PhD Advanced Labor - Econ 8584

Lecture 5: Household and Firm heterogeneity - Product markets

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Last two lectures

1. *Households and Firms - Product markets - Empirical facts*

    - Large firms: High quality, High marginal cost, High markup, High price

    - High income households: Less elastic, Buy high price goods

2. *Simple model, Quantitative model*

    - Mongey Waugh (2025) - *Pricing Inequality*

3. *Next week - Labor markets*

    - Similar facts

    - Berger Herkenhoff Jeong Mongey (2026) - *LMP and Worker Heterogeneity*

Data

- Last 15 years has seen an explosion of research using *scanner data sets*
    - Early examples: Chevalier, Kashyap, Rossi (2003, AER) - *Why don't prices rise during periods of peak demand?*

- Exist in many countries

- In the U.S. the gold standard is the *A.C. Nielsen* data
    - *Household scanner data* - All purchases at level of a trip. Additional data on household income.
    - *Retail scanner data* - Store level data on all goods: prices, quantities, discounts, coupons

- Primary sources for topics like (a) price stickiness, (b) pass-through of tariffs to prices, (c) response of households to fiscal stimulus checks, ...

- Accessible through the U via *Kilts Nielsen*. Accessible at the Fed via *OBDC*

Large firms

1. *Sell higher 'quality' goods, at higher prices, higher marginal cost*
2. *Price at higher markups*
3. *Are bigger because they sell to more customers*
4. *Sell to richer customers*

Large firms

1. *Sell higher 'quality' goods, at higher prices, higher marginal cost*
   - Hottman, Redding, Weinstein (QJE, 2016) - *Quantifying Sources of Firm Heterogeneity*
     - Retail scanner data + 'Nested CES' model of demand
     - Firms differ in (a) marginal cost, (b) product appeal, (c) markups
     - Aggregate all products up to the firm level
     - Larger firms sell higher quantities at higher prices
     - Drives conclusion that must have higher: (i) appeal, (ii) marginal cost
   - Manova, Zhang (QJE, 2012) - *Export Prices Across Firms and Destinations*
     - Use customs data, trade flows → See quantities and inputs
     - Higher priced exports → Higher revenue, Higher cost inputs
2. *Price at higher markups*
3. *Are bigger because they sell to more customers*
4. *Sell to richer customers*

Large firms

1. *Sell higher 'quality' goods, at higher prices, higher marginal cost*
2. *Price at higher markups*
    - Edmond Midrigan Xu (JPE, 2023) - *How Costly Are Markups?*
        - U.S. Census of Manufactures
        - Production function approach to markups

$$\log \mu^i_{jt} = \alpha_{jt} + 0.03 \times \log \frac{Sales^i_{jt}}{\sum_{k=1}^{J} Sales^k_{jt}} + \eta^i_{jt}$$

3. *Are bigger because they sell to more customers*
4. *Sell to richer customers*

Large firms

1. *Sell higher 'quality' goods, at higher prices, higher marginal cost*
2. *Price at higher markups*
3. *Are bigger because they sell to more customers*
   - Afrouzi, Drenik, Kim (2023) - *Concentration, Market Power, Misallocation*
     - KN + Compustat. 86% of variance of sales due to customers, not sales-per-customer

$$\log \text{Sales}_{j,ind,t} = \log \text{Customers}_{j,ind,t} + \log \left(\frac{\text{Sales}_{j,ind,t}}{\text{Customers}_{j,ind,t}} \right)$$

   - Einav, Klenow, Levin, Murciano-Goroff - *Customers and Retail Growth*
     - Visa data. 80% of sales variation across establishments in retail due to customers
4. *Sell to richer customers*

Large firms

1. *Sell higher 'quality' goods, at higher prices, higher marginal cost*
2. *Price at higher markups*
3. *Are bigger because they sell to more customers*
4. *Sell to richer customers*
    - Faber Fally (ReStud, 2022) - *Firm Heterogeneity in Consumption Baskets*
        - Nielsen retail + consumer scanner data
        - Top vs. bottom decile expenditure households buy from firms with 27% larger sales

Hottman Redding Weinstein (QJE, 2016)

