p_{jm}\right)\right\}}{\exp\left\{\widetilde{V}\left(a, e, p_{jm}, \mathbf{p}_m\right)\right\}}\right)^{\boldsymbol{\eta}} \left(\frac{\exp\left\{\widetilde{V}\left(a, e, p_{jm}, \mathbf{p}_m\right)\right\}}{\exp\left\{\overline{V}\left(a, e\right)\right\}}\right)^{\boldsymbol{\theta}}$$

What Firms Do

Given competitors' prices $\mathbf{p}_m$ and aggregates $\mathbf{S}$, choose price p_{jm} to maximize profits.

The equilibrium quantity sold is (and simplifying notation a bit)

$$x_{jm} = \int \rho^i_{jm} x^i_{jm} \, di$$

$$\rho^i_{jm} = \underbrace{\left(\frac{\exp\left\{\psi_{jm} V^i(p_{jm})\right\}}{\exp\left\{\widetilde{V}^i(\mathbf{p}_m)\right\}} \right)^{\boldsymbol{\eta}}}_{x^i_{j|m}} \underbrace{\left(\frac{\exp\left\{\widetilde{V}^i(\mathbf{p}_m)\right\}}{\exp\left\{\overline{V}^i\right\}} \right)^{\boldsymbol{\theta}}}_{x^i_m}$$

What Firms Do

Given competitors' prices $\mathbf{p}_m$ and aggregates $\mathbf{S}$, choose price p_{jm} to maximize profits.

Optimality — standard markup condition under Bertrand

$$p^*_{jm} = \underbrace{\frac{\varepsilon_{jm}}{\varepsilon_{jm} - 1}}_{\text{Markup}} \times \text{marginal cost}_{jm}, \qquad \text{where} \quad \varepsilon_{jm} = -\left.\frac{\partial \log x_{jm}}{\partial \log p_{jm}}\right|_{\mathbf{p}^*_{-jm}}$$

Key issue in the next couple of slides:

- how the firms aggregate elasticity ε_{jm} is shaped by household-level elasticities and the pattern of sorting into varieties.

Elasticities of Demand

A firm's elasticity of demand is

$$\varepsilon_{jm} = -\frac{\partial \log x_{jm}}{\partial \log p_{jm}} = \int \underbrace{\left(\frac{\rho^i_{jm} x^i_{jm}}{x_{jm}}\right)}_{\text{weights}} \underbrace{\left(\varepsilon^{\rho,i}_{jm} + \varepsilon^{x,i}_{jm}\right)}_{\text{individual elasticities}} \, di,$$

a weighted average of **individuals** elasticities of demand. . . on the **extensive** and **intensive** margin.

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$$\varepsilon^{\rho,i}_{jm} = \underbrace{\left[\boldsymbol{\eta}\left(1 - \rho^i_{j|m}\right) + \boldsymbol{\theta}\rho^i_{j|m}\right]}_{\text{oligopoly}} \times \underbrace{\left[\lambda^i_{jm} \; p_{jm} \; x^i_{jm}\right]}_{\text{wealth}}$$

Extensive margin depends on two factors:

1. How important firm *jm* is in the market of type *i* consumers — where the oligopoly part matters.
2. How rich or poor those consumers as summarized by λ^i_{jm} — where heterogeneity matters.

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a weighted average of **individuals** elasticities of demand...on the **extensive** and **intensive** margin.

$$\varepsilon^{\rho,i}_{jm} = \eta \times \underbrace{\left[u'(x^i_{jm})\; x^i_{jm}\right]}_{\text{wealth}}$$

Special case: $\eta = \theta$ (no market power); only differentiated goods...

Elasticities of Demand

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$$\varepsilon^{\rho,i}_{jm} = \eta \times \underbrace{\left[x^i_{jm}\right]}_{\text{wealth}}^{1-\sigma}$$

Special case: $\eta = \theta$ (no market power); only differentiated goods. . .

With CRRA $\Rightarrow$ and $\sigma > 1$, than the poor are more elastic on extensive margin.

With log, then we have an Anderson et al. (1987) like result and heterogeneity plays no role. This is how we **turn off** heterogeneity in the policy experiments.

