Shopping Frictions and Household Heterogeneity 🛒

Theory and Empirics

Krzysztof Pytka (U Mannheim)

August 22, 2022

EEA-ESEM 2022

Research Question ⑦

How do households make consumption decisions in the presence of price dispersion?

Research Question ②

How do households make consumption decisions in the presence of price dispersion?

In particular, I am interested in:

(i) how do paid prices for the same goods differ across *the income distribution*?

(ii) what theoretical frameworks are consistent with the observed differences?

(iii) what are macroeconomic implications of the new theories in comparison to the standard consumption models?

Preview of the results

⚏ (Some of) the main empirical findings

1. Employees with earnings above the median level pay from 1.5% to 7.1% higher prices than employees with below-median earnings.
2. The causal link between the income level and paid prices is established by exploiting a quasi-experimental setup of the Economic Stimulus Act of 2008.
3. The price channel accounts for between 8 and 22% of overall responses in consumption expenditures to transitory shocks.

🗺 Theory:

1. A standard incomplete-market model where households *endogenously choose paid prices through consumer search*.
2. The calibrated model confirms that substantial impact of the price channel on adjustments of consumption expenditures in other dimensions.

Empirical Patterns

Kilts-Nielsen Consumer Panel

- ✔ 40,000-60,000 American households from 2004 through 2014.

- ✔ Each panelist uses in-home scanners or mobile apps to provide information to Nielsen about their grocery purchases from any outlet in all US markets.

- ✔ 630 million transactions for ≈ 2 million unique products defined at the barcode level, purchased in 87 million shopping trips.

Data & Methodology

Kilts-Nielsen Consumer Panel

- ✔ 40,000-60,000 American households from 2004 through 2014.

- ✔ Each panelist uses in-home scanners or mobile apps to provide information to Nielsen about their grocery purchases from any outlet in all US markets.

- ✔ 630 million transactions for $\approx$ 2 million unique products defined at the barcode level, purchased in 87 million shopping trips.

Household price indices

- ✔ The consumption baskets differ across households.

- ✔ To explore heterogeneity in prices, for each household using methodology proposed by Aguiar-Hurst (AER, 2007), I compute individual price indices for each household.

High Earners Pay Higher Prices

Aguiar-Hurst price index of household j in month m :

$$\bar{P}_{j,m} = \frac{\sum_{i \in I, t \in m} p_{i,t}^{j} q_{i,t}^{j}}{\sum_{i \in I, t \in m} \bar{p}_{i,t}^{r(j)} q_{i,t}^{j}},$$

where $\bar{p}_{i,m}^{r(j)}$ is the average price of good i in region $r(j)$ in month m.

	$\ln \bar{P}_{j,m}$			
	(1)	(2)	(3)	(4)
HH Earnings > median(HH Earnings)	0.020***	0.015***	0.071***	0.052***
	(0.002)	(0.002)	(0.002)	(0.002)
Non-employed in working age (Male)	−0.007***	−0.006***	−0.014***	−0.010***
	(0.001)	(0.001)	(0.002)	(0.002)
Non-employed in working age (Female)	−0.007***	−0.004***	−0.010***	−0.006***
	(0.001)	(0.001)	(0.002)	(0.001)
Retired (Male)	−0.002	0.0001	−0.00002	−0.001
	(0.002)	(0.002)	(0.004)	(0.003)
Retired (Female)	0.002	0.001	0.002	0.001
	(0.002)	(0.002)	(0.004)	(0.003)
HH composition dummies	Yes	Yes	Yes	Yes
Age dummies (both heads)	Yes	Yes	Yes	Yes
Month dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Scantrack market dummies	Yes	Yes	Yes	Yes
Product aggregation	Bar code	Bar code	Features	Features
Area aggregation	Nationwide	Scantrack	Nationwide	Scantrack
Number of observations	5,084,254	5,084,254	5,084,254	5,084,254
Number of panelists	150,153	150,153	150,153	150,153

High Earners Pay Higher Prices

Aguiar-Hurst price index of household j in month m :

$$\bar{P}_{j,m} = \frac{\sum_{i \in I, t \in m} p_{i,t}^j q_{i,t}^j}{\sum_{i \in I, t \in m} \bar{p}_{i,t}^{r(j)} q_{i,t}^j},$$

where $\bar{p}_{i,m}^{r(j)}$ is the average price of good i in region $r(j)$ in month m.