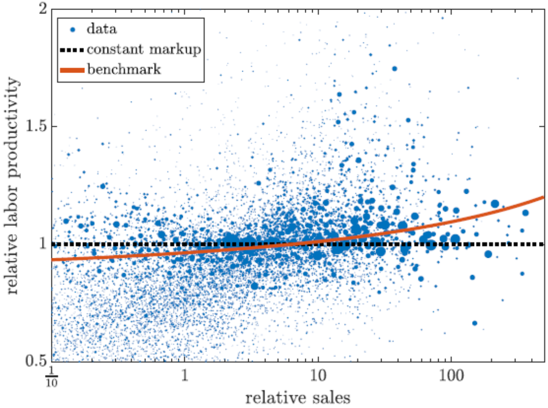
TABLE X

VARIANCE DECOMPOSITIONS

Decomposition	Appeal	Scope	Average MC	Cost dispersion	Markup	Upgrading
Panel A: All firms						
Cross-sectional	0.758	0.2103	−0.037	0.0706	−0.00195	
	(0.002)	(0.0002)	(0.002)	(0.0001)	(0.00001)	
Firm growth	0.909	0.1581	−0.135	0.0685	−0.00060	0.0004
	(0.009)	(0.0013)	(0.009)	(0.0010)	(0.00004)	(0.0014)
Panel B: Firms with >0.5% product-group share						
Cross-sectional	0.547	0.2638	0.172	0.0614	−0.04396	
	(0.013)	(0.0016)	(0.013)	(0.0008)	(0.00016)	
Firm growth	0.906	0.2627	−0.169	0.0270	−0.02620	0.0226
	(0.053)	(0.0080)	(0.052)	(0.0083)	(0.00129)	(0.0140)

Edmond Midrigan Xu (JPE, 2023)

Figure 6: Relative Labor Productivity vs. Relative Sales



Relative labor productivity and relative sales in 6-digit NAICS industries. Each circle corresponds to one size class in a given industry with the diameter indicating the total sales accounted for by firms in that size class. If all firms (within a given industry) had the same labor productivity, then all observations would lie on the dashed black line. We choose the superelasticity ε to minimize the distance between our model's predictions for a firm's relative labor productivity as a function of relative size and the corresponding observations in the data. The implied nonlinear relationship is shown by the solid red line.

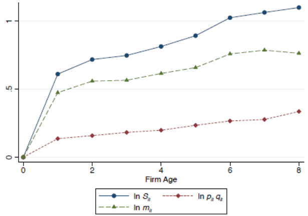
Afrouzi, Drenik, Kim (2023)

Table 2: Decomposing the Variance of Sales

Var(ln S_{igt})	Var(ln $p_{igt}q_{igt}$)	Var(ln m_{igt})	2Cov(ln $p_{igt}q_{igt}$,ln m_{igt})
7.5807	0.8672	6.1146	0.5989

Notes: S_{igt} denotes sales, $p_{igt}q_{igt}$ average sales per customers, and m_{igt} the number of customers. We use 557,820 firm-group-year-level observations in Nielsen-GS1 data. All variables are projection-factor adjusted.

Figure 1: Decomposition of Firm Sales Growth by Firm Age



Notes: This figure plots the average firm sales, sales per customer, and the number of customers for each firm-age based on Equation (2.3), after controlling for firm and year fixed effects. The blue circled line shows the results for log sales, the red diamond line for the log average sales per customer, and the green triangle line for the log number of customers. There are 40,442 observations and 9,990 firms that newly enter the economy starting from the year 2008 in the Nielsen-GS1 data. All estimates are normalized based on age 0. All variables are projection-factor adjusted.

Faber Fally (2022)

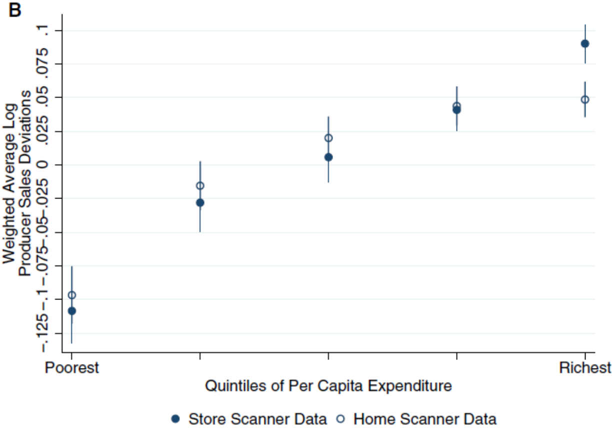
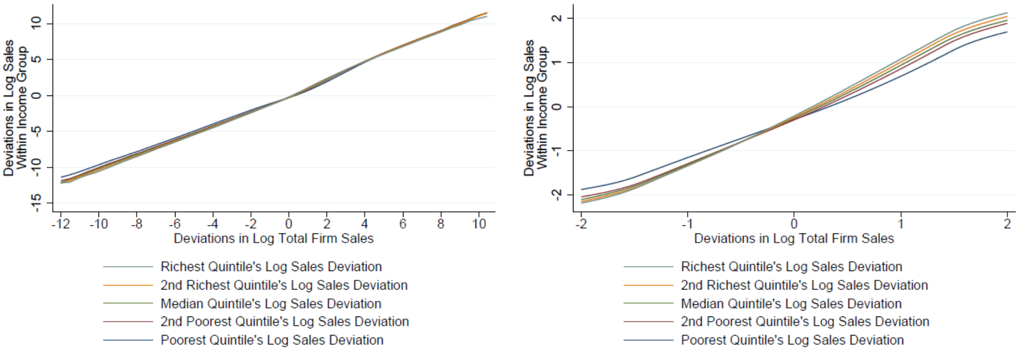