Elasticities of Demand

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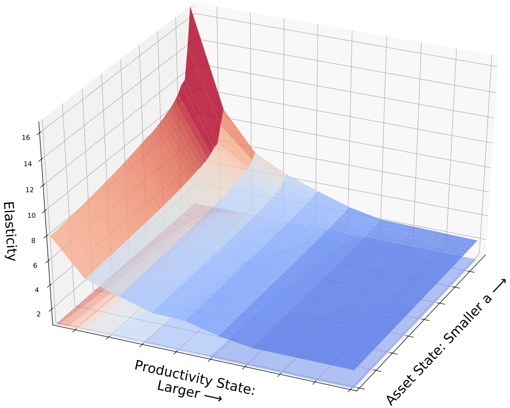
a weighted average of **individuals** elasticities of demand...on the **extensive** and **intensive** margin.

$$\varepsilon^{x,i}_{jm} = -\frac{\partial \log x^i_{jm}}{\partial \log p_{jm}}$$

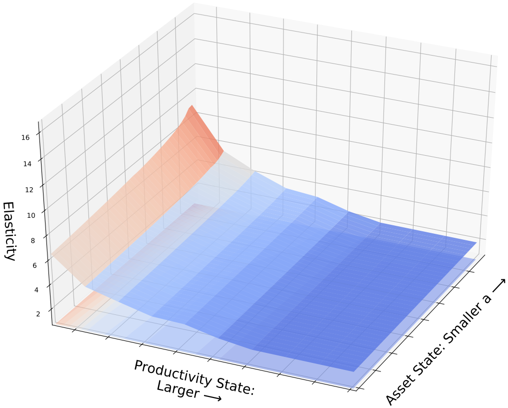
Intensive margin is harder to characterize, but it depends on...

- substitutability / complimentarily between c and x,
- intertemporal motives.
- In our quantitative setting, this is small relative to extensive margin.

Example: Elasticities by HH-Level State



High Price Firm



Low Price Firm

Sorting

A firm's elasticity of demand is

$$\varepsilon_{jm} = -\frac{\partial \log x_{jm}}{\partial \log p_{jm}} = \int \underbrace{\left(\frac{\rho^i_{jm} x^i_{jm}}{x_{jm}}\right)}_{\text{weights}} \underbrace{\left(\varepsilon^{\rho,i}_{jm} + \varepsilon^{x,i}_{jm}\right)}_{\text{individual elasticities}} di,$$

a weighted average of **individuals** elasticities of demand. . . on the extensive and intensive margin.

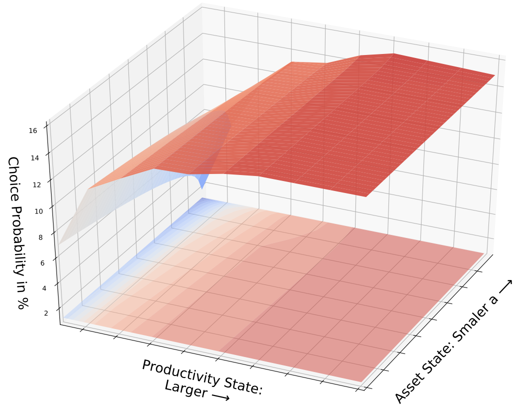
What about the weights? This depends upon how rich and poor households sort across varieties. In the case of no-outside good, how the choice probability varies with wealth and price is

$$\frac{\partial}{\partial p_{jm}} \frac{\partial \log \rho^i_{j|m}}{\partial a^i} \approx (1+r)\,\eta \left(\frac{\lambda^i_{\overline{jm}} - \lambda^i_{\underline{jm}}}{p_{\overline{jm}} - p_{\underline{jm}}}\right) > 0,$$

where $\overline{jm}$ is a high price good relative to $\underline{jm}$.

Key implication: **rich hhs are more likely to purchase from high price firms.**

Example: Choice Probabilities by HH-Level State



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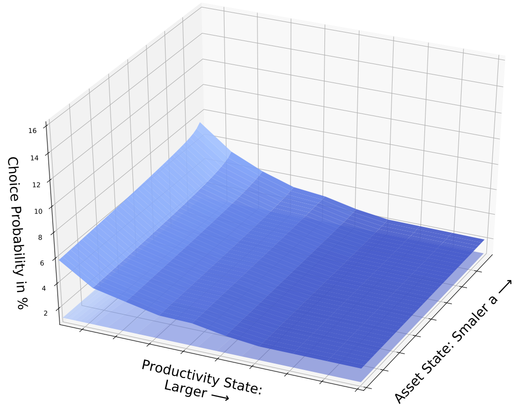

Low Price Firm

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Functional Forms and Predetermined Parameters

Time: A time period is one quarter.

Household:

- No outside good, CRRA for $u(x)$.
- Earnings process as in Krueger, Mitman, and Perri (2016).
- No Borrowing, $\bar{a} = 0$.

Firms:

- All markets $\mathcal{M}$ are symmetric; θ is set to 1.0.
- Firm quality ψ_j and productivity z_j are joint log normally distributed.

Government (Kaplan and Violante (2022), Kaplan et al. (2020)):

- Labor income taxes are 15% of GDP, transfers are 5% of GDP.
- Fix annual interest rate of 2%.
- Government debt of 56% of GDP, then we find β so that the Gov's asset supply matches the hh asset demand.

