Complete Pass-Through in Levels

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Disclaimer

This presentation contains my own analyses calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the NielsenIQ data are those of the author and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

Pass-Through in Logs and Levels

- Incomplete long-run pass-through of input cost changes.
  E.g., Peltzman (2000), Kim and Cotterill (2008), Nakamura and Zerom (2010), Hong and Li (2017).

  - When costs increase 10%, firms raise prices <10%.

  - Incomplete even after accounting for input cost share and at long horizons.

  - Prevailing explanation: "Superelasticity" of demand leads to markup adjustment.

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  - Incomplete even after accounting for input cost share and at long horizons.

  - Prevailing explanation: "Superelasticity" of demand leads to markup adjustment.

- Today: Measure pass-through on a dollars-and-cents basis.

- Result: Firms exhibit complete pass-through in levels.

  - $1/unit increase in cost leads firms to increase prices $1/unit. Looks incomplete in logs.

  - Pass-through in levels explains variation in "log pass-through" across products/firms.

  - Pattern spans many markets (gas stations, food products, manufacturing industries).

Explaining Pass-Through in Levels

- In workhorse macro models, pass-through in levels equals the markup, $\mu > 1$.

  - For CES demand. (E.g., Dixit and Stiglitz 1977, Melitz 2003.)

  - For richer **homothetic** demand systems, for cost shocks that affect all firms in industry.
    (E.g., Kimball 1995; Atkeson and Burstein 2008; HSA from Matsuyama and Ushchev 2022.)

Explaining Pass-Through in Levels

- In workhorse macro models, pass-through in levels equals the markup, $\mu > 1$.

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  - For richer **homothetic** demand systems, for cost shocks that affect all firms in industry.
    (E.g., Kimball 1995; Atkeson and Burstein 2008; HSA from Matsuyama and Ushchev 2022.)

- Depart from homothetic demand using discrete choice framework.

  - Key parameter η: intensive margin elasticity of demand.

  - Demand within industry is homothetic if, and only if, $\eta = 1$.

  - Result: Demand systems with $\eta = 0$ pass through aggregate cost shocks in levels.
    E.g., Logit, nested/mixed logit, multinomial probit, spatial (Hotelling 1929; Salop 1979).

- Preserves assumptions on firm conduct, link between markups and demand elasticity.

Macro Implications

1. Asymmetry, size-dependence, and heterogeneity in "log pass-through."

2. In industry model: Dynamics of industry gross margins, profits, and entry.

3. In multi-sector model: Differential pass-through of labor vs. material costs. (Okun 1981).

4. In input-output model: Low volatility of consumer inflation relative to commodity prices.

5. Fluctuations in inflation inequality over commodity cost cycle.
   - Explains "cheapflation" during recent inflation without price gouging / excess demand.
   - Absent this channel, inflation inequality from 2020–2023 would have been 1/3 as large.

Selected Related Literature

- **Theoretical and empirical determinants of pass-through**:

  - E.g., Bulow and Pfleiderer (1983), Campa and Goldberg (2005), Burstein et al. (2006), Nakamura and Zerom (2010), Weyl and Fabinger (2013), Burstein and Gopinath (2014), Hong and Li (2017), Mrázová and Neary (2017), Amiti et al. (2019), Butters et al. (2022), Miravete et al. (2022), Minton and Wheaton (2022).

  - In paper: Appendix Table A1 collects studies measuring pass-through in levels and logs.

  - Focus on long-run pass-through of aggregate shocks.
    Abstract from (1) speed of adjustment, (2) firm-specific shocks.

- **Discrete choice and demand systems**:

  - Surveys by Anderson et al. (1992), Berry and Haile (2021), Gandhi and Nevo (2021).

  - Selected related work: Sattinger (1984), Perloff and Salop (1985), Anderson and de Palma (2020), Birchall et al. (2024).

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Pass-Through in Levels: Example

- Leontief production in commodity (\$1/unit) and other variable costs (\$1/unit).

Cost per unit	Baseline
Commodity	\$1
Other components of marginal cost	\$1
Total marginal cost	\$2
Price	\$4

Pass-Through in Levels: Example

- Leontief production in commodity ($1/unit) and other variable costs ($1/unit).

Cost per unit	Baseline	
Commodity	$1	+$0.20
Other components of marginal cost	$1	
Total marginal cost	$2	+$0.20
Price	$4	

Pass-Through in Levels: Example

- Leontief production in commodity ($1/unit) and other variable costs ($1/unit).

Cost per unit	Baseline		New
Commodity	$1	+$0.20	$1.20
Other components of marginal cost	$1		$1.00
Total marginal cost	$2	+$0.20	$2.20
Price	$4	?	?

Pass-Through in Levels: Example

- Leontief production in commodity (\$1/unit) and other variable costs (\$1/unit).

Cost per unit	Baseline		New	*% Change*
Commodity	\$1	+\$0.20	\$1.20	*+20%*
Other components of marginal cost	\$1		\$1.00	
Total marginal cost	\$2	+\$0.20	\$2.20	*+10%*
Price	\$4	?	?	

Pass-Through in Levels: Example

- Leontief production in commodity ($1/unit) and other variable costs ($1/unit).

Cost per unit	Baseline		New	*% Change*
Commodity	$1	+$0.20	$1.20	*+20%*
Other components of marginal cost	$1		$1.00	
Total marginal cost	$2	+$0.20	$2.20	*+10%*
Price	$4	+$0.40	$4.40	*+10%*

- Complete pass-through in logs / fixed percentage markup:
  $p = \mu(c + w) \implies \Delta p = \mu \Delta c.$

Pass-Through in Levels: Example

- Leontief production in commodity (\$1/unit) and other variable costs (\$1/unit).

Cost per unit	Baseline		New	*% Change*
Commodity	\$1	+\$0.20	\$1.20	*+20%*
Other components of marginal cost	\$1		\$1.00	
Total marginal cost	\$2	+\$0.20	\$2.20	*+10%*
Price	\$4	+\$0.20	\$4.20	*+5%*

- Complete pass-through in logs / fixed percentage markup:
  $p = \mu(c + w) \;\Rightarrow\; \Delta p = \mu \Delta c.$

- Complete pass-through in levels / fixed "additive markup":
  $p = (c + w) + m \;\Rightarrow\; \Delta p = \Delta c.$
  Appears incomplete in logs, even relative to cost share.

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Pass-through for six staple food products

- BLS tracks price levels for staple food products (Average Price Data program).
- Identify six products where we can match units and prices of commodity inputs.
  - Coffee, sugar, beef, rice, flour, frozen orange juice concentrate.

Figure: Arabica coffee commodity costs (IMF) and retail ground coffee prices (BLS).

Canonical approach to measure pass-through of cost changes

- Specification à la Campa and Goldberg (2005), Nakamura and Zerom (2010), etc.

- Price change at time t in market m due to commodity cost changes in last K periods:

$$\Delta p_{m,t} = a_m + \sum_{k=0}^{K} b_k \Delta c_{m,t-k} + \varepsilon_{m,t}.$$

  Long-run pass-through is $\sum_{k=0}^{K} b_k$.

- Details:
    - For large K, long-run pass-through estimates gross markup if c is unit root.
    - All commodity series used appear unit root (autocorrelation coefficients 0.967–0.997).
    - Ensure one way Granger causality from Δc to Δp.
    - Use $K = 8$ weeks for gasoline, $K = 12$ months for all other products.
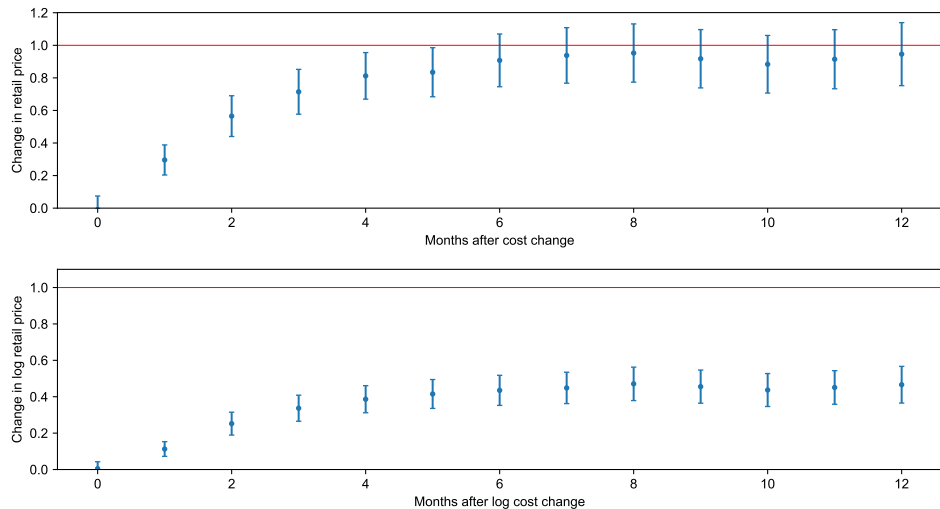
Example: Pass-through of coffee commodity costs to CPI

Figure: Passthrough in levels (top) and in logs (bottom).

Pass-through for six food products matched to commodities

Commodity (IMF)	Final Good (BLS)
Arabica coffee price, per lb.	Coffee, 100%, ground roast
Sugar, No. 16, per lb.	Sugar, white, per lb.
Beef, global price, per lb.	Ground beef, 100% beef
Rice, Thailand, per metric ton	Rice, white, long grain, uncooked
Wheat, global price, per metric ton	Flour, white, all purpose
Frozen orange juice solids, per lb.	Orange juice, frozen concentrate

- Monthly commodity prices (IMF), retail prices (BLS Average Price Data), 1990–2020.