FIGURE 1

Richer households source their consumption from larger firms

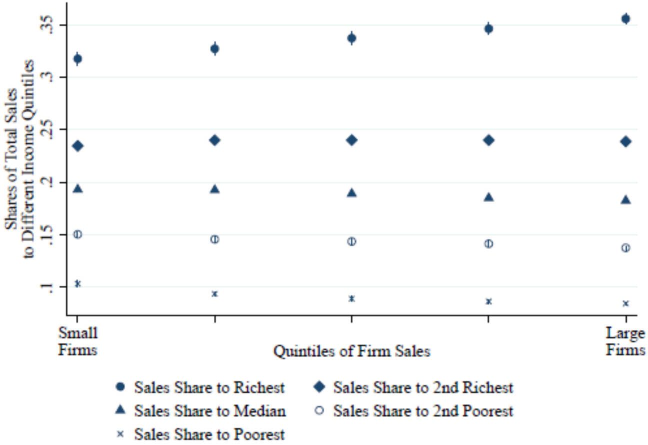
Faber Fally (2022)

Figure A.6: Households on Average Agree on Relative Product Quality Evaluations



Notes: The figure depicts the relationship between income group-specific deviations in log expenditures spent across producers within more than 1000 product modules (y-axis), and deviations in log total market sales of those same producers in the store scanner data (x-axis) for on average 59,000 US households during 18 half-year periods between 2006-14. The left panel shows the full sample, and the right panel restricts attention to firm size deviations on the x-axis between -2 to 2 log points. The fitted relationships in both graphs correspond to local polynomial regressions. See Section 3 for discussion.

Faber Fally (2022)



Richer households

1. **Sorting** - *Buy higher priced varieties of the same good*
2. **Elasticities** - *Substitute less when prices of a good change*

Richer households

1. **Sorting** - *Buy higher priced varieties of the same good*
   - Bils Klenow (AER 2001) - *Quanitfying Quality Growth*
     - Use CEX data on bulky items, e.g. vacuum cleaner. Gives *price-per-purchase*
     - 10 percent higher *total expenditure*, 5.7 percent higher *quality* (price-per-good)
   - Jaimovich Rebelo Wong Zhang (NBER Annual 2019) - *Trading Up and the Skill Premium*
     - Repeat the exercise using Nielsen data. Compute *price-per-unit*
     - Top vs. Bottom quintile income households pay 22.7% more. BK/CEX: 83%
   - Mongey Waugh (2025) - *Pricing Inequality*
     - Extend JRWZ. Add *market-time* fixed effects. Compute quintiles locally. Result: 14.4%
2. **Elasticities** - *Substitute less when prices of a good change*

Richer households

1. **Sorting** - *Buy higher priced varieties of the same good*
2. **Elasticities** - *Substitute less when prices of a good change*
   - Nakamura Zerom (ReStud 2010) - *Accounting for Incomplete Pass-through*
     - Indirect utility - Logit model of demand

$$u_j^i = \phi_j + \beta^i \left(\log y^i - \log p_j \right) + \beta' x_j + \epsilon_j^i \quad , \quad \beta^i = \beta_0 + \beta_1 \log y^i$$

     - *"A household with an income one standard deviation above the mean has a price elasticity about 20% below the price elasticity of the median consumer".*
   - Auer, Burstein, Lein, Vogel (ReStud 2024) - *Unequal Expenditure Switching: Evidence from Switzerland*
     - Changes in relative prices following Swiss Franc appreciation

$$\log \left(\frac{b_{Mt}^i}{b_{Dt}^i} \right) = \boldsymbol{\beta}_1 \left(\frac{\phi_{Mt}}{\phi_{Dt}} \right) - \boldsymbol{\beta}_2 \log \left(\frac{p_{Mt}}{p_{Dt}} \right) + \boldsymbol{\beta}_3 \log y^i \log \left(\frac{p_{Mt}}{p_{Dt}} \right) + \varepsilon_{it} \quad , \quad \widehat{\boldsymbol{\beta}}_2 = 2.20$$

Jaimovich Rebelo Wong Zhang (NBER, 2019)

We compute an average price across households, $\bar{P}_{imt}$, for every item i in product module m and time t. By using this average price we ensure that differences in overall prices paid by households reflect differences in choice of item-store, rather than shopping intensity (i.e. using coupons and taking advantage of promotions). For each household, we compute the price of module m at time t as:

$$\log\left(P_{hmt}\right) = \sum_i w_{iht} \log\left(\bar{P}_{imt}\right).$$

We then estimate the following regression:

$$\log\left(P_{hmt}\right) = \beta_0 + \sum_k \beta_k 1\left(y_{ht} \in k\right) + \gamma X_{ht} + \lambda_t + \lambda_m + \varepsilon_{hmt}, \qquad (2)$$