Parameters to Calibrate and Targets

Description	Value	Target
Discount Factor, β	0.98	interest rate of 2%
Good-level taste shock, η	14.15	average markup (cost weighted) of 1.30
Number of firms	25	HH-index, Amiti and Heise (2024)
Quality variance	0.007	top 4 concentration, Amiti and Heise (2024)
Productivity variance	0.005	slope of markups and size, Edmond et al. (2023)
Correlation of productivity and quality	-0.34	variation in prices, Kaplan and Menzio (2015)
Returns to scale	0.74	how prices paid vary with income, Jaimovich et al. (2020)
CRRA parameter, σ	2.73	how elasticities vary with income, Auer et al. (2022)

Calibration — Disciplining σ

Auer, Burstein, Lein, and Vogel (2022) regression:

$$\log\left(\frac{b^i_{Mt}}{b^i_{Dt}}\right) = \boldsymbol{\beta}_0 - \boldsymbol{\beta}_1 \log\left(\frac{p_{Mt}}{p_{Dt}}\right) + \boldsymbol{\beta}_2 \log e^i \log\left(\frac{p_{Mt}}{p_{Dt}}\right) + \varepsilon_{it}$$

which is run on Swiss households during the Franc appreciation of 2015.

Idea is that French goods (imports) became cheaper relative to Swiss goods (domestic), so people buy more French stuff...the key finding /issue is that this is much less for richer households β_2 is positive.

The same thought experiment in our model. . . run the same type of regression in the model

$$\log\left(\frac{b^H_{j'}}{b^H_j}\right) - \log\left(\frac{b^L_{j'}}{b^L_j}\right) \approx \underbrace{\left\{\varepsilon^{\rho,L}_j\right\}\left\{\sigma\right\}\left\{\frac{\partial \log c^L_j}{\partial \log e^L}\right\}}_{\text{Coefficient estimated in Auer et al (2022)}} \underbrace{\log\left(\frac{e^H}{e^L}\right)\log\left(\frac{p_{j'}}{p_j}\right)}_{\text{Interaction term}},$$

Key implication: The Auer et al. (2022) results are highly informative about σ.

Calibration — Quality variation and DRS

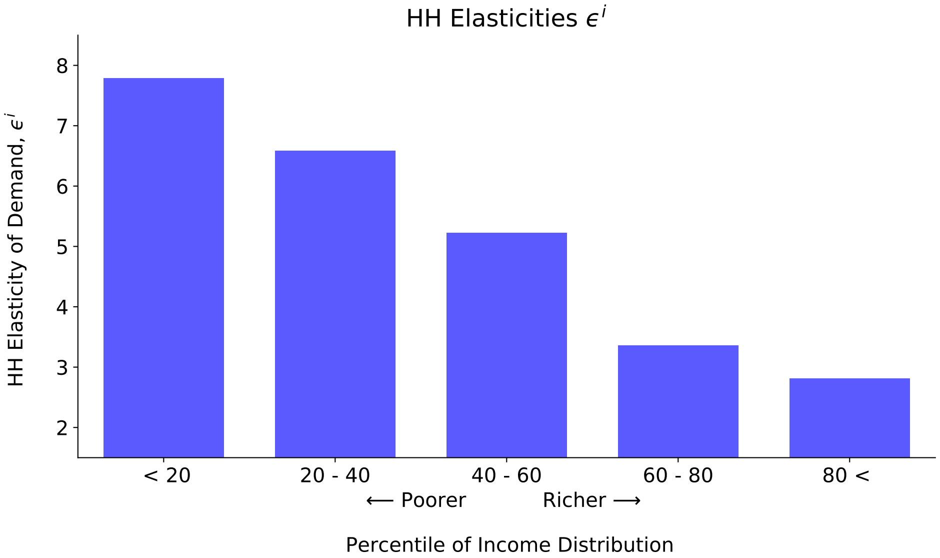
Quality and DRS $\Rightarrow$ big firms are high quality, high marginal cost, high price firms. Why do we find this? Consider a high quality firm versus low quality firm $\psi_h > \psi_l$

- Market power + DRS imply that $p_h > p_l$
- Sorting implies that the rich sort relatively more towards the high price, high quality firm.
- Data — consistent with empirical evidence that the rich pay higher prices for the same good ✓
- Data — consistent with empirical evidence that big firms have high markups ✓

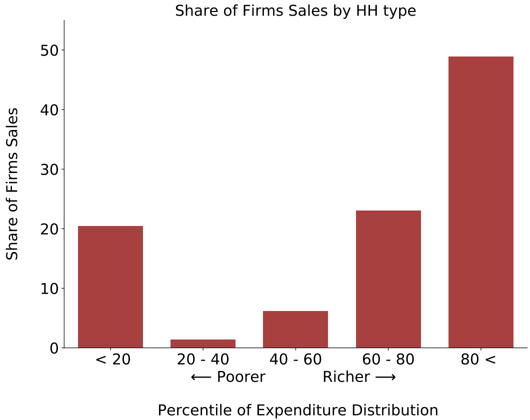
Pure story of productivity heterogeneity has problems. . .