Remarks

1. High earners pay higher prices than low earners.

2. Low earners pay similar prices to non-employed and retirees.

	$\ln \bar{P}_{j,m}$			
	(1)	(2)	(3)	(4)
HH Earnings > median(HH Earnings)	0.020***	0.015***	0.071***	0.052***
	(0.002)	(0.002)	(0.002)	(0.002)
Non-employed in working age (Male)	−0.007***	−0.006***	−0.014***	−0.010***
	(0.001)	(0.001)	(0.002)	(0.002)
Non-employed in working age (Female)	−0.007***	−0.004***	−0.010***	−0.006***
	(0.001)	(0.001)	(0.002)	(0.001)
Retired (Male)	−0.002	0.0001	−0.00002	−0.001
	(0.002)	(0.002)	(0.004)	(0.003)
Retired (Female)	0.002	0.001	0.002	0.001
	(0.002)	(0.002)	(0.004)	(0.003)
HH composition dummies	Yes	Yes	Yes	Yes
Age dummies (both heads)	Yes	Yes	Yes	Yes
Month dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Scantrack market dummies	Yes	Yes	Yes	Yes
Product aggregation	Bar code	Bar code	Features	Features
Area aggregation	Nationwide	Scantrack	Nationwide	Scantrack
Number of observations	5,084,254	5,084,254	5,084,254	5,084,254
Number of panelists	150,153	150,153	150,153	150,153

Prices are causally related to income

✔ Quite rich and robust evidence on systematic heterogeneity in price indices across different households

✔ Quite rich and robust evidence on systematic heterogeneity in price indices across different households *but* is it causal?

Prices are causally related to income

✔ Quite rich and robust evidence on systematic heterogeneity in price indices across different households *but* is it causal?

✔ I exploit a quasi-experimental setup of the Economic Stimulus Act of 2008, a program consisting in sending tax rebates to about 130 million eligible taxpayers. Eligible households received their payments as tax rebates. Due to the scale of the program, *randomization in the timing of disbursement had to be introduced.*

✔ For single individuals ESPs were between $300 and $600, while for married couples filing jointly, between $600 and $1,200.

✔ The tax rebates survey conducted by Nielsen on behalf of Broda and Parker (JME, 2014) contains information on the week of receiving the ESP. This is merged with data from the KNCP.

Prices are causally related to income (cont'd)

Response to the ESP		$\ln \bar{P}_{j,m}$		
	(1)	(2)	(3)	(4)
Quarter before, β_{-1}	0.002	0.001	0.002	0.003
	(0.001)	(0.001)	(0.002)	(0.002)
Quarter of receipt, β_0	0.006***	0.004*	0.009**	0.008***
	(0.002)	(0.002)	(0.003)	(0.003)
One quarter after, β_1	0.008***	0.005**	0.009**	0.011***
	(0.003)	(0.002)	(0.005)	(0.004)
Two quarters after, β_2	0.008**	0.006**	0.011**	0.013***
	(0.003)	(0.003)	(0.006)	(0.005)
Month dummies	Yes	Yes	Yes	Yes
Product aggregation	Bar code	Bar code	Features	Features
Area aggregation	Nationwide	Scantrack	Nationwide	Scantrack
Number of observations	345,768	345,768	345,768	345,768
Number of panelists	29,289	29,289	29,289	29,289

Decomposition of the expenditure responses to the ESP

$$\underbrace{\mathbb{E}\ln\left(\frac{\bar{P}_{j,\tau+s}Q_{j,\tau+s}}{\bar{P}_{j,\tau-1}Q_{j,\tau-1}}\right)}_{\text{Overall response to ESP}} = \underbrace{\mathbb{E}\left(\ln\bar{P}_{j,\tau+s} - \ln\bar{P}_{j,\tau-1}\right)}_{\text{Price channel}} + \underbrace{\mathbb{E}\left(\ln Q_{j,\tau+s} - \ln Q_{j,\tau-1}\right)}_{\text{Consumption channel}}, \tag{1}$$

Decomposition of the expenditure responses to the ESP

$$\underbrace{\mathbb{E}\ln\left(\frac{\bar{P}_{j,\tau+s}Q_{j,\tau+s}}{\bar{P}_{j,\tau-1}Q_{j,\tau-1}}\right)}_{\text{Overall response to ESP}} = \underbrace{\mathbb{E}\left(\ln\bar{P}_{j,\tau+s} - \ln\bar{P}_{j,\tau-1}\right)}_{\text{Price channel}} + \underbrace{\mathbb{E}\left(\ln Q_{j,\tau+s} - \ln Q_{j,\tau-1}\right)}_{\text{Consumption channel}}, \qquad (1)$$

Product aggregation	Area aggregation	Price channel: $\dfrac{\mathbb{E}\left(\ln\bar{P}_{j,\tau+s}-\ln\bar{P}_{j,\tau-1}\right)}{\mathbb{E}\ln\left(\frac{\bar{P}_{j,\tau+s}Q_{j,\tau+s}}{\bar{P}_{j,\tau-1}Q_{j,\tau-1}}\right)}$			Consumption channel: $\dfrac{\mathbb{E}\left(\ln Q_{j,\tau+s}-\ln Q_{j,\tau-1}\right)}{\mathbb{E}\ln\left(\frac{\bar{P}_{j,\tau+s}Q_{j,\tau+s}}{\bar{P}_{j,\tau-1}Q_{j,\tau-1}}\right)}$		
		QTR_0	QTR_1	QTR_2	QTR_0	QTR_1	QTR_2
Bar code	Nationwide	12.5%	11.6%	12.0%	87.5%	88.4%	88.0%
Bar code	Scantrack	8.1%	8.5%	10.0%	91.9%	91.5%	90.0%
Features	Nationwide	22.2%	15.3%	18.1%	77.8%	84.7%	81.9%
Features	Scantrack	16.8%	16.3%	19.0%	83.2%	83.7%	81.0%