Jaimovich Rebelo Wong Zhang (NBER, 2019)

Table 6: Prices and income: Nielsen Homescan data

Nielsen Homescan	(I)	(II)
Relative to income quintile 1:		
Income quintile 2	0.0399	0.0398
	(0.0004)	(0.0004)
Income quintile 3	0.0911	0.0908
	(0.0004)	(0.0004)
Income quintile 4	0.151	0.150
	(0.0004)	(0.0004)
Income quintile 5 (top)	0.227	0.224
	(0.0004)	(0.0004)

Notes: This table shows the coefficients for β_k implied by regression 2. The table reports the log-difference in price paid by each income quintile relative to the lowest income quintile. We used Nielsen Homescan data for the period 2004-2010. Column I includes demographic controls for age, family size and number of income earners in the household. Column II does not include demographic controls. Estimates in both columns I and II are clustered by household. See text for more details.

Jaimovich Rebelo Wong Zhang (NBER, 2019)

Table 5: Prices and income: CEX

Consumer Expenditure Survey Durables	(I)	(II)
Relative to income quintile 1:		
Income quintile 2	0.205	0.197
	(0.010)	(0.010)
Income quintile 3	0.368	0.353
	(0.010)	(0.010)
Income quintile 4	0.533	0.513
	(0.010)	(0.009)
Income quintile 5 (top)	0.834	0.82
	(0.010)	(0.010)
Time fixed effects	Yes	Yes
Category fixed effects	Yes	Yes
Demographic controls	Yes	
Number of observations	824,851	824,851

Notes: This table shows the θ estimates implied by regression 1. The table reports the log-difference in price paid by each income quintile relative to the lowest income quintile. We used CEX data for the period 1980-2013. Column I includes demographic controls for age, family size and number of income earners in the household. Column II does not include demographic controls. Estimates in both columns I and II are clustered by household. See text for more details.

Want: Simple model that speaks to these facts

Large firms:

1. *Sell higher 'quality' goods, at higher prices, higher marginal cost*
2. *Price at higher markups*
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Rich households:

1. **Sorting** - *Buy higher priced varieties of the same good*
2. **Elasticities** - *Substitute less when prices of a good change*

Final observation - To Search or Not-to-search?

- **Where is the price variation?**
  - *Across Stores (Same Good):* Low.
    - DellaVigna Gentzkow (2019): Chains price uniformly.
    - Handbury Weinstein (2015): Law of One Price holds well for UPCs across cities.
  - Kaplan Menzio (IER, 2015) - *Morphology of Price Dispersion*
    - Within exact same good, across stores about 30% of price: $7-[$10]-$13
    - Swamped by within-good-store, across-goods
  - *Within Store (Different Goods):* High.
    - Vertical differentiation / Quality ladders.
    - Hottman Redding Weinstein (2016): Firms span the quality distribution.

Palacios (JMP, 2025)

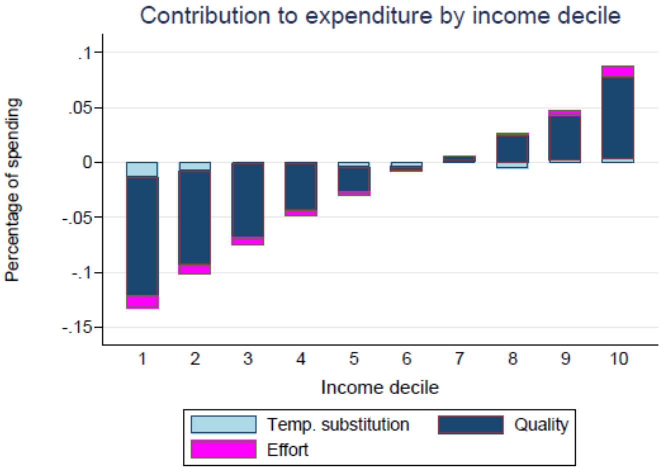
$$e_{i,t} = \sum_k \sum_{j \in J_k} p_{jkit} c_{jkit}$$
$$= \sum_k \sum_{j \in J_k} \left[\underbrace{(p_{jkit} - \bar{p}_{jkst}) c_{jkit}}_{Effort} + \underbrace{((\bar{p}_{jkst} - \bar{p}_{jks}) - (\tilde{p}_{kst} - \tilde{p}_{ks})) c_{jkit}}_{Temp.substitution} + \underbrace{(\bar{p}_{jks} - \tilde{p}_{ks}) c_{jkit}}_{Quality} + \underbrace{\tilde{p}_{kst} c_{jkit}}_{Counterfactual} \right] \tag{1}$$

For household i at time t (quarters), k refers to the specific product and j to the variety; $\bar{p}$ refers to the average price of a barcode in a given state (länder) s and $\tilde{p}$ is the average price of a product in a given state.