- Not enough sorting and / or the wrong direction.
- Size-markup correlation is wrong — big firms are low price, face elastic consumers, and low markup.

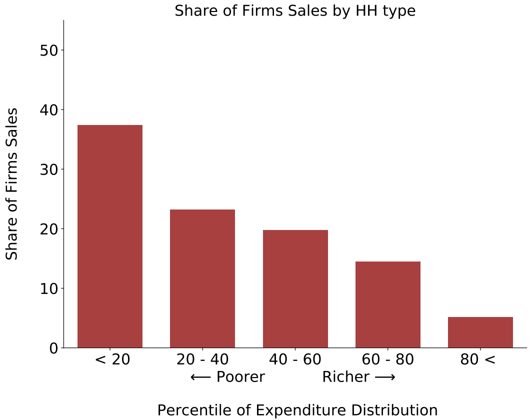
Calibration: HH-Level Elasticities



Calibration: Sorting



High Quality, High Price Firm



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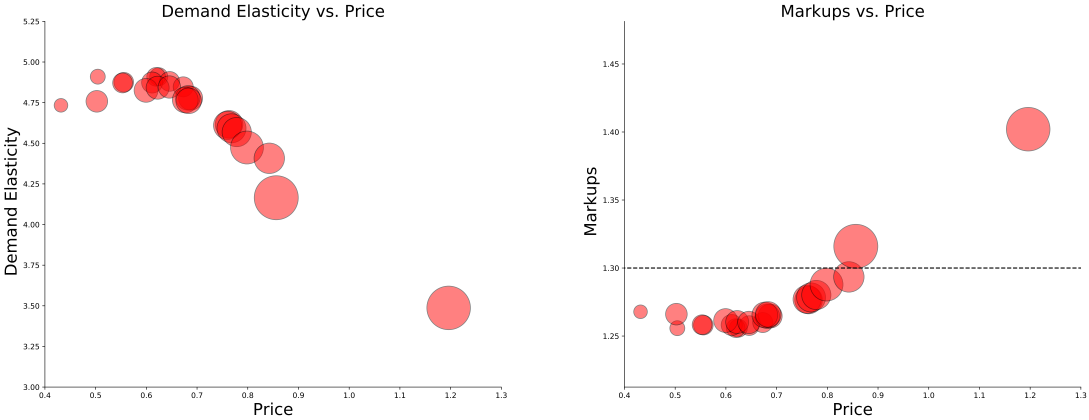
Calibration: Demand Elasticities and Markups



Demand Elasticities **Markups**

What Accounts for Elasticity / Markup Variation?

Differences across firms in elasticities / markups came from **two** sources:

- Market power,
- Household heterogeneity.

Which force is more important?

Elasticity Decomposition

	Market Power	Household Heterogenaity
Top – Bottom Quintile Firms	32.4	67.6
Middle – Bottom Quintile Firms	35.2	64.8

Note: Quintile are formed on the basis of sales.

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Non-Targeted Moments

Non-Targeted Moments

Description	Data Moment	Model Moment	Source
Pass-through small firms (in %)	93.1	99.2	Amiti et al. (2019)
Pass-through large firms	62.6	105.0	Amiti et al. (2019)
Share of sales quality decomposition	1.05	1.06	Hottman et al. (2016)
Top vs. Bottom 10% of hh buying at large firms	27	40	Faber and Fally (2022)
Semi-elasticity of average markup to log income	0.021	0.012	Sangani (2022)
Average MPC out of $500	0.15 – 0.25	0.19	Kaplan and Violante (2022)
Response of Markups to Wealth	0.10	0.10 – 0.23	Stroebel and Vavra (2019)

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How Does the Economy Respond to a Fiscal Transfer?

Idea: Put in a COVID-era size fiscal transfer and see what happens...

- Excess savings increased by 7.56% of GDP by August 2021 (SF Fed).

What we do: Shock the economy with an unanticipated increase in government transfers T by 7.56% of GDP dispersed over 3 quarters.

