# Complete Pass-Through in Levels

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April 2025

# 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., Hellerstein (2008), Nakamura and Zerom (2010), De Loecker et al. (2016), Hong and Li (2017).

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

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

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

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

  - 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 when 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

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  - For richer **homothetic** demand systems when 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 $\eta$: intensive margin elasticity of demand.

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

  - Result: Complete pass-through in levels of aggregate cost shocks whenever $\eta = 0$.
    E.g., Logit, nested/mixed logit, multinomial probit, address models incl. Hotelling (1929), Salop (1979).

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

- Preserves neutrality with respect to aggregate price level.

# 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.

# 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:
$p = \mu(c + w) \Rightarrow \Delta p = \mu \Delta c.$

# 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 $\sum_{k=0}^{K} b_k$.

- Suppose $p = \mu(c + w) + m$. Then $\sum_{k=0}^{K} b_k \to \mu$ if...
  - The commodity price $c$ is unit root (autocorrelation coefficients 0.967–0.997).
  - $K$ large enough (we use $K = 12$ months).
  - No reverse causality / anticipation (we ensure one-way Granger causality from $\Delta c$ to $\Delta p$ and show that leads of $\Delta c$ do not predict $\Delta p$).
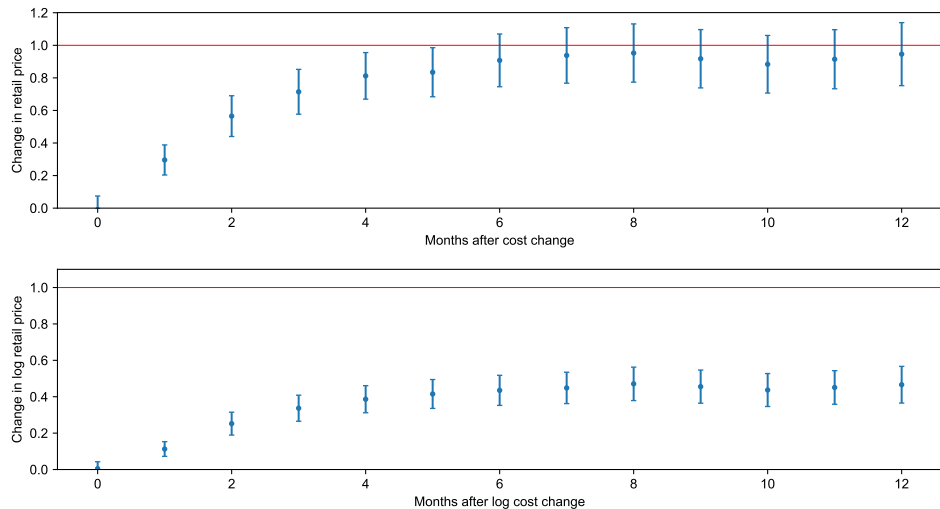
# Example: Pass-through of coffee commodity costs to CPI



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 200 retail chains).

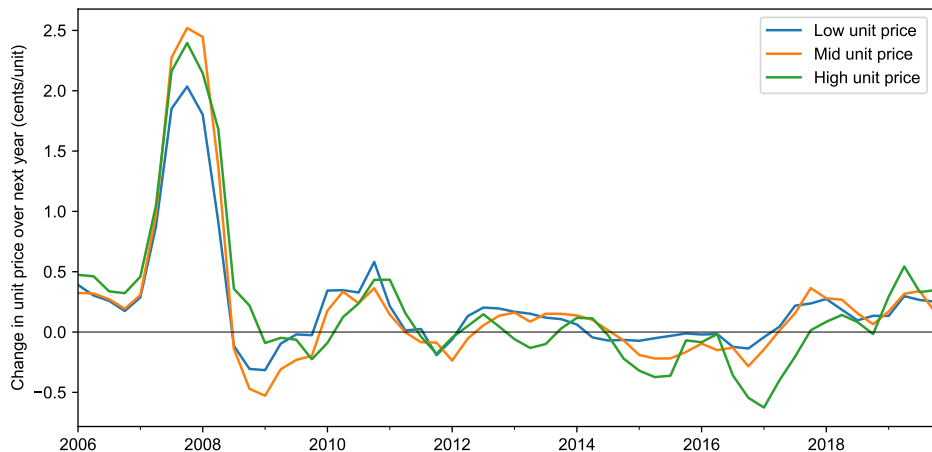# High-price products within category lower "log pass-through"

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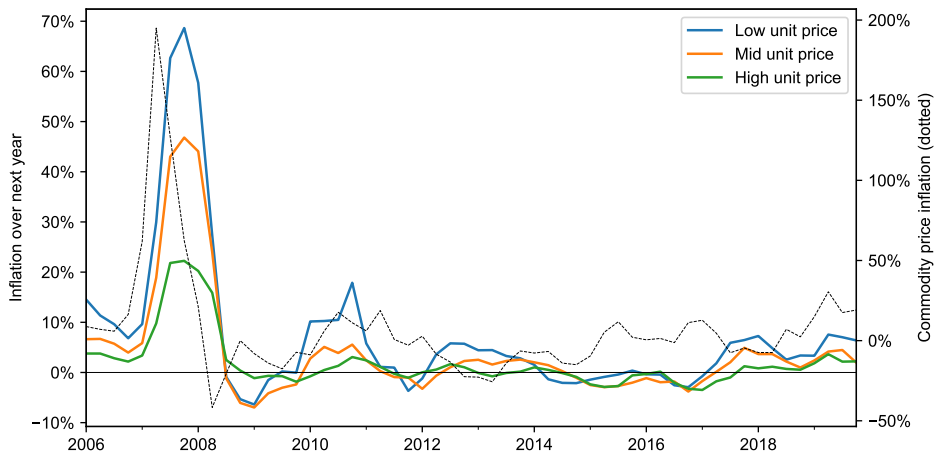
# Differences in pass-through disappear in absolute terms (levels)