- Match units (e.g., lbs flour per bushel of wheat) using USDA conversion tables.

Pass-through for six food products matched to commodities

| Commodity (IMF) | Final Good (BLS) | Pass-through (12 mos.) | | | |
		Logs		Levels	
Arabica coffee price, per lb.	Coffee, 100%, ground roast	0.466	(0.051)	**0.946**	**(0.099)**
Sugar, No. 16, per lb.	Sugar, white, per lb.	0.370	(0.035)	0.691	(0.072)
Beef, global price, per lb.	Ground beef, 100% beef	0.410	(0.068)	**0.899**	**(0.126)**
Rice, Thailand, per metric ton	Rice, white, long grain, uncooked	0.307	(0.049)	**0.882**	**(0.169)**
Wheat, global price, per metric ton	Flour, white, all purpose	0.240	(0.048)	**0.865**	**(0.160)**
Frozen orange juice solids, per lb.	Orange juice, frozen concentrate	0.327	(0.040)	**0.974**	**(0.111)**

- Monthly commodity prices (IMF), retail prices (BLS Average Price Data), 1990–2020.

- Match units (e.g., lbs flour per bushel of wheat) using USDA conversion tables.

- **Cannot reject complete pass-through in levels for 5 of 6.** (Reject in logs for all.)

Further exploiting cross-sectional variation

- We see complete pass-through in levels across seemingly different products.

- Exploit UPC-level data from NielsenIQ for three food products (flour, rice, coffee).
  - High-priced products have systematically lower "log pass-through."
  - Explained by similar pass-through in levels across all products.

- Exploit variation across retailers for broader set of NielsenIQ products:
  - Retailers selling same UPC at higher price systematically have lower "log pass-through."
  - Explained by similar pass-through in levels across all retailers.
  - Holds for universe of food products in NielsenIQ data (1M UPCs across 235 retail chains).

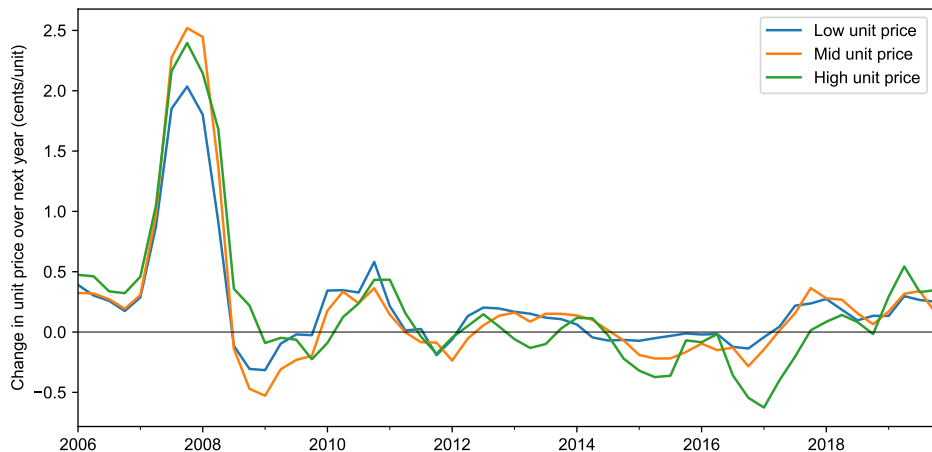# High-price products within category lower "log pass-through"

Figure: Inflation of Rice products in NielsenIQ data, split by tercile of unit price.
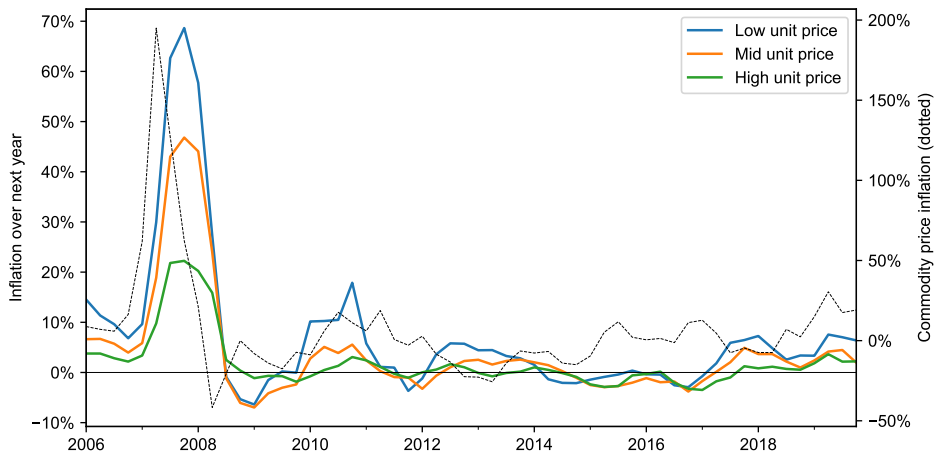
Differences in pass-through disappear in absolute terms (levels)

Figure: Change in unit price of Rice products in NielsenIQ data, split by tercile of unit price.

All categories: High-price items have systematically lower "log pass-through"

$$\Delta \log p_{it} = \alpha_i + \beta_1 \Delta \log c_t + \sum_{g=2}^{3} \beta_g \left(1\{G(i,t) = g\} \times \Delta \log c_t \right) + \varepsilon_{it}.$$

Panel A: In percentages

| | Retail price inflation | | |
	Rice	Flour	Coffee
Commodity Inflation $\times$ Mid Unit Price	−0.075**	−0.007	−0.064**
	(0.014)	(0.009)	(0.015)
Commodity Inflation $\times$ High Unit Price	−0.150**	−0.045**	−0.091**
	(0.022)	(0.009)	(0.017)
UPC FEs	Yes	Yes	Yes
N (thousands)	399.4	101.4	1570.0
R^2	0.15	0.05	0.14

- Higher unit price $=$ larger gap btwn price and commodity cost (markup and/or non-commodity inputs).

All categories: No systematic differences in pass-through in levels

$$\Delta p_{it} = \alpha_i + \beta_1 \Delta c_t + \sum_{g=2}^{3} \beta_g \left(1\{ G(i,t) = g \} \times \Delta c_t \right) + \varepsilon_{it}.$$

Panel B: In levels

| | Δ Retail price | | |
	Rice	Flour	Coffee
Δ Commodity Price $\times$ Mid Unit Price	0.059	0.027	-0.069
	(0.052)	(0.040)	(0.046)
Δ Commodity Price $\times$ High Unit Price	0.042	-0.067	-0.099^*
	(0.100)	(0.044)	(0.058)
UPC FEs	Yes	Yes	Yes
N (thousands)	399.4	101.4	1570.0
R^2	0.07	0.05	0.14

- No systematic difference in pass-through in levels across unit price groups.

Exploiting variation in prices across retailers

- Consider two retailers selling the same UPC.
- If price differences partly due to variation in markups, then when the UPC cost rises, the high-markup retailer should increase price more in levels.

Figure: Prices of identical coffee UPC in two stores in same 3-digit ZIP code in Philadelphia, PA.
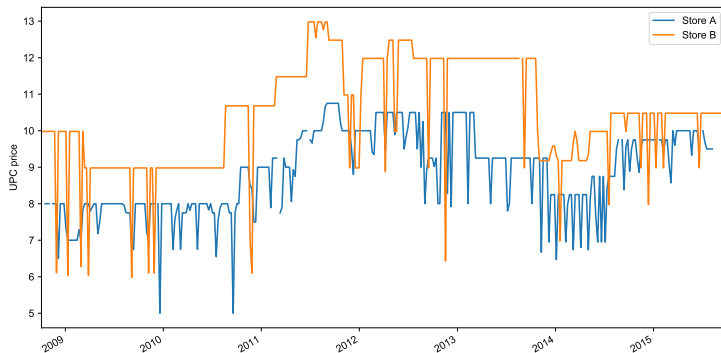
Exploiting variation in markups across retailers: Predictions

$$\Delta p_{ikt} = \beta^{\text{level}} \left(\Delta \bar{p}_{kt} \times \text{RelativePrice}_{ikt} \right) + \delta \text{RelativePrice}_{ikt} + \alpha_{kt} + \varepsilon_{ikt}, \qquad (1)$$

$$\Delta \log p_{ikt} = \beta^{\text{log}} \left(\Delta \log \bar{p}_{kt} \times \text{RelativePrice}_{ikt} \right) + \tilde{\delta} \text{RelativePrice}_{ikt} + \tilde{\alpha}_{kt} + \varepsilon_{ikt}, \qquad (2)$$

- Δp_{ikt} is change in price of UPC k at retailer i from t to $t+4$.
- $\Delta \bar{p}_{kt}$ is average change in UPC k's price across all retailers.
- $\text{RelativePrice}_{ikt} = \log(p_{ikt}/\bar{p}_{kt})$ is retailer's price relative to others.