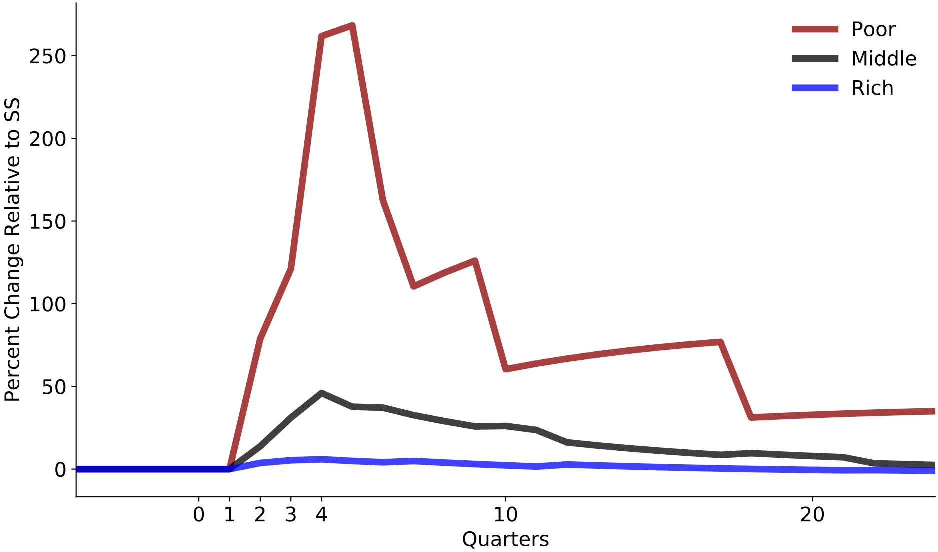
Important details:

- Government spending G is fixed.
- R is held fixed (Kaplan et al. (2020)).
- Taxes are gradually adjusted to finance the increase in debt according to the function

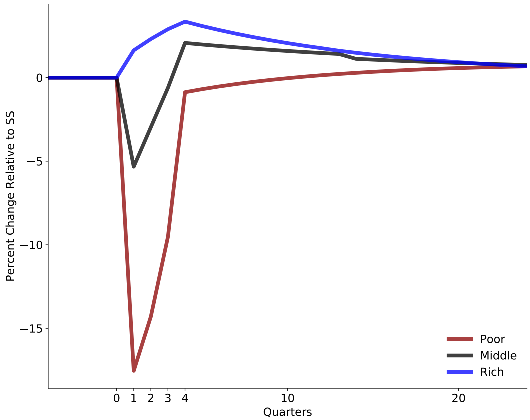
$$\tau_t = \tau \left(\frac{B_{t-1}}{B} \right)^{\varsigma}$$

and set ς for a half-life of debt of 10 years.