Theoretical Framework

Building Blocks of the Economy

1. Standard incomplete-markets economy with life cycle.

   (Huggett, JME 1996; Ríos-Rull, REStud 1996; Imrohoroglu et al., ET 1995)

2. Two classes of agents:
   - fixed measure of households,
   - continuum of retailers.

3. Households:
   - face idiosyncratic productivity shocks;
   - make shopping decisions:
     - ✓ search for bargain prices,
     - ✓ number of purchases;
   - make consumption-savings decisions using risk free bond.

1. Consumption:

$$c = m \cdot \kappa$$

Consumption Basket and Its Cost

1. Consumption:

$$c = m \cdot \kappa$$

2. The cost of consumption bundle:

$$p \cdot c = \int_0^{m\kappa} p(i)di,$$

where $p(i) \sim_{iid} F(p; s)$.

Let $G(p)$ be the cdf of prices quoted by retailers.

$$F(p; s) = (1 - s) \underbrace{G(p)}_{\substack{\text{Captive} \\ \text{purchase}}} + s \underbrace{\left(1 - [1 - G(p)]^2\right)}_{\substack{\text{Non-captive} \\ \text{purchase}}}.$$

Let $G(p)$ be the cdf of prices quoted by retailers.

$$F(p; s) = (1 - s) \underbrace{G(p)}_{\substack{\text{Captive} \\ \text{purchase}}} + s \underbrace{\left(1 - [1 - G(p)]^2\right)}_{\substack{\text{Non-captive} \\ \text{purchase}}}.$$

Using the weak law of large numbers proposed by Uhlig (ET, 1996):

$$\int_0^{m\kappa} p(i) \, di \overset{\text{a.s.}}{\to} \underbrace{m\kappa}_{c} \, \mathbb{E}(p|s).$$

Proposition

The effective price is linear in the search intensity, s:

$$\mathbb{E}(p|s_t) = p^0 - s_t MPB,$$

where:

i. $p^0 := \int_{\underline{p}}^{\zeta} x \, dG(x)$ is the price for the fully captive consumer;

ii. $MPB := \mathbb{E} \max\{p', p''\} - p^0$ is the marginal (price) benefit of increasing the search intensity s_t.

$$\mathcal{V}_t(a, \varepsilon, \eta) = \max_{c, m, s, p, a'} u(c) - v(s, m) + \beta \mathbb{E}_{\eta' | \eta} \mathcal{V}_{t+1}(a', \varepsilon', \eta')$$

s.t.

$$
\begin{aligned}
pc + a' &\leq (1 + r)a + wy, \\
c &= m\kappa, \\
p &= p^0 - sMPB, \\
a' &\geq \underline{B}, \\
s &\in [0, 1], \\
\log y &= \begin{cases} \kappa_t + \eta + \varepsilon, & \text{for } t \leq T_{work}, \\ \log(repl) \cdot \left\{ \kappa_{T_{work}} + \eta_{T_{work}} + \varepsilon_{T_{work}} \right\}, & \text{for } t > T_{work}, \end{cases} \\
\eta' &= \eta + \nu'.
\end{aligned}
$$

5 parameters targeted with 5 moments

Moment		Data	Model
Transaction prices:	top v. bottom decile	1.7	1.7
HH price index:	rich work. v. poor work.	1.045	1.05
	poor HtM v. poor work.	.99	.99
	retirees v. poor work.	1	1.01
Saving-income ratio		2.5	2.5

Price channel and other states

Channel	$\dfrac{\mathbb{E}(\ln P_{j,\tau} - \ln P_{j,\tau-1})}{\mathbb{E}\ln\left(\frac{\bar{P}_{j,\tau} Q_{j,\tau}}{\bar{P}_{j,\tau-1} Q_{j,\tau-1}}\right)}$
Assets	8.17%
Persistent income shocks	8.13%
Transitory income shocks	7.78%

Conclusions

✓ Household prices differ across the income distribution. The effect more pronounced that previously documented for other dimensions.

✓ Using the 2008 ESP, the causal link between paid prices and income of the households is established. The price channel accounts for between 8 and 22% of overall responses in consumption expenditures.

✓ All findings can be rationalized by a new incomplete-market model augmented with a price search protocol.

✓ Findings cast a new light on how household consumption responses in fiscal stimuli should be understood.

Thank you for your attention!