The first term is the difference between what the individual household pays for the same variety relative to other households and therefore can be thought of as a measure of the effort or time invested in shopping, that is, search costs. The second term reflects the extent to which a household takes advantage of temporary discounts of products. The third term can be seen as the substitution between varieties within a given product. A more positive term indicates

Palacios (JMP, 2025)

Figure 2: Decomposition by income group



Notes: Average contribution of each temporary substitution, quality and effort into overall spending by income group and average over time. Each term in Equation 1 is divided by expenditures and averaged across households

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Frictionless product markets.

Simple model of demand and pricing

- Two types of households wealth $a^i \in \{a^L, a^H\}$, where $a^H > a^L$
- Two firms produce varieties of a single good with different *qualities* $\phi_j \in \{\phi_1, \phi_2\}$, where $\phi_1 > \phi_2$
- No marginal cost differences among firms
- Neo-classical model of demand, no search frictions

Household problem

- Two types of households $i \in \{1, 2\}$ with wealth $a^i \in \{a^L, a^H\}$
- Consume one of two goods $j \in \{1, 2\}$. Assume $p_1 > p_2$, then show it later.

- Problem

  1. Draw tastes for each good

$$\zeta_1^i \sim \Gamma\left(\boldsymbol{\zeta}\right) \quad , \quad \zeta_2^i \sim \Gamma\left(\boldsymbol{\zeta}\right), \quad \text{where} \quad \log \Gamma\left(\zeta\right) = -e^{-\boldsymbol{\eta}\zeta}$$

  2. Choose which good to consume

$$\max \left\{ V\left(a^i, p_1\right) + \zeta_1^i \qquad\qquad , V\left(a^i, p_2\right) + \zeta_2^i \qquad\qquad \right\}$$

Household problem

- Two types of households $i \in \{1, 2\}$ with wealth $a^i \in \{a^L, a^H\}$
- Consume one of two goods $j \in \{1, 2\}$. Assume $p_1 > p_2$, then show it later.

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  2. Choose which good to consume

$$\max \left\{ V\Big(a^i, p_1\Big) + \zeta_1^i \qquad\qquad , \; V\Big(a^i, p_2\Big) + \zeta_2^i \qquad\qquad \right\}$$

  3. Intensive margin

$$V\Big(a^i, p_j\Big) \; = \; u\Big(q_j^i\Big) \quad \text{subject to} \quad p_j q_j^i = a^i$$

Household problem

- Two types of households $i \in \{1, 2\}$ with wealth $a^i \in \{a^L, a^H\}$
- Consume one of two goods $j \in \{1, 2\}$. Assume $p_1 > p_2$, then show it later.

- Problem

  1. Draw tastes for each good

$$\zeta_1^i \sim \Gamma\Big(\boldsymbol{\zeta}\Big) \quad , \quad \zeta_2^i \sim \Gamma\Big(\boldsymbol{\zeta}\Big) \, , \quad \text{where} \quad \log \Gamma\Big(\zeta\Big) = -e^{-\boldsymbol{\eta}\zeta}$$

  2. Choose which good to consume   Quality: $\phi_1 > \phi_2$

$$\max \left\{ V\Big(a^i, p_1\Big) + \zeta_1^i + \frac{1}{\eta} \log \phi_1 \, , \, V\Big(a^i, p_2\Big) + \zeta_2^i + \frac{1}{\eta} \log \phi_2 \right\}$$

  3. Intensive margin

$$V\Big(a^i, p_j\Big) \;=\; u\Big(q_j^i\Big) \quad \text{subject to} \quad p_j q_j^i = a^i$$

Household problem - Demand

- Extensive margin of demand

$$\rho_1^i = \frac{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\}}{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\} + \phi_2 \exp\left\{\eta V(a^i, p_2)\right\}}$$

Household problem - Demand

- Extensive margin of demand

$$\rho_1^i = \frac{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\}}{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\} + \phi_2 \exp\left\{\eta V(a^i, p_2)\right\}}$$

- Extensive margin elasticity of demand

$$\varepsilon_1^{\rho,i} = \underbrace{\frac{\partial \log \rho_1^i}{\partial V(a^i, p_1)}}_{\text{Size-based market power}} \times \underbrace{-\frac{\partial V(a^i, p_1)}{\partial \log p_1}}_{\text{Household heterogeneity}}$$

Household problem - Demand

- Extensive margin of demand

$$\rho_1^i = \frac{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\}}{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\} + \phi_2 \exp\left\{\eta V(a^i, p_2)\right\}}$$

- Extensive margin elasticity of demand

$$\varepsilon_1^{\rho,i} = \underbrace{\eta\left(1 - \rho_1^i\right)}_{\text{Size-based market power}} \times \underbrace{-\frac{\partial V(a^i, p_1)}{\partial \log p_1}}_{\text{Household heterogeneity}}$$