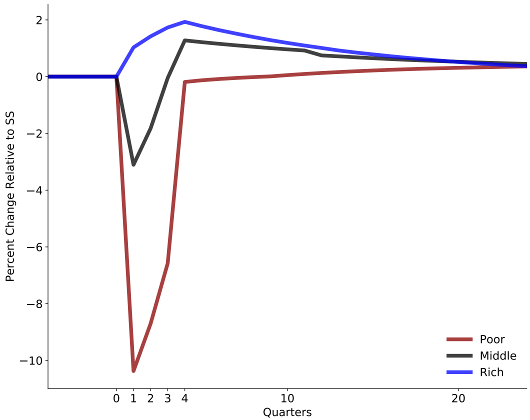
Excess Savings



Marginal Utility of Consumption and Demand Elasticities

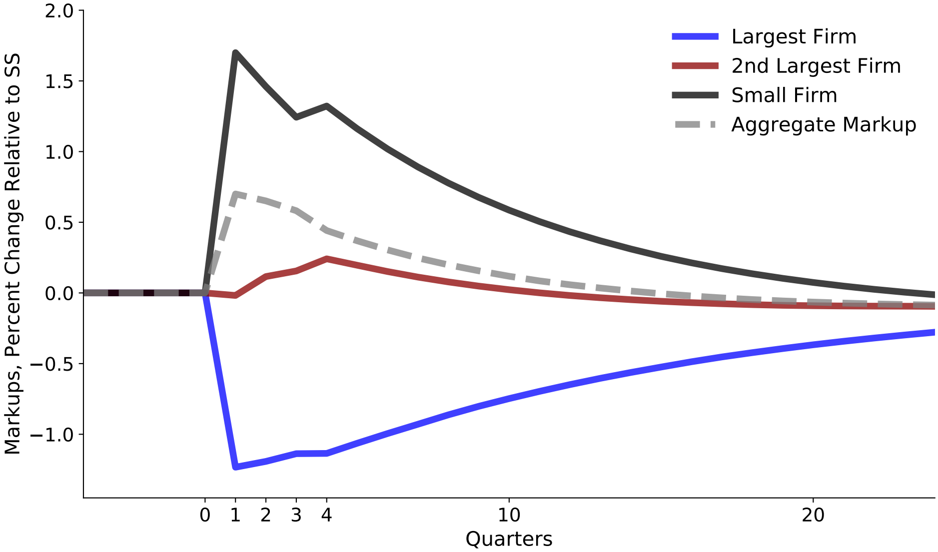


Marginal Utility in Consumption

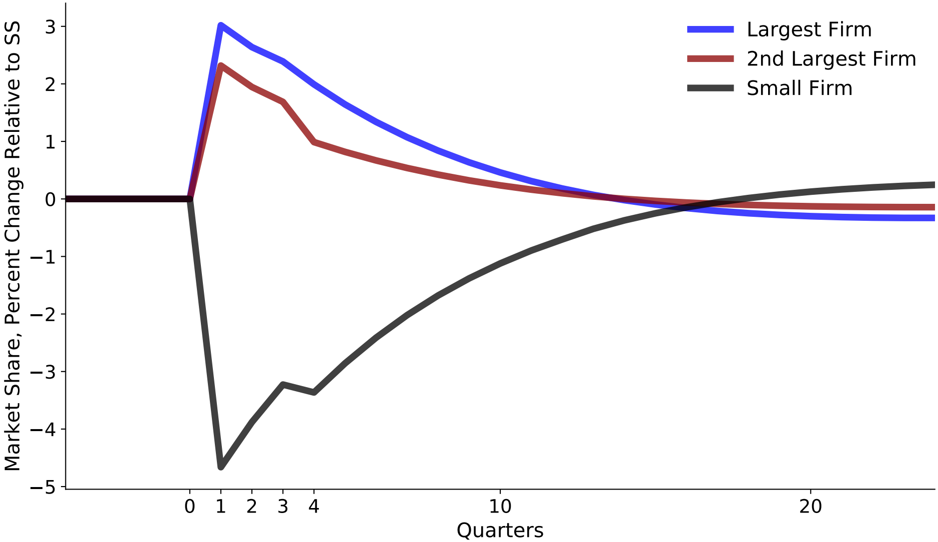


Demand Elasticities

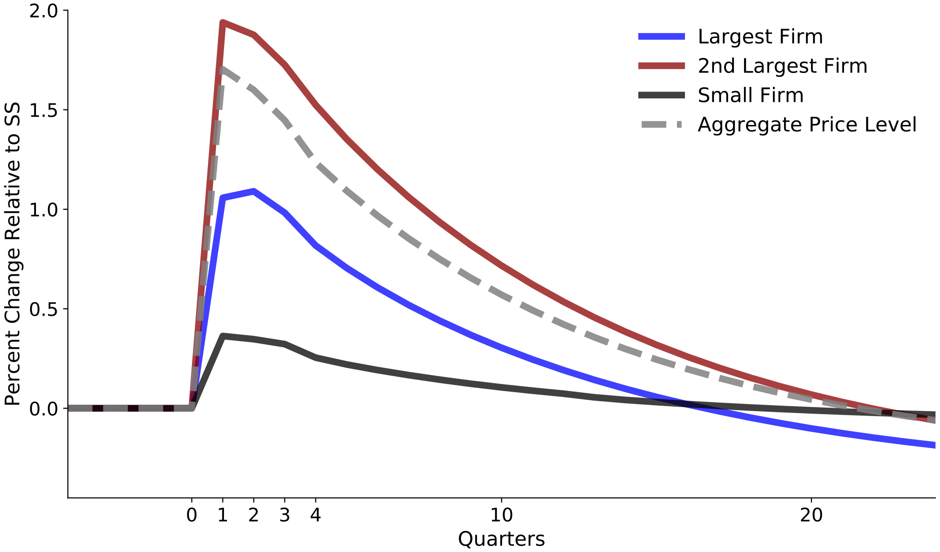
Markups


Largest Firm
2nd Largest Firm
Small Firm
Aggregate Markup
Markups, Percent Change Relative to SS
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
0
1
2
3
4
10
20
Quarters

Market Share



Prices



Largest Firm
2nd Largest Firm
Small Firm
Aggregate Price Level
Percent Change Relative to SS
2.0
1.5
1.0
0.5
0.0
0
1
2
3
4
10
20
Quarters

Taking Stock

In response to a fiscal transfer, aggregate markups and prices increased by 0.75% and 1.75% . . .

Q1. Is this big or small? (audience participation needed here)

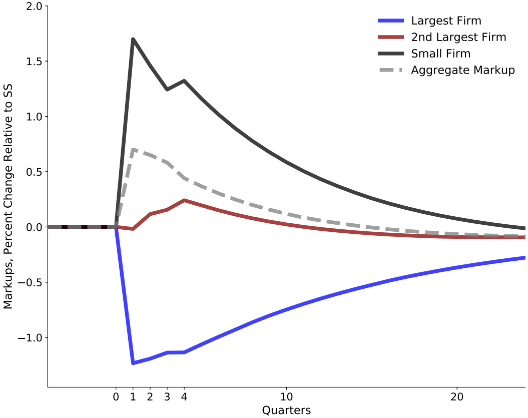
Some benchmarks we thought of:

- Faria-e Castro (2024) NK-DSGE model with some household heterogeneity and explicit modeling of the fiscal side and applied to Covid era — the fiscal impulse contributed 2pp to inflation.
- Amiti, Heise, Karahan, and Şahin (2024) NK-DSGE model with Atkeson and Burstein (2008)-like structure — supply shocks increased inflation by 4pp.