	Fixed percentage markup $p_i = \mu_i c$	Fixed additive markup $p_i = c + m_i$
Price change relative to average:		
Levels ($dp_i/d\bar{p}$)	$\approx 1 + \log(p_i/\bar{p})$	1
Logs ($d \log p_i/d \log \bar{p}$)	1	$\approx 1 - \log(p_i/\bar{p})$
Predicted interaction coefficient:		
Levels specification (1), β^{level}	1	0
Logs specification (2), β^{log}	0	-1

Exploiting variation in markups across retailers

		Δ UPC Price (Δp_{ikt})			
	Rice (1)	Flour (2)	Coffee (3)	All (4)	
$\Delta \bar{p}_{kt} \times$ RelativePrice$_{ikt}$	−0.022 (0.141)	0.058 (0.209)	0.192 (0.170)	−0.001 (0.839)	
UPC-Quarter FEs	Yes	Yes	Yes	Yes	
N (millions)	0.399	0.101	1.570	100.4	
R^2	0.46	0.48	0.51	0.59	

- Result: $\beta^{\text{level}} \approx 0 \Rightarrow$ retailers change UPC price by same amount in *levels*.

Exploiting variation in markups across retailers

	Δ UPC Price (Δp_{ikt})				Δ Log UPC Price ($\Delta \log p_{ikt}$)			
	Rice (1)	Flour (2)	Coffee (3)	All (4)	Rice (5)	Flour (6)	Coffee (7)	All (8)
$\Delta \bar{p}_{kt} \times \text{RelativePrice}_{ikt}$	−0.022 (0.141)	0.058 (0.209)	0.192 (0.170)	−0.001 (0.839)				
$\Delta \log \bar{p}_{kt} \times \text{RelativePrice}_{ikt}$					−1.004** (0.125)	−1.014** (0.184)	−1.261** (0.084)	−1.043** (0.073)
UPC-Quarter FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N (millions)	0.399	0.101	1.570	100.4	0.399	0.101	1.570	100.4
R^2	0.46	0.48	0.51	0.59	0.62	0.61	0.58	0.61

- Result: $\beta^{\text{level}} \approx 0 \Rightarrow$ retailers change UPC price by same amount in *levels*.

- Makes "log pass-through" fall with markup. ($\beta^{\text{log}} \approx -1$.)

- Holds for broader sample of nearly 1M UPCs across 235 retail chains!

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Manufacturing Industries

- NBER-CES Manufacturing Data: 459 four-digit SIC industries from 1958–2018.

  - Sales (shipments) and input costs: materials, energy, and production labor.

  - Price indices for output, materials, energy, labor from BLS PPI, BEA make-use tables.

- Challenge: Price indices, not price levels! But with constant-returns, Leontief prod fn,

$$\rho^{\text{level}} \equiv \frac{\Delta p}{\Delta c} \qquad \Rightarrow \qquad \frac{\Delta p}{p} = \rho^{\text{level}} \left(\frac{cy}{py} \right) \frac{\Delta c}{c}.$$

So we can estimate ρ^{level} using

$$\Delta \log p_{it} = \rho^{\text{level}} \left(\Delta \log c_{it} \times (\text{InputCosts}/\text{Sales})_{it-1} \right) + \varepsilon_{it}.$$

- Percentage markups imply $\rho^{\text{level}} = \mu > 1$, while additive markups imply $\rho^{\text{level}} \approx 1$.

Manufacturing Industries: Pass-Through

	Δ *Log Output Price*$_t$					
Inputs:	Materials		$+$ Energy		$+$ Production Labor	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Log Input Price$_t$	0.690**	0.079	0.704**	0.005	0.796**	0.052
	(0.072)	(0.132)	(0.073)	(0.134)	(0.083)	(0.232)
(InputCost/Sales)$_{t-1}$		0.004		0.008		0.023**
		(0.011)		(0.011)		(0.011)
Δ Log Input Price$_t$ $\times$ (InputCost/Sales)$_{t-1}$		0.947**		1.041**		0.984**
		(0.203)		(0.201)		(0.286)
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
N	27 381	27 381	27 381	27 381	27 381	27 381
R^2	0.40	0.42	0.40	0.42	0.41	0.42

- Estimate $\rho^{\text{level}} \approx 1$ (complete pass-through in levels). Variation in InputCosts/Sales leads to incomplete log pass-through.
- Similar results with commodity price IV for input costs, horizons $1, \ldots, 5$ years.

Taking Stock of the Empirical Evidence

- Statistic: Long-run pass-through in levels of aggregate shock ≈ 1.

- Retail gasoline. [in paper]
  - Complete pass-through in levels, explains variation in "log pass-through" across stations.

- Food products.
  - Complete pass-through in levels for nearly all products.
  - Explains variation in "log pass-through" across products within category.
  - Explains variation in "log pass-through" across retailers.

- Manufacturing industries.
  - Complete pass-through in levels across 400 industries spanning U.S. manufacturing.

- Previous literature. [in paper]
  - Survey of papers that estimate pass-through in levels of aggregate cost shocks.
  - Weight of evidence finds complete pass-through in levels of cost shocks, excise taxes.

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Homothetic demand systems violate complete pass-through in levels

- Workhorse models in macroeconomics/trade use homothetic demand systems.

  E.g., CES, Kimball (1995), HSA (Matsuyama and Ushchev 2022), Atkeson and Burstein (2008).

- This class of models does not deliver pass-through in levels of aggregate cost shocks.

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- This class of models does not deliver pass-through in levels of aggregate cost shocks.

- Firms $j \in \{1, ..., J\}$, each with constant marginal cost c_j, set prices p_j to max profits.

- Rep. household maximizes utility $U(q_1, ..., q_J)$ s.t. budget constraint $\sum_j p_j q_j = I$.

- Given exogenous costs $\{c_j\}$ and income I, equilibrium $(\{p_j\}, \{q_j\})$ such that each firm chooses price p_j to maximize profits and households choose $\{q_j\}$ to maximize utility.

Proposition (Pass-through of aggregate shock with homothetic preferences)

Suppose U is homothetic. If all firms' marginal costs increase by $d \log c_j = d \log c$, then $\forall j$,

$$d \log p_j = d \log c, \qquad \Rightarrow \qquad dp_j = \mu_j dc_j.$$

That is, "log pass-through" is complete and pass-through in levels $\mu_j > 1$.

Departing from homothetic demand

- Need to relax assumptions about conduct / market structure or homothetic demand.

- Depart from homothetic demand using discrete choice framework.
  Anderson, de Palma, and Thisse (1992).

- Parameter η discriminates across important groups of demand systems.

  - Industry demand is homothetic (e.g., CES) iff $\eta = 1$.

  - Models with unit demand (e.g., mixed logit, Hotelling) have $\eta = 0$.

- Equilibrium exhibits complete pass-through in levels whenever $\eta = 0$.

Discrete Choice Model of Industry Demand

- Mass M of consumers indexed by $i \in [0,1]$. Each consumer has income Y.

- Firms $j \in \{1,...,J\}$. Consumers choose one firm to purchase from.

- Quasilinear preferences over "inside good" and consumption of numeraire good q_{i0},

$$U_i = \max_j \{u_{ij}\}, \qquad \text{where} \qquad u_{ij} = \delta_{ij} q_{ij} + q_{i0},$$

subject to budget constraint, $p_j q_{ij} + p_0 q_{i0} \leq Y$. Consumer-good-specific tastes δ_{ij}.

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  subject to budget constraint, $p_j q_{ij} + p_0 q_{i0} \leq Y$. Consumer-good-specific tastes δ_{ij}.

- **Assumption 1.** Quantity consumed conditional on buying from j is $q_{ij} = \bar{q}(Y/p_j)^{\eta}$.

  - Parameter η determines intensive margin elasticity of consumption to price.
  - Anderson and de Palma (2020) and Birchall, Mohapatra, and Verboven (2024) assume indirect utility is a Box-Cox transform of price and income: $u_{ij} = \delta_{ij} + \frac{(Y^{1-\eta}-1)/\bar{q}-(p_j^{1-\eta}-1)}{1-\eta}$.

Firm Pricing

- Firm j produces with exogenous, constant marginal cost c_j.

- Demand curve for firm j is

$$D_j(p) = \int_0^1 1\{u_{ij} \geq u_{ik}, \forall k \neq j\}\, q_{ij}\, M\, di.$$

- **Assumption 2.** For any two firms j, k where $j \neq k$, the set of consumers where $a\delta_{ij} - b\delta_{in} = c$ for any positive constants $a, b > 0$ and any constant c is measure zero.
  - Consumers almost surely do not face ties in utility across firms.

- Firms choose p_j to maximize variable profits, taking tastes and other prices as given,

$$\max_{p_j} (p_j - c_j) D_j(p).$$

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  - Consumers almost surely do not face ties in utility across firms.

- Firms choose p_j to maximize variable profits, taking tastes and other prices as given,

$$\max_{p_j} (p_j - c_j) D_j(p).$$

- **Equilibrium**: Given costs $\{c_j\}$, numeraire p_0, tastes δ_{ij} and income Y, equilibrium $(\{p_j\}, D(p))$ s.t. firms max profits and consumers choose firms to max utility.

Relationship to Popular Demand Systems

- Special cases when $\eta = 1$ include CES, nested CES (Atkeson and Burstein 2008), and mixed CES (Adao et al. 2017).

    - E.g., CES: $\delta_{ij} = \beta_j \varepsilon_{ij}$, where β_j are taste shifters and $\varepsilon_{ij} \sim$ Frechet$(\sigma - 1)$.

- Special cases when $\eta = 0$ include logit, nested logit (Verboven 1996), mixed logit (Nevo 2001), multinomial probit, competition on a line (Hotelling 1929), and competition on a unit circle (Salop 1979).