Household problem - Demand

- Extensive margin of demand

$$\rho_1^i = \frac{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\}}{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\} + \phi_2 \exp\left\{\eta V(a^i, p_2)\right\}}$$

- Extensive margin elasticity of demand

$$\varepsilon_1^{\rho,i} = \underbrace{\eta\left(1 - \rho_1^i\right)}_{\text{Size-based market power}} \times \underbrace{\lambda_1^i p_1 q_1^i}_{\text{Household heterogeneity}}$$

Household problem - Demand

- Extensive margin of demand

$$\rho_1^i = \frac{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\}}{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\} + \phi_2 \exp\left\{\eta V(a^i, p_2)\right\}}$$

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$$\varepsilon_1^{\rho,i} = \underbrace{\eta\left(1 - \rho_1^i\right)}_{\text{Size-based market power}} \times \underbrace{\lambda_1^i p_1 q_1^i}_{\text{Household heterogeneity}}$$

- Rich households

✓ Are less price sensitive

Household problem - Demand

- Extensive margin of demand

$$\rho_1^i = \frac{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\}}{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\} + \phi_2 \exp\left\{\eta V(a^i, p_2)\right\}}$$

- Extensive margin elasticity of demand

$$\varepsilon_1^{\rho,i} = \underbrace{\eta\left(1 - \rho_1^i\right)}_{\text{Size-based market power}} \times \underbrace{\lambda_1^i p_1 q_1^i}_{\text{Household heterogeneity}}$$

- Rich households
  - ✓ Are less price sensitive
  - ✓ Consume higher priced goods within the same market

Household problem - Demand

- Extensive margin of demand

$$\rho_1^i = \frac{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\}}{\phi_1 \exp\left\{\eta V(a^i, p_1)\right\} + \phi_2 \exp\left\{\eta V(a^i, p_2)\right\}}$$

- Extensive margin elasticity of demand

$$\varepsilon_1^{\rho,i} = \underbrace{\eta\left(1 - \rho_1^i\right)}_{\text{Size-based market power}} \times \underbrace{\left(q_1^i\right)^{-(\sigma-1)}}_{\text{Household heterogeneity}}$$

- Rich households
  - ✓ Are less price sensitive
  - ✓ Consume higher priced goods within the same market

Household problem - Interpreting ABLV

- In the data:

$$\log\left(\frac{b^i_{1t}}{b^i_{2t}}\right) = \boldsymbol{\beta}_1\left(\frac{\phi_{1t}}{\phi_{2t}}\right) - \boldsymbol{\beta}_2 \log\left(\frac{p_{1t}}{p_{2t}}\right) + \boldsymbol{\beta}_3 \log y^i \log\left(\frac{p_{1t}}{p_{2t}}\right) + \varepsilon_{it} \quad , \quad \widehat{\boldsymbol{\beta}}_2 = 2.20$$

- In the model:

$$\log\left(\frac{b^H_1}{b^H_2}\right) = \log\left(\frac{\rho^H_1}{\rho^H_2}\right) = \log\left(\frac{\phi_1}{\phi_2}\right) + \eta\left(V^H(p_1) - V^H(p_2)\right) = \log\left(\frac{\phi_1}{\phi_2}\right) + \eta \left.\frac{\partial V^H(p)}{\partial \log p}\right|_{p=p_2} \log\left(\frac{p_1}{p_2}\right)$$

- Across individuals:

$$\log\left(\frac{b^H_1}{b^H_2}\right) - \log\left(\frac{b^L_1}{b^L_2}\right) = -\eta\left[\lambda^H_2 q^H_2 p_2 - \lambda^L_2 q^L_2 p_2\right] \log\left(\frac{p_1}{p_2}\right)$$

Household problem - Interpreting ABLV

- In the data:

$$\log\left(\frac{b^i_{1t}}{b^i_{2t}}\right) \quad = \quad \boldsymbol{\beta}_1\left(\frac{\phi_{1t}}{\phi_{2t}}\right) - \boldsymbol{\beta}_2\log\left(\frac{p_{1t}}{p_{2t}}\right) + \boldsymbol{\beta}_3\log y^i\log\left(\frac{p_{1t}}{p_{2t}}\right) + \varepsilon_{it} \quad , \quad \widehat{\boldsymbol{\beta}}_2 = 2.20$$

- In the model:

$$\log\left(\frac{b^H_1}{b^H_2}\right) = \log\left(\frac{\rho^H_1}{\rho^H_2}\right) = \log\left(\frac{\phi_1}{\phi_2}\right) + \eta\left(V^H(p_1) - V^H(p_2)\right) = \log\left(\frac{\phi_1}{\phi_2}\right) + \eta\left.\frac{\partial V^H(p)}{\partial\log p}\right|_{p=p_2}\log\left(\frac{p_1}{p_2}\right)$$