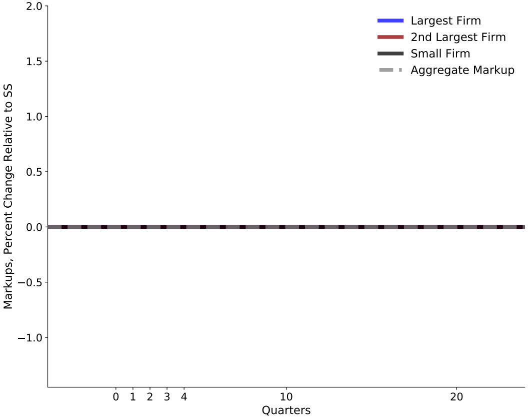
Q2. What is the role of household heterogeneity?

Next slides: Same experiment but when preferences are log and demand elasticities **do not** vary across households.

The Role of Household Heterogeneity — Markups

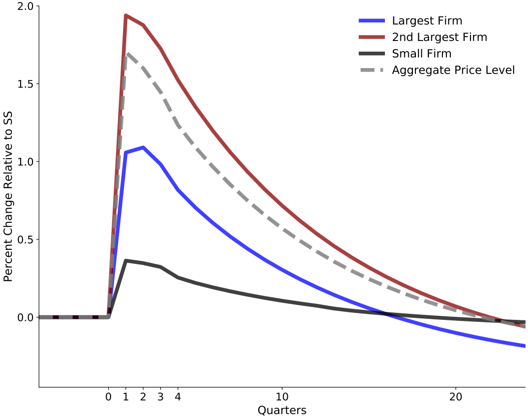


Baseline Model

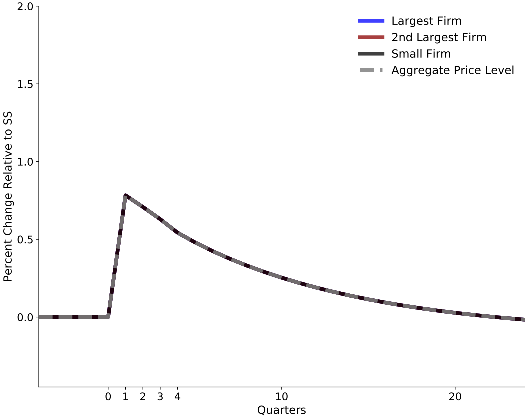


Log Model

The Role of Household Heterogeneity — Prices



Baseline Model — Prices



Log Model — Prices

Final Thoughts...

1. Framework — Flexible framework for disaggregated demand across heterogeneous households and how it matters for firm pricing.

- Leverages the standard economic logic of heterogeneous agent consumption / savings models.
- Applied to labor supply (Berger, Herkenhoff, Mongey, Oppenheimer 2024). My HAT paper Waugh (2024) is a perfect competition, trade version of this.

2. Empirics — Makes sense of a broad set of well known empirical regularities on firm size, firm pricing and household purchasing. More work to be done!

3. Implications — More work to be done!

- Welfare effects of price changes / inflation very different to "aggregative" consumption model.

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Pass-Through

How do prices change given a change in marginal costs, aka pass-through:

$$\frac{\partial \log p_{jm}}{\partial \log mc_{jm}} = \frac{[\varepsilon_{jm} - 1]}{[\varepsilon_{jm} - 1] + \left\{ \frac{\partial \log \varepsilon_{jm}}{\partial \log p_{jm}} \right\}_{(+)}} \in (0, 1),$$

where $\frac{\partial \log \varepsilon_{jm}}{\partial \log p_{jm}} := \mathcal{E}_{jm}$ is the "super-elasticity" which takes this form...

The Super-Elasticity

The super-elasticity...

$$\mathcal{E}_{jm} = \int \overbrace{\underbrace{\left(\frac{\rho^i_{jm} x^i_{jm} \varepsilon^i_{jm}}{\int \rho^i_{jm} x^i_{jm} \varepsilon^i_{jm}}\right)}_{\text{weights}} \left(\frac{\partial \log \left[\rho^i_{jm} x^i_{jm} / x_{jm}\right]}{\partial \log p_{jm}}\right) di}^{\text{composition}} \quad + \quad \int \left(\frac{\rho^i_{jm} x^i_{jm} \varepsilon^i_{jm}}{\int \rho^i_{jm} x^i_{jm} \varepsilon^i_{jm}}\right) \quad \underbrace{\mathcal{E}^i_{jm}}_{\text{i's super elasticity}} \quad di.$$

The aggregate super-elasticity is a weighted average of

- how do expenditure weights change,
- how individual elasticities change.