    - E.g., Salop (1979) competition on a circle: $\delta_{ij} = \min\{|i - \frac{j}{J}|, |i - \frac{j}{J} - 1|\}$.

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  - E.g., Salop (1979) competition on a circle: $\delta_{ij} = \min\{|i - \frac{j}{J}|, |i - \frac{j}{J} - 1|\}$.

Proposition (Homothetic demand)

Let $D(p, I)$ denote the vector of demand for each inside good $1, ..., J$ given firms' prices p and total expenditures on inside goods I. If $J > 1$, the demand function $D(p, I)$ is homothetic if and only if $\eta = 1$.

Pass-Through in Logs and Levels

Proposition (Pass-Through in Logs)

Suppose all marginal costs increase $d \log c_j = d \log c$. If $\eta = 1$, then pass-through in logs

$$d \log p_j = d \log p = d \log c,$$

is an equilibrium solution.

- Intuition: With $\eta = 1$, consumer choice depends on comparison of δ_{ij}/p_j across all j.

- If we multiply all p_j by same proportion, no change to consumer choices.

- No change to elasticity of demand $\Rightarrow$ no change to desired markup.

Pass-Through in Logs and Levels

Proposition (Pass-Through in Levels)

Suppose all marginal costs increase $dc_j = dc$. If $\eta = 0$, then pass-through in levels

$$dp_j = dp = dc,$$

is an equilibrium solution.

- Intuition: With $\eta = 0$, consumer choice depends on comparison of $\delta_{ij} - p_j$ across all j.

- If we increase all p_j by dp, no change to consumer choices, desired additive markups.

- Any model with $\eta = 0$ generates pass-through in levels of aggregate cost shocks.

Example: Symmetric Firms

Proposition (Prices with symmetric firms)

If firms are symmetric ($c_j = c$ for all j and δ_{ij} are i.i.d. draws from F), prices solve

$$(p - c) \left((1 - \eta) \frac{\phi_0}{p_0} + \eta \frac{\phi_1}{p} \right) = 1,$$

where ϕ_0, ϕ_1 are constants that depend on the number of firms J and taste distribution F.
If $\eta = 1$, price equals cost c times a percentage markup,

$$p = \frac{\phi_1}{\phi_1 - 1} c.$$

If $\eta = 0$, price equals cost c plus additive markup (priced relative to the numeraire p_0),

$$p = c + \frac{p_0}{\phi_0}.$$

Discussion

- Neutrality with respect to price level.

  - Prices scale if change to aggregate price level increases both cost c and numeraire p_0.

- Pass-through of idiosyncratic shocks.

  - Can flexibly vary across demand systems with $\eta = 0$.

  - Logit with atomistic firms: pass-through in levels of idiosyncratic shocks.

  - Alvarez et al. (2024) find pass-through in levels for both aggregate / idiosyncratic shocks for large, nondurables manufacturer.

- Evidence on the intensive margin elasticity of demand η?

  - Firm size variation largely due to # of customers, rather than consumption per customer.
    Argente et al. (2021), Einav et al. (2021), Afrouzi et al. (2023).

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Misspecification in measuring "log pass-through"

- Previous work finds log pass-through is asymmetric, size-dependent, and falls with firm size / product quality.

  (Peltzman 2000, Chen and Juvenal 2016, Auer et al. 2018, Amiti et al. 2019, Gupta 2020, Gagliardone et al. 2025.)

- If $\eta = 0$ and firms set prices $p = c + p_0/\phi_0$, to a second order

$$\rho^{\log} = \frac{\Delta \log p}{\Delta \log c} \approx \frac{c}{p} \left(1 + \frac{p_0/\phi_0}{p} \Delta \log c \right).$$

  - **Asymmetry**: Positive shocks appear to have higher pass-through: $\rho^{\log}(\Delta \log c) > \rho^{\log}(-\Delta \log c)$.
  - **Size-dependence**: Large shocks appear to have higher pass-through than small shocks: $\rho^{\log}(\Delta \log c_H) > \rho^{\log}(\Delta \log c_L)$ if $\Delta \log c_H > \Delta \log c_L$.
  - **Heterogeneity**: If markups increase with firm size / quality, $\rho^{\log}$ falls with both.

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Profits and entry in standard models of industry dynamics

- Many models of industry dynamics build on monopolistic competition with homothetic demand. (e.g., Dixit and Stiglitz 1977; Melitz 2003).

- Percentage markups: change in input costs $\Rightarrow$ higher profits per-unit.

- If aggregate industry demand is inelastic, **entry** or **operating profits** must increase.

- Puzzle: Neither accompanies input cost fluctuations in the data.

Pass-through in levels: Adjustment in gross margins

- Embed our demand system in standard monopolistic competition setup.
    - Mass N of symmetric firms, marginal cost c. Fixed entry cost f_e. Overhead cost f_o.
    - Aggregate industry demand inelastic, $Q = p^{-\theta}$, with $\theta < 1$.
    - Gross and operating margins = variable / operating profits as % of sales.
    - ζ is elasticity of entry to economic profits ($\zeta = 0$: fixed mass, $\zeta \to \infty$: free entry).

Response to cost increase, $dc > 0$			Gross margins dm^{gross}	Operating margins dm^{op}	Mass of firms $d \log N$
$\eta = 1$	$\zeta = 0$	(Fixed mass)	0	> 0	0
$\eta = 1$	$\zeta \in (0, \infty)$		0	> 0	> 0
$\eta = 1$	$\zeta \to \infty$	(Free entry)	0	0	> 0
$\eta = 0$	$\zeta = 0$	(Fixed mass)	< 0	≤ 0	0
$\eta = 0$	$\zeta \in (0, \infty)$		< 0	≤ 0	≤ 0
$\eta = 0$	$\zeta \to \infty$	(Free entry)	< 0	0	≤ 0

Gross margins exhibit strong negative correlation with input costs
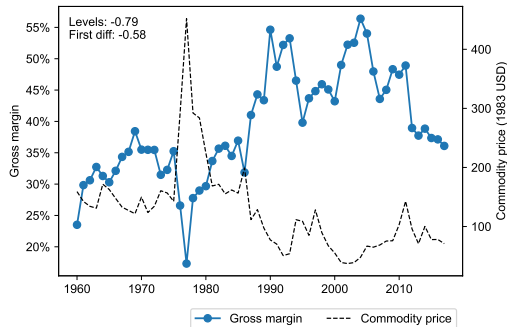
(a) Roasted coffee mfg vs. coffee.
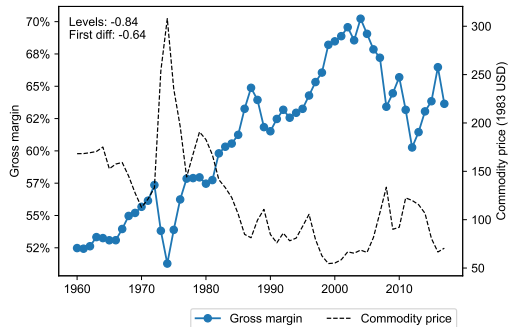
(b) Bread, cake & related products mfg vs. wheat.

- In contrast to $\eta = 1$, gross margins for NBER-CES industries are not constant.

- Exhibit strong negative correlation with commodity input prices.

Dynamics of gross, operating margins and entry all consistent with $\eta = 0$

Panel A: Retail Gasoline Source:	Δ *Log Gross Margin*		Δ *Log Oper. Margin*		Δ *Log Num. Estabs*	
	ARTS	IRS	ARTS	IRS	BDS	SUSB
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Log Wholesale Price$_t$	−0.263**	−0.291**	0.218	−0.167	−0.002	0.001
	(0.045)	(0.061)	(0.377)	(0.331)	(0.006)	(0.007)
N	39	26	15	26	39	24
R^2	0.54	0.49	0.04	0.01	0.00	0.00
Panel B: Manufacturing Industries	Δ *Log Gross Margin*		Δ *Log Oper. Margin*		Δ *Log Num. Estabs*	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Log Input Price$_t$	−0.188**	0.154	−0.122	0.095	0.007	−0.028
	(0.039)	(0.103)	(0.079)	(0.211)	(0.013)	(0.044)
Δ Log Input Price$_t$ × Inputs/Sales$_{t-1}$		−0.504**		−0.285		0.049
		(0.188)		(0.376)		(0.063)
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
N	27 381	27 381	27 305	27 305	18 201	18 201
R^2	0.05	0.11	0.02	0.06	0.22	0.23

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Okun (1981) on materials costs

- Okun (1981) speculates a "special role for materials costs."

  - "Some views of marking up direct costs distinguish increases in the costs of purchased materials from increases in standard unit labor costs, implying that the former are likely to be passed through to customers essentially on a dollars-and-cents basis, while the latter are passed through with a percentage markup."

- Okun (1981) was right! Labor costs appear to be passed-through at higher rate.

- But Okun (1981) was wrong.

  - Not material costs that are special, but labor that is special!

  - In multi-sector model, wages determine numeraire price p_0 and thus additive markup.

  - Correct for this, and we restore equal pass-through in levels of labor vs. other costs.

Stylized multi-sector model with material and labor costs

- Continuum of sectors indexed by ω, with firms indexed by j. Consumers maximize:

$$U_i = \max_{\Omega, j(\omega)} \int_0^\Omega \delta_{ij}(\omega) q_{ij}(\omega) d\omega, \qquad \text{s.t.} \qquad \int_0^\Omega p_{ij}(\omega) q_{ij}(\omega) d\omega = Y,$$

where e.g., $p_{ij}(\omega)$ is the price of firm $j(\omega)$ that consumer i chooses from ω.