- Across individuals:

$$\log\left(\frac{b^H_1}{b^H_2}\right) - \log\left(\frac{b^L_1}{b^L_2}\right) \quad = \quad -\eta\left[a_2^{H-(\sigma-1)} - a_2^{L-(\sigma-1)}\right]p_2^{\sigma-1}\log\left(\frac{p_1}{p_2}\right)$$

Household problem - Interpreting ABLV

- In the data:

$$\log\left(\frac{b^i_{1t}}{b^i_{2t}}\right) = \boldsymbol{\beta}_1\left(\frac{\phi_{1t}}{\phi_{2t}}\right) - \boldsymbol{\beta}_2 \log\left(\frac{p_{1t}}{p_{2t}}\right) + \boldsymbol{\beta}_3 \log y^i \log\left(\frac{p_{1t}}{p_{2t}}\right) + \varepsilon_{it} \quad , \quad \widehat{\boldsymbol{\beta}}_2 = 2.20$$

- In the model:

$$\log\left(\frac{b^H_1}{b^H_2}\right) = \log\left(\frac{\rho^H_1}{\rho^H_2}\right) = \log\left(\frac{\phi_1}{\phi_2}\right) + \eta\left(V^H(p_1) - V^H(p_2)\right) = \log\left(\frac{\phi_1}{\phi_2}\right) + \eta \left.\frac{\partial V^H(p)}{\partial \log p}\right|_{p=p_2} \log\left(\frac{p_1}{p_2}\right)$$

- Across individuals:

$$\log\left(\frac{b^H_1}{b^H_2}\right) - \log\left(\frac{b^L_1}{b^L_2}\right) \approx \eta(\sigma-1)\frac{p_2^{\sigma-1}}{a_2^{L\sigma-1}} \log\left(\frac{a^H}{a^L}\right) \log\left(\frac{p_1}{p_2}\right)$$

Household problem - Interpreting JRWZ - Sorting

- Sorting condition expressed in terms of *log-supermodularity*

$$\log\left(\frac{\rho_1^H/\rho_2^H}{\rho_1^L/\rho_2^L}\right) = \log\left(\frac{\exp\{\eta V(a^H,p_1)\}\,/\,\exp\{\eta V(a^H,p_2)\}}{\exp\{\eta V(a^L,p_1)\}\,/\,\exp\{\eta V(a^L,p_2)\}}\right)$$

$$= \eta \times \left\{\left[V(a^H,p_1) - V(a^H,p_2)\right] - \left[V(a^L,p_1) - V(a^L,p_2)\right]\right\}$$

$$= \eta \times \int_{\log p_2}^{\log p_1} \frac{\partial V\left(a^H, e^{\log p}\right)}{\partial \log p} - \frac{\partial V\left(a^L, e^{\log p}\right)}{\partial \log p} d\log p$$

$$= \eta \times \int_{\log p_2}^{\log p_1} q^L\left(p\right)^{-(\sigma-1)} - q^H\left(p\right)^{-(\sigma-1)} d\log p$$

$$\log\left(\frac{\rho_1^H/\rho_2^H}{\rho_1^L/\rho_2^L}\right) = \underbrace{\frac{\eta}{\sigma-1}}_{\sigma>1}\underbrace{\left(p_1^{\sigma-1} - p_2^{\sigma-1}\right)}_{\sigma>1,p_1>p_2}\underbrace{\left(a^{L-(\sigma-1)} - a^{H-(\sigma-1)}\right)}_{\sigma>1,a^L<a^H} > 0$$

Household problem - Interpreting JRWZ - Sorting

- Sorting condition expressed in terms of *log-supermodularity*

$$\log\left(\frac{\rho_1^H/\rho_2^H}{\rho_1^L/\rho_2^L}\right) > 0$$

- Immediate that this extends to log-supermodularity in:
  - Quantities: $\rho_j^i q_j^i = \rho_j^i \left(a^i/p_j\right)$
  - Expenditure shares: $\omega_j^i = p_j \rho_j^i q_j^i / \sum_k p_k \rho_k^i q_k^i$

Household problem - Interpreting JRWZ - Regression

- Regression in the data

$$\log p_j^i = \beta_1 \mathbf{1}\left[a^i = a^L\right] + \beta_2 \mathbf{1}\left[a^i = a^H\right] + \varepsilon^i$$

- Therefore

$$\beta_2 - \beta_1 = \mathbb{E}\left[\log p_j^i | a^i = a^H\right] - \mathbb{E}\left[\log p_j^i | a^i = a^L\right] = \sum_j \omega_j^H \log p_j - \sum_j \omega_j^L \log p_j$$

- Show this is:

$$\beta_2 - \beta_1 = \left(\omega_1^H - \omega_1^L\right)\left(\log p_1 - \log p_2\right)$$

- Result: *If expenditure shares, ω_j^i are log-supermodular, then* $\widehat{\beta}_2 - \widehat{\beta}_1 > 0$