The Individual Super-Elasticity

Individual super elasticity is weighted average of extensive and intensive margin super elasticities. . . abstract from the intensive margin and we have:

$$\mathcal{E}^i_{jm} \approx \underbrace{\left[\frac{\eta(\eta-\theta)\rho^i_{j|m}(1-\rho^i_{j|m})}{\eta-(\eta-\theta)\rho^i_{j|m}}\right] \times \left[\lambda^i_{jm} p_{jm} x^i_{jm}\right]}_{\text{market power effect}} + \underbrace{\frac{\partial \log \lambda^i_{jm}}{\partial \log p_{jm}} + \varepsilon^{i,x}_{jm} + 1}_{\text{wealth effect}}.$$

As with the elasticities, very similar ideas here:

- market power,
- how the marginal utility of wealth changes.

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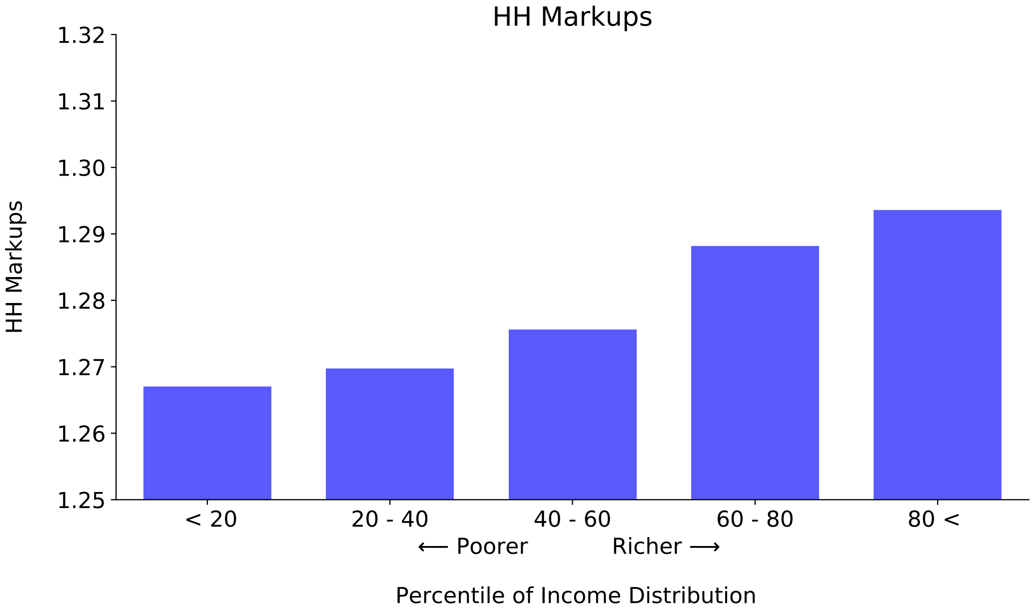
As with the elasticities, very similar ideas here:

- market power,
- how the marginal utility of wealth changes.

So what? The key issue is how markups and super-elasticities are (i) not "parameterized" and (ii) depend upon market power forces and the distribution of wealth.

Calibration: HH-Level Markups



Elasticity Decomposition

- For each firm, extensive margin elasticity is:

$$\varepsilon_j^{\rho} = \int_i \omega^i \left(\eta - (\eta - \theta)\rho_j^i\right) \lambda_j^i p_j c_j^i \, di$$

- Approximately, this is

$$\widetilde{\varepsilon}_j^{\rho} = \underbrace{\left[\int_i \omega^i \left(\eta - (\eta - \theta)\rho_j^i\right) \, di\right]}_{\text{Market power: } \varepsilon_j^{MP}} \times \underbrace{\left[\int_i \omega^i \lambda_j^i p_j c_j^i \, di\right]}_{\text{Heterogeneity: } \varepsilon_j^{H}}$$

- Decompose difference in $\widetilde{\varepsilon}_j^{\rho}$ across Q_1 and Q_5 firms by price:

$$\log \widetilde{\varepsilon}_j^{\rho} = \log \varepsilon_j^{MP} + \log \varepsilon_j^{H}$$

$$Share^H = \frac{\mathbb{E}\left[\log \widetilde{\varepsilon}_j^{H} \middle| j \in Q_1\right] - \mathbb{E}\left[\log \widetilde{\varepsilon}_j^{H} \middle| j \in Q_5\right]}{\mathbb{E}\left[\log \widetilde{\varepsilon}_j^{\rho} \middle| j \in Q_1\right] - \mathbb{E}\left[\log \widetilde{\varepsilon}_j^{\rho} \middle| j \in Q_5\right]} = 72.1 \text{ percent}$$