- We impose $q_{ij}(\omega) = \bar{q}(Y/p_{ij}(\omega))^\eta$.

- Each sector has Leontief production in labor (wage w) and materials (price c):

$$mc(\omega) = \beta(\omega) w + (1 - \beta(\omega)) c.$$

$\beta(\omega) \in [0, 1]$ determines weights in production.

  - $\beta(\omega)$ increases with ω: marginal sectors are services / more labor-intensive.
    (Aguiar and Bils 2015; Jaimovich et al. 2019; Orchard 2022).

Stylized multi-sector model: Predictions for pass-through

- We can measure pass-through in logs and levels using:

$$\frac{d\log p(\omega)}{d\log w} = \rho_w^{\log}\frac{\text{LaborCosts}(\omega)}{\text{VariableCosts}(\omega)}, \qquad \text{and} \qquad \frac{d\log p(\omega)}{d\log w} = \rho_w^{\text{level}}\frac{\text{LaborCosts}(\omega)}{\text{Sales}(\omega)}.$$

Proposition (Differential pass-through of labor costs)

- If $\eta = 1$, then $\rho_w^{log} = \rho_c^{log} = 1$, and $\rho_w^{level} = \rho_c^{level} = \mu(\omega)$.

- If $\eta = 0$ and $\beta(\Omega) = 1$, then:

  - $\rho_c^{level} = 1$, *(Pass-through in levels of material costs)*

  - $\rho_w^{level} \geq \mu(\omega)$ and $\rho_w^{log} \geq 1$, *(Complete log pass-through of labor costs)*

  - The "adjusted pass-through in levels" of labor costs $\rho_w^{adj} = 1$, where

  $$\frac{d\log p(\omega)}{d\log w} = \rho_w^{adj}\frac{\text{LaborCosts}(\omega) + \text{VariableProfits}(\omega)}{\text{Sales}(\omega)}.$$

Revisiting Okun (1981): Empirical evidence

| | Δ Log Output Price$_t$ | | |
	(1) Cost Shares	(2) Sales Shares	(3) Sales Shares
Δ Log Material Price$_t$ $\times$ Material Share$_{t-1}$	0.798**	1.046**	
	(0.085)	(0.108)	
Δ Log Energy Price$_t$ $\times$ Energy Share$_{t-1}$	0.715**	0.859**	
	(0.271)	(0.378)	
Δ Log Production Wage$_t$ $\times$ Labor Share$_{t-1}$	1.070**	2.095**	
	(0.217)	(0.281)	
Δ Log Production Wage$_t$ $\times$ (Labor + Variable Profits) Share$_{t-1}$			
Industry FEs	Yes	Yes	
Year FEs	Yes	Yes	
N	27 374	27 374	
R^2	0.49	0.50	

- Labor costs appear to have complete log pass-through, $>$1:1 pass-through in levels.

Revisiting Okun (1981): Empirical evidence

	Δ Log Output Price$_t$		
	(1) Cost Shares	(2) Sales Shares	(3) Sales Shares
Δ Log Material Price$_t$ $\times$ Material Share$_{t-1}$	0.798**	1.046**	1.049**
	(0.085)	(0.108)	(0.109)
Δ Log Energy Price$_t$ $\times$ Energy Share$_{t-1}$	0.715**	0.859**	0.997**
	(0.271)	(0.378)	(0.362)
Δ Log Production Wage$_t$ $\times$ Labor Share$_{t-1}$	1.070**	2.095**	
	(0.217)	(0.281)	
Δ Log Production Wage$_t$ $\times$ (Labor + Variable Profits) Share$_{t-1}$			0.951**
			(0.209)
Industry FEs	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes
N	27374	27374	27374
R^2	0.49	0.50	0.49

- Labor costs appear to have complete log pass-through, >1:1 pass-through in levels.

- Corrected when we account for the fact that additive markup priced relative to wage.

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Low volatility of consumer inflation

- I-O model with Calvo frictions, taking BLS Stage 1 industry prices as exogenous.

- Volatility of PCE / CPI is too high with $\eta = 1$ compared to the data.

	Std. deviation of annual inflation, 1982–2018	Cost-weighted average markup Mfg.	All
Personal Consumption Expenditures (PCE) Price Index	1.1%		
Consumer Price Index for All Urban Consumers	1.3%		
$\eta = 1$, Variable costs (VC) = Materials	2.5%	1.48	2.19

Low volatility of consumer inflation

- I-O model with Calvo frictions, taking BLS Stage 1 industry prices as exogenous.

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- Reduce volatility by assuming more costs variable. But need low markups.

	Std. deviation of annual inflation, 1982–2018	Cost-weighted average markup	
		Mfg.	All
Personal Consumption Expenditures (PCE) Price Index	1.1%		
Consumer Price Index for All Urban Consumers	1.3%		
$\eta = 1$, Variable costs (VC) = Materials	2.5%	1.48	2.19
$\eta = 1$, VC = Materials + wages	1.7%	1.19	1.31
$\eta = 1$, VC = Materials + wages + consumption of fixed capital	1.6%	1.11	1.17

Low volatility of consumer inflation

- I-O model with Calvo frictions, taking BLS Stage 1 industry prices as exogenous.

- Volatility of PCE / CPI is too high with $\eta = 1$ compared to the data.

- Reduce volatility by assuming more costs variable. But need low markups.

- Additive markups ($\eta = 0$) reconciles low volatility of inflation with large markups.

	Std. deviation of annual inflation, 1982–2018	Cost-weighted average markup	
		Mfg.	All
Personal Consumption Expenditures (PCE) Price Index	1.1%		
Consumer Price Index for All Urban Consumers	1.3%		
$\eta = 1$, Variable costs (VC) = Materials	2.5%	1.48	2.19
$\eta = 1$, VC = Materials + wages	1.7%	1.19	1.31
$\eta = 1$, VC = Materials + wages + consumption of fixed capital	1.6%	1.11	1.17
$\eta = 0$, Additive markups	1.3%	1.0–1.5	1.0–2.2

Response of consumer inflation to oil supply shock
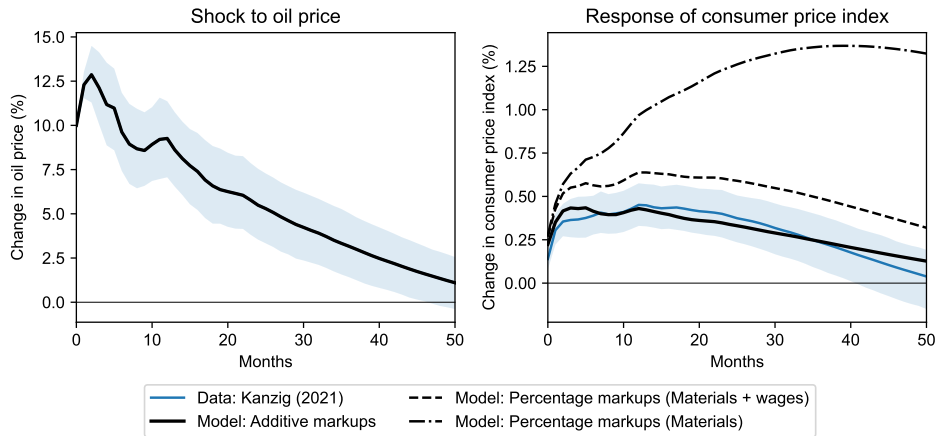
- *Note:* Impulse responses to an oil supply news shock from Känzig (2021). The solid line is the point estimate and the shaded areas are 68 percent confidence bands. The changes in the oil price in the left panel are treated as exogenous changes in the oil price in the model. The model lines in the right panel plot the response of the personal consumption expenditures (PCE) price index in the calibrated models given the changes in oil prices.

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Attention to heightened inflation of low-end products in 2021
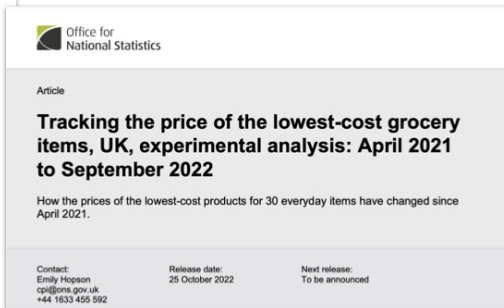
- "Supermarkets recouping margins on budget products" / elevated demand at low-end.
- Simpler explanation: Pass-through in levels $\rightarrow$ rising costs increase inflation inequality.