Firm problem

- Demand

$$x_1 \;=\; \rho_1^L q_1^L + \rho_1^H q_1^H$$

- Pricing

$$p_1^* \;=\; \frac{\varepsilon_1}{\varepsilon_1 - 1}\,\overline{mc} \quad , \quad \varepsilon_1 = \sum_i \left(\frac{\rho_1^i q_1^i}{x_1}\right)\varepsilon_1^i$$

Firm problem

- Demand

$$x_1 \;=\; \rho_1^L q_1^L + \rho_1^H q_1^H$$

- Pricing

$$p_1^* \;=\; \frac{\varepsilon_1}{\varepsilon_1 - 1}\,\overline{mc} \quad , \quad \varepsilon_1 = \sum_i \left(\frac{\rho_1^i q_1^i}{x_1}\right)\left[\eta\left(1-\rho_1^i\right)\left(q_1^i\right)^{-(\sigma-1)} + 1\right]$$

Firm problem

- Demand

$$x_1 = \rho_1^L q_1^L + \rho_1^H q_1^H$$

- Pricing

$$p_1^* = \frac{\varepsilon_1}{\varepsilon_1 - 1} \overline{mc} \quad , \quad \varepsilon_1 = \sum_i \left(\frac{\rho_1^i q_1^i}{x_1} \right) \left[\eta \left(1 - \rho_1^i \right) \left(q_1^i \right)^{-(\sigma-1)} + 1 \right]$$

- Large firms
  - ✓ Sell higher quality goods, at higher prices, with higher sales
  - ✓ To more customers
  - ✓ At higher markups

    Size-based market power: Higher quality → Higher market share → Higher prices

    Household heterogeneity: Higher prices → Less elastic customers → Higher prices

Firm problem - Proof of $p_1 > p_2$

- Elasticity:

$$\begin{aligned}
\varepsilon_1 &= \left(\frac{\rho_1^L a^L}{Sales_1}\right)\eta\left(1-\rho_1^L\right)q_1^{L-(\sigma-1)} + \left(\frac{\rho_1^H a^H}{Sales_1}\right)\eta\left(1-\rho_1^H\right)q_1^{H-(\sigma-1)} \\
\varepsilon_1 &= \eta\left(\frac{p_1^{\sigma-1}}{Sales_1}\right)\left\langle\left(\rho_1^L\rho_2^L a^L\right)a^{L-(\sigma-1)} + \left(\rho_1^H\rho_2^H a^H\right)a^{H-(\sigma-1)}\right\rangle \\
\frac{\varepsilon_1}{\varepsilon_2} &= \left(\frac{p_1}{p_2}\right)^{\sigma-1}\frac{Sales_2}{Sales_1} \qquad (*)
\end{aligned}$$

- Suppose that $p_1 < p_2$
- Since $p_1 < p_2$ and $\phi_1 > \phi_2$, then $\rho_1^i > \rho_2^i$ and $q_1^i > q_2^i$. Hence $Sales_1 > Sales_2$.
- Therefore from $(*)$, $\varepsilon_1 < \varepsilon_2$. Hence optimal $p_1 > p_2$. **Contradiction.**
- Then immediate from $p_j = \frac{\varepsilon_j}{\varepsilon_j - 1}$ and $(*)$ that $\varepsilon_1 < \varepsilon_2$, and $Sales_1 > Sales_2$

Firm problem - 'Monopolistic competition' yields $p_1 = p_2$

- Then $\varepsilon_j^{\rho,i} = \eta q_j^{i\,-(\sigma-1)}$. Guess that $p_1 = p_2$ is an equilibrium
- If $p_1 = p_2$, then $V(a^i, p_1) = V(a^i, p_2)$, hence $\rho_j^i = \phi_j/(\phi_1 + \phi_2) = \overline{\rho}_j$
- If $p_1 = p_2$, then $q_1^i = a^i/p_j = \overline{q}^i$
- Then in the firm's price elasticity of demand:

$$\varepsilon_1 = \left(\frac{\overline{\rho}_1 a^L}{\overline{\rho}_1 a^L + \overline{\rho}_1 a^H}\right)\eta\overline{q}^{L\,-(\sigma-1)} + \left(\frac{\overline{\rho}_1 a^H}{\overline{\rho}_1 a^L + \overline{\rho}_1 a^H}\right)\eta\overline{q}^{H\,-(\sigma-1)}$$

- And

$$\varepsilon_1 = \left(\frac{a^L}{a^L + a^H}\right)\eta\overline{q}^{L-(\sigma-1)} + \left(\frac{a^H}{a^L + a^H}\right)\eta\overline{q}^{H-(\sigma-1)} \quad = \varepsilon_2. \quad \underline{\text{Guess is correct.}}$$

- Still satisfies ABLV! And $Corr(Sales_j, \phi_j) > 0$. But with $p_1 = p_2$, no sorting!

From here ...

- *Quantitative model* - See Slides for Mongey Waugh (2025)

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