Inflation inequality moves with commodity costs within category (e.g. coffee)

- **Coffee**: Same Δp across products $\rightarrow$ higher % inflation for low-price products.
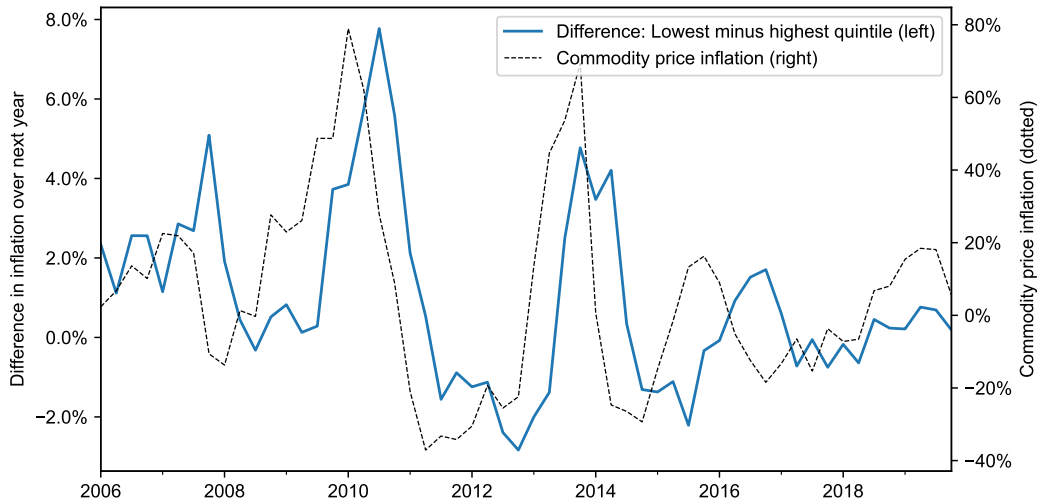
Cycles in inflation inequality over entire food-at-home bundle
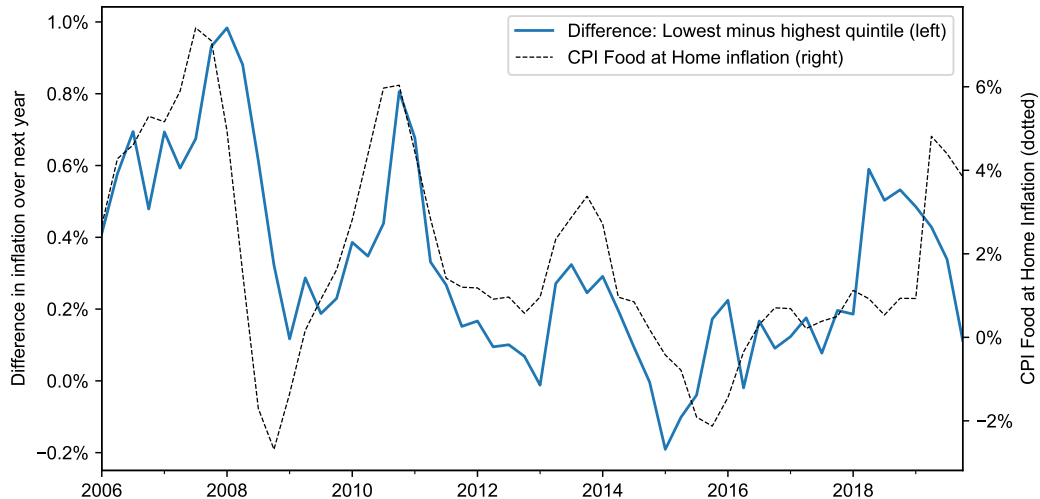
Can pass-through in levels explain recent "cheapflation"?

- Approach: split each product category into 10 groups by relative price.
- Fit pass-through of upstream costs to prices over 2006–2019, then extrapolate using 2020–2023 increase in costs.

(a) Log pass-through of Food Manufacturing PPI.
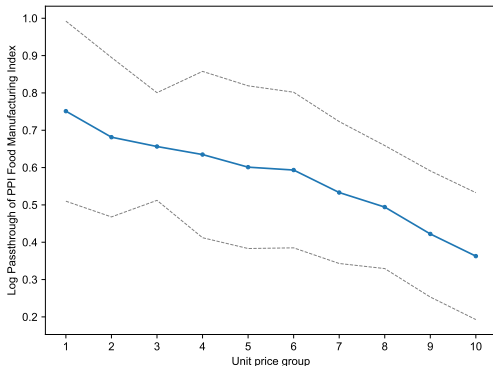
(b) Log pass-through of Farm Products PPI.
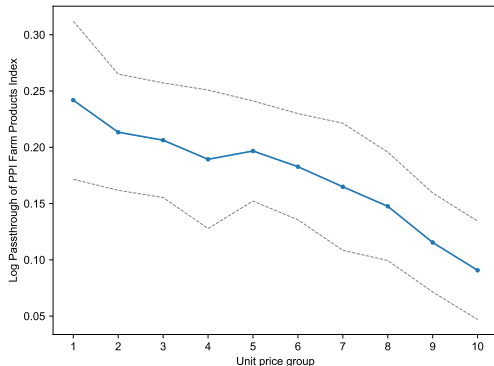
Predictions for food-at-home inflation, 2020–2023

- 20pp (11pp) price growth for high- (low-) price products.

- 3x higher than implied by secular inflation diffs. (Jaravel 2019).

- Magnitude similar to recent estimates.
  Cavallo and Kryvtsov (2024),
  Chen et al. (2024).
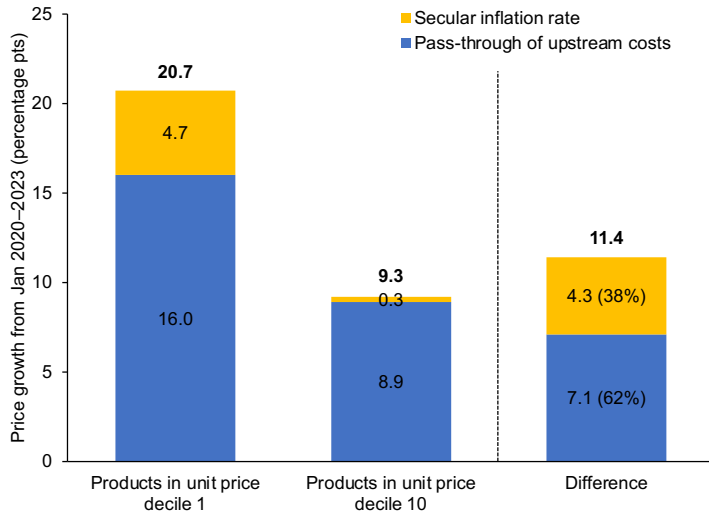
Conclusion

- Empirical evidence: Pass-through of costs tends to be complete in *levels*.

- Not consistent with homothetic models of demand used in workhorse models.

- Class of demand systems with $\eta = 0$ can explain pass-through behavior.

- Helps us understand dynamics of prices and industry outcomes:

  - Incomplete log pass-through $+$ asymmetry, size-dependence, heterogeneity.

  - Dynamics of industry profits, margins, and entry.

  - Pass-through of labor vs. materials costs.

  - Low volatility of consumer price inflation.

  - "Cheapflation" & unequal incidence of commodity inflation across income distribution.

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Misspecification in "log pass-through": Positive squared $\Delta\log(c)$ term

$\Delta\log(\text{Price})_{it}$	Unleaded petrol (ULP)		Premium (PULP)	
	(1)	(2)	(3)	(4)
$\Delta\log(\text{Cost})_t$	0.870**	0.889**	0.865**	0.881**
	(0.031)	(0.024)	(0.032)	(0.025)
$(\Delta\log(\text{Cost})_t)^2$		0.155**		0.147
		(0.068)		(0.097)
N	312215	312215	259437	259437
R^2	0.88	0.89	0.87	0.87

- Since cost share varies with commodity cost, misspecification in log regression.

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Station-level panel dataset of gas prices in Perth, Australia

- 2.3M price observations (2001–present) for 875 stations in Perth metropolitan area.

- Spot price sold to retailers (Terminal Gate Price) available daily.

    1. Pass-through is complete in levels.

    2. No apparent heterogeneity in pass-through in levels.

    3. Pass-through in levels + margins explains incomplete "log pass-through" and cross-sectional heterogeneity.

Pass-through of terminal gas price to station gas prices: Unleaded
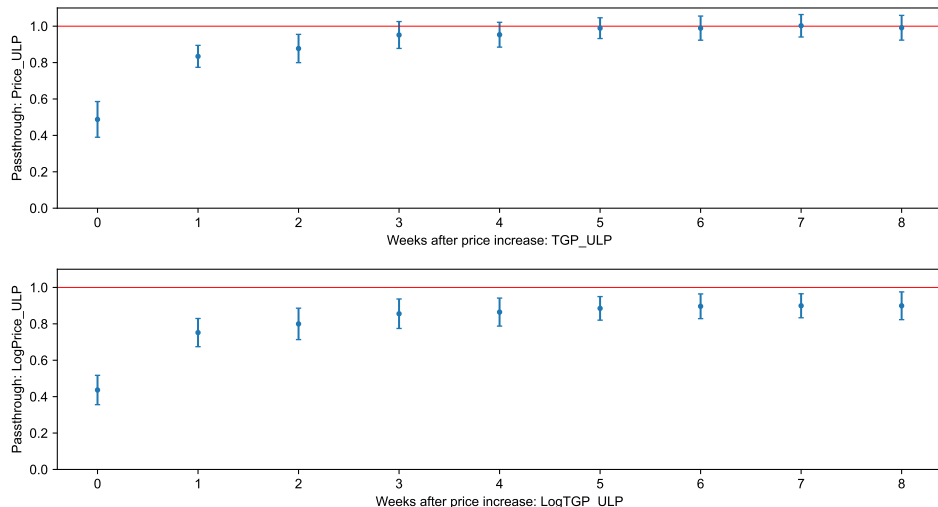
Figure: Passthrough in levels (top) and in logs (bottom). SEs two-way clustered by postcode $\times$ year.

Summary of retail gasoline pass-through estimates

Description	Pass-through (8 weeks)			
	Logs		Levels	
Australia, station-level, 2001–2022				
Terminal to retail, Unleaded	0.899	(0.043)	**0.991**	(0.038)
Terminal to retail, Premium Unleaded	0.887	(0.041)	**0.985**	(0.036)
Canada, city-level, 2007–2022				
Crude to wholesale	0.553	(0.098)	**0.927**	(0.100)
Wholesale to retail (excl. taxes)	0.859	(0.016)	**1.008**	(0.022)
South Korea, station-level, 2008–2022				
Refinery to retail, Unleaded	0.926	(0.044)	**0.997**	(0.052)
United States, national, 1990–2022				
NY Harbor spot price to retail	0.570	(0.051)	**0.954**	(0.053)

- **Cannot reject complete pass-through in levels**. (Reject in logs for all.)

Exploiting variation in markups

- Low markups, hard to differentiate pass-through in levels of 1 from 1.02–1.05.

- Test: Pass-through in levels should be higher for stations with 5% vs. 2% markup.

$$\Delta p_{it} = \alpha + \beta_1 \Delta c_{it} + \delta \text{AvgMarkup}_{it} + \beta_2 \left(\Delta c_{it} \times \text{AvgMarkup}_{it} \right) + \varepsilon_{it},$$

  - where $\Delta p_{i,t}$, $\Delta c_{i,t}$ are change in station retail price and wholesale cost over 16 weeks.
  - Exploit cross-sectional / time series variation in AvgMarkup_{it}, with IVs to isolate markups.

- Prediction: If constant multiplicative markup, $\beta_2 > 0$.

Exploiting variation in markups

ΔPrice_{it}	(1) (OLS)	(2) (OLS)	(3) (IV1)	(4) (OLS)	(5) (IV2)
ΔCost_t	0.950^{**}				
	(0.021)				
$\Delta \text{Cost}_t \times \text{Avg. Station Markup}_i$ (Net %)					
$\Delta \text{Cost}_t \times \text{Avg. Quarter Markup}_t$ (Net %)					
N	312215				
R^2	0.89				

Exploiting variation in markups

ΔPrice$_{it}$	(1) (OLS)	(2) (OLS)	(3) (IV1)	(4) (OLS)	(5) (IV2)
ΔCost$_t$	0.950**	0.989**			
	(0.021)	(0.037)			
ΔCost$_t \times$ Avg. Station Markup$_i$ (Net %)		-0.005			
		(0.003)			
ΔCost$_t \times$ Avg. Quarter Markup$_t$ (Net %)					
N	312215	312215			
R^2	0.89	0.89			

- Stations with higher markups do not have higher pass-through in levels ($\beta_2 \approx 0$).

Exploiting variation in markups

ΔPrice$_{it}$	(1) (OLS)	(2) (OLS)	(3) (IV1)	(4) (OLS)	(5) (IV2)
ΔCost$_t$	0.950**	0.989**	0.952**		
	(0.021)	(0.037)	(0.044)		
ΔCost$_t \times$ Avg. Station Markup$_i$ (Net %)		-0.005	-0.000		
		(0.003)	(0.005)		
ΔCost$_t \times$ Avg. Quarter Markup$_t$ (Net %)					
N	312215	312215	312215		
R^2	0.89	0.89	0.89		

- Stations with higher markups do not have higher pass-through in levels ($\beta_2 \approx 0$).

Exploiting variation in markups

ΔPrice$_{it}$	(1) (OLS)	(2) (OLS)	(3) (IV1)	(4) (OLS)	(5) (IV2)
ΔCost$_t$	0.950**	0.989**	0.952**	0.987**	0.971**
	(0.021)	(0.037)	(0.044)	(0.034)	(0.043)
ΔCost$_t \times$ Avg. Station Markup$_i$ (Net %)		-0.005	-0.000		
		(0.003)	(0.005)		
ΔCost$_t \times$ Avg. Quarter Markup$_t$ (Net %)				-0.003	-0.002
				(0.003)	(0.004)
N	312215	312215	312215	312215	312215
R^2	0.89	0.89	0.89	0.89	0.89

- Stations with higher markups do not have higher pass-through in levels ($\beta_2 \approx 0$).

Pass-through in levels explains extent & variation of "log pass-through"

$\Delta \log(\text{Price})_{it}$	(1) (OLS)	(2) (OLS)	(3) (IV1)	(4) (OLS)	(5) (IV2)
$\Delta \log(\text{Cost})_t$	0.870** (0.031)				
$\Delta \log(\text{Cost})_t \times$ Avg. Station Markup$_i$ (Net %)					
$\Delta \log(\text{Cost})_t \times$ Avg. Quarter Markup$_t$ (Net %)					
N	312215				
R^2	0.88				

Pass-through in levels explains extent & variation of "log pass-through"

$\Delta \log(\text{Price})_{it}$	(1) (OLS)	(2) (OLS)	(3) (IV1)	(4) (OLS)	(5) (IV2)
$\Delta \log(\text{Cost})_t$	0.870**	0.998**	0.968**	0.977**	0.967**
	(0.031)	(0.035)	(0.041)	(0.026)	(0.033)
$\Delta \log(\text{Cost})_t \times$ Avg. Station Markup$_i$ (Net %)		-0.015**	-0.011**		
		(0.003)	(0.004)		
$\Delta \log(\text{Cost})_t \times$ Avg. Quarter Markup$_t$ (Net %)				-0.010**	-0.010**
				(0.002)	(0.003)
N	312215	312215	312215	312215	312215
R^2	0.88	0.89	0.89	0.89	0.89

- As a result, stations with high margins appear to have "incomplete" pass-through.

Pass-through in levels explains extent & variation of "log pass-through"

$\Delta \log(\text{Price})_{it}$	(1) (OLS)	(2) (OLS)	(3) (IV1)	(4) (OLS)	(5) (IV2)
$\Delta \log(\text{Cost})_t$	0.870**	0.998**	0.968**	0.977**	0.967**
	(0.031)	(0.035)	(0.041)	(0.026)	(0.033)
$\Delta \log(\text{Cost})_t \times$ Avg. Station Markup$_i$ (Net %)		-0.015**	-0.011**		
		(0.003)	(0.004)		
$\Delta \log(\text{Cost})_t \times$ Avg. Quarter Markup$_t$ (Net %)				-0.010**	-0.010**
				(0.002)	(0.003)
N	312215	312215	312215	312215	312215
R^2	0.88	0.89	0.89	0.89	0.89

- As a result, stations with high margins appear to have "incomplete" pass-through.

- Intercept: Pass-through is complete as Net Markup$_{i,t} \to 0$.

Retail Gasoline: Taking Stock

1. Pass-through complete in levels.

2. Pass-through incomplete in logs, even accounting for cost share of gasoline.

3. No apparent heterogeneity in pass-through in levels.

4. Differences in margins rationalize cross-sectional heterogeneity in log pass-through.

- In paper: Similar results from other geographies (Canada, South Korea, U.S.).

- Similar results using Känzig (2021) OPEC announcement IV for upstream costs.

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Explaining Okun (1981): Setup

- Continuum of products indexed by ω.

- Households choose which varieties $j(\omega)$ to buy and total mass of products Ω,

$$Y = \max_{\Omega, j(\omega)} \int_0^\Omega \delta_{ij(\omega)} q_{ij(\omega)} d\omega, \qquad \text{s.t.} \qquad \int_0^\Omega p_{j(\omega)} q_{ij(\omega)} = I.$$

- Production of each product ω is Leontief in labor (wage w) and commodity (cost c),

$$mc(\omega) = \beta(\omega)w + (1 - \beta(\omega))c.$$

- We will assume for simplicity:
  - Identical firms selling each variety ($\Rightarrow$ symmetric prices $p_{j(\omega)} = p_\omega$).
  - Each $\delta_{ij(\omega)}$ drawn i.i.d. from same distribution across all i, j, ω.

Numeraire determined endogenously

- The change in welfare from purchasing some product ω from firm $j(\omega)$ is

$$dY \approx q_{j(\omega)} d\omega \left[d\delta_{ij(\omega)} - \left[\eta \frac{\delta_{ij(\omega)}}{p_{j(\omega)}} + (1-\eta) \frac{\delta_{\Omega}}{p_{\Omega}} \right] dp_{j(\omega)} \right].$$

Note: "Numeraire" price determined by price/taste of marginal product Ω.

- When $\eta = 0$, each product's price is given by

$$p(\omega) = mc(\omega) + \underbrace{(\mu(\Omega) - 1) mc(\Omega)}_{\substack{\text{Additive margin} \\ \text{depends on } mc(\Omega), \mu(\Omega)}}.$$

Pass-through of commodity vs. wage changes

- Pass-through of change to unit commodity costs and wage costs:

$$\frac{\Delta p}{(1 - \beta(\omega))\Delta c} = 1 + (\mu(\Omega) - 1)\frac{1 - \beta(\Omega)}{1 - \beta(\omega)},$$

$$\frac{\Delta p}{\beta(\omega)\Delta w} = \mu(\omega) + (\mu(\Omega) - 1)\left[\frac{\beta(\Omega) - \beta(\omega)}{\beta(\omega)}\right]\frac{c}{\mathrm{mc}(\omega)}.$$

- If marginal product Ω does not use commodity, i.e. $\beta(\Omega) = 1$, we get
  - Complete pass-through in levels for commodity input.
  - (Slightly more than) complete "log pass-through" for wages.

- Okun's (1981) "special role" actually is a special role of labor costs!

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Backup: Upstream PPI explains food-at-home inflation well

Figure: Predicted Retail Scanner index inflation using Food Manufacturing PPI and unemp. gap.
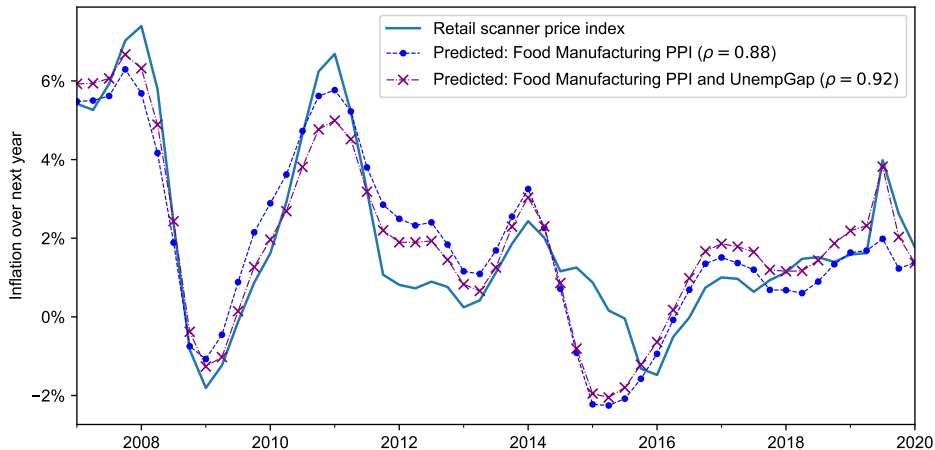
Backup: Upstream PPI explains food-at-home inflation well

Figure: Predicted Retail Scanner index inflation using Farm Products PPI and unemp. gap.
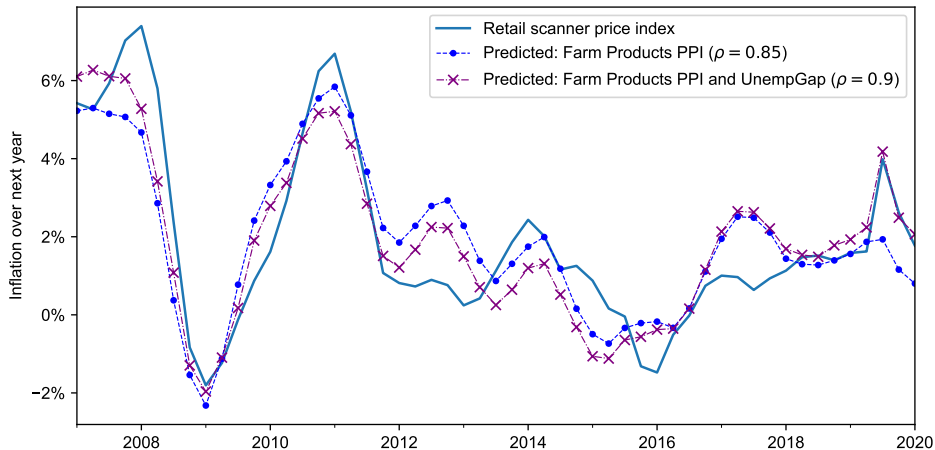
Backup: Match rate of consumer expenditures to retail scanner infl. data

Table: Percent of expenditures matched to retail scanner and inflation data, by income group.

Income quintile	Matched to UPC		Matched to retailer-UPC	
	Total	With infl.	Total	With infl.
1	60.2	52.7	22.5	18.5
2	59.9	52.6	23.1	19.0
3	60.2	53.5	24.0	20.1
4	60.7	54.5	25.7	21.7
5	59.7	52.6	27.2	22.7

Backup: R^2 upstream PPI changes on inflation by income

Table: R^2 from long-term log pass-through regression.

Index	Food Manufacturing PPI		Farm Products PPI	
	UPC	Retailer-UPC	UPC	Retailer-UPC
Food-at-home CPI	0.59	0.59	0.42	0.42
Retail scanner index	0.58	0.62	0.50	0.51
All income groups	0.42	0.45	0.31	0.27
1st quintile	0.43	0.43	0.30	0.21
2	0.43	0.44	0.30	0.25
3	0.43	0.44	0.30	0.27
4	0.42	0.45	0.30	0.27
5th quintile	0.43	0.44	0.30	0.30

Backup: R^2 upstream PPI changes on inflation by unit price group

Table: R^2 from long-term log pass-through regression.

Index	Food Manufacturing PPI		Farm Products PPI	
	UPC	Retailer-UPC	UPC	Retailer-UPC
Food-at-home CPI	0.59	0.59	0.42	0.42
Retail scanner index	0.58	0.62	0.50	0.51
1st decile	0.61	0.58	0.55	0.42
2	0.41	0.49	0.34	0.34
3	0.34	0.64	0.27	0.51
4	0.41	0.54	0.33	0.46
5	0.46	0.50	0.42	0.49
6	0.42	0.55	0.40	0.42
7	0.47	0.52	0.47	0.39
8	0.40	0.52	0.23	0.43
9	0.38	0.46	0.38	0.43
10th decile	0.39	0.34	0.33	0.31

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Pass-through quotes

- "P&G, of Cincinatti, said Friday that it raised the list price of Folgers ground coffee by 28 cents per 11.5-ounce equivalent [...] to \$2.56 from \$2.28."
- "In futures trading Friday, arabica coffee beans for March delivery closed down 1.30 cents at \$1.3445 a pound on the New York Board of Trade. A Folgers spokeswoman said the last time the company changed retail coffee prices, in December, the contract was trading around 96 cents a pound."
- \$0.28 $\times$ (16/11.5 ounces) = \$0.38 per pound. *Wall Street Journal*.

Kahneman et al. (1986) surveys on occasions for price changes

- **Price increases to offset cost increases are perceived as fair.**

  - "Suppose that, due to a transportation mixup, there is a local shortage of lettuce and the wholesale price has increased. A local grocer has bought the usual quantity of ltetuce at a price that is 30 cents per head higher than normal. The grocer raises the price of lettuce to customers by 30 cents per head."
    Acceptable 79%, Unfair 21%.

  - "A landlord owns and rents out a single small house to a tenant who is living on a fixed income. A higher rent would mean the tenant would have to move. Other small rental houses are available. The landlord's costs have increased substantially over the past year and the landlord raises rent to cover the cost increases when the tenant's lease is due for renewal."
    Acceptable 75%, Unfair 25%.

- **With inventories, fairness considerations delay pass-through.**

  - "A grocery store has several months supply of peanut butter in stock which it has on the shelves and in the storeroom. The owner hears that the wholesale price of peanut butter has increased and immediately raises the price on the current stock of peanut butter."
    Acceptable 21%, Unfair 79%.

- **Price increases in response to demand shocks deemed unfair.**

  - "A severe shortage of Red Delicious apples has developed in a community and none of the grocery stores or produce markets have any of this type of apple on their shelves. Other varieties of apples are plentiful in all of the other stores. One grocer receives a single shipment of Red Delicious apples at the regular wholesale cost and raises the retail price of these Red Delicious apples by 25% over the regular price."

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Food inflation exp. of low-income households more sensitive to inflation rate

Data	*Food 1-yr Inflation Expectations* NY Fed, 2013–2023		
Aggregation	Median (1)	Indiv. (2)	Indiv. (3)
Mid-Income	-0.371**	-1.657**	-
	(0.160)	(0.078)	-
High-Income	-0.799**	-2.361**	-
	(0.223)	(0.093)	-
Food-at-home infl. over past year	0.430**	0.462**	0.215**
	(0.034)	(0.061)	(0.078)
Mid-Income × Food-at-home infl.	-0.255**	-0.163**	-0.075**
	(0.038)	(0.024)	(0.037)
High-Income × Food-at-home infl.	-0.293**	-0.250**	-0.129**
	(0.041)	(0.026)	(0.043)
Respondent FEs	No	No	Yes
N	360	133780	133780

- Food infl. exp. of low-income higher, but also more sensitive to past food-at-home infl.

Overall inflation exp. of low-income more sensitive to food-at-home infl.

Data	*1-yr Inflation Expectations*				
Aggregation	NY Fed, 2013–2023			Michigan Survey, 1978–2024	
	Median	Indiv.	Indiv.	Mean	Median
	(1)	(2)	(3)	(4)	(5)
Mid-Income	-0.885**	-1.647**	-	-0.779**	-0.775**
	(0.216)	(0.289)	-	(0.092)	(0.071)
High-Income	-0.984**	-3.130**	-	-1.430**	-1.244**
	(0.263)	(0.380)	-	(0.136)	(0.091)
Food-at-home infl.	0.258**	0.243**	0.129*	0.139**	0.104**
	(0.040)	(0.071)	(0.074)	(0.026)	(0.023)
Mid-Income $\times$ Food-at-home infl.	-0.142**	-0.055	-0.042	-0.027	-0.023*
	(0.036)	(0.042)	(0.039)	(0.024)	(0.013)
High-Income $\times$ Food-at-home infl.	-0.148**	-0.150**	-0.079	-0.060*	-0.044**
	(0.043)	(0.064)	(0.063)	(0.031)	(0.019)
Controls	CPI less food & energy infl., gas infl., income interactions				
Respondent FEs	-	No	Yes	-	-
N	360	153051	153051	1599	1599

- Overall infl. exp. more sensitive to food-at-home infl (not true for broader CPI or gas).

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