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*

|  | $\Delta$ Retail price | | |
|  | Rice | Flour | Coffee |
|---|---|---|---|
| $\Delta$ Commodity Price $\times$ Mid Unit Price | 0.059 | 0.027 | $-0.069$ |
|  | (0.052) | (0.040) | (0.046) |
| $\Delta$ 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.
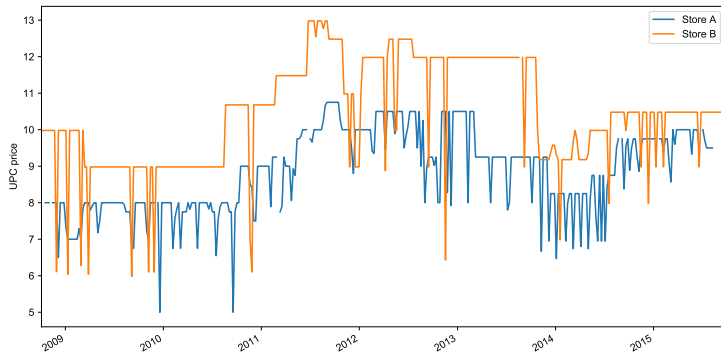
# Exploiting variation in markups across retailers: Predictions

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

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

- $\Delta p_{ikt}$ 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), $\beta^{\text{level}}$ | 1 | 0 |
| Logs specification (2), $\beta^{\text{log}}$ | 0 | -1 |

# Exploiting variation in markups across retailers

|  | $\Delta$ UPC Price ($\Delta p_{ikt}$) | | | |
|---|---|---|---|---|
|  | 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

| | $\Delta$ UPC Price ($\Delta p_{ikt}$) | | | | $\Delta$ Log UPC Price ($\Delta \log p_{ikt}$) | | | |
|---|---|---|---|---|---|---|---|---|
| | Rice (1) | Flour (2) | Coffee (3) | All (4) | Rice (5) | Flour (6) | Coffee (7) | All (8) |
| $\Delta \bar{p}_{kt} \times$ RelativePrice$_{ikt}$ | −0.022 (0.141) | 0.058 (0.209) | 0.192 (0.170) | −0.001 (0.839) | | | | |
| $\Delta \log \bar{p}_{kt} \times$ 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 $\rho^{\text{level}}$ 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

| Inputs: | $\Delta$ *Log Output Price$_t$* | | | | | |
|---|---|---|---|---|---|---|
| | Materials | | + Energy | | + Production Labor | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta$ 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) |
| $\Delta$ 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 |
| $N$ | 27381 | 27381 | 27381 | 27381 | 27381 | 27381 |
| $R^2$ | 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 $1, ..., 5$ years.

# Taking Stock of the Empirical Evidence

- Statistic: Long-run pass-through in levels of aggregate shock $\approx 1$.

- 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

- Pass-through in levels is a challenge for workhorse models with homothetic demand.

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

# Homothetic demand systems violate complete pass-through in levels

- Pass-through in levels is a challenge for workhorse models with homothetic demand.

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

- 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 $\forall j$,*

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

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

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## Departing from homothetic demand using discrete choice

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

- Mass $M$ of consumers indexed by $i \in [0, 1]$, each 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 $\delta_{ij}$.

# Departing from homothetic demand using discrete choice

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

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

- **Assumption 1.** Quantity consumed conditional on buying from $j$ is $q_{ij} = \bar{q}(Y/p_j)^{\eta}$.
    - Parameter $\eta$ is the "intensive margin elasticity" of consumption to price.
    - Note: Can micro-found if indirect utility is a Box-Cox transform (Anderson and de Palma 2020; Birchall et al. 2024): $u_{ij} = \delta_{ij} + [(Y^{1-\eta} - 1)/\bar{q} - (p_j^{1-\eta} - 1)]/(1 - \eta)$.

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

# Pass-through of aggregate shocks depends on $\eta$

## Proposition (Homothetic demand with $\eta = 1$)

*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 $\eta = 1$.*

*Thus, if $\eta = 1$ and all marginal costs increase by $d \log c_j = d \log c$, then $d \log p_j = d \log c$.*

- Intuition: Consumer choice depends on comparison of $\delta_{ij}/p_j$ across all $j$.

# Pass-through of aggregate shocks depends on $\eta$

### Proposition (Homothetic demand with $\eta = 1$)

*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 $\eta = 1$.*

*Thus, if $\eta = 1$ and all marginal costs increase by $d \log c_j = d \log c$, then $d \log p_j = d \log c$.*

- Intuition: Consumer choice depends on comparison of $\delta_{ij}/p_j$ across all $j$.

### Proposition (Pass-Through in Levels with $\eta = 0$)

*Suppose all marginal costs increase by $dc_j = dc$. If $\eta = 0$, then $dp_j = dc$.*

- Intuition: Consumer choice depends on comparison of $\delta_{ij} - p_j$ across all $j$.

- Examples of $\eta = 0$: nested/mixed logit (Verboven 1996; Nevo 2001), multinomial probit, competition on a line (Hotelling 1929) and unit circle (Salop 1979).

# Example: Symmetric Firms

### Proposition (Prices with symmetric firms)

*If firms are symmetric ($c_j = c$ for all $j$ and $\delta_{ij}$ 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 $\phi_0, \phi_1$ 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 $\eta = 0$.

  - Note: 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 $\eta$?

  - 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).

  - Evidence from quantities: Quantity-shares of low- vs. high-priced rice/flour/coffee products do not change in response to commodity cost changes.

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# 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.

# Macro Implications

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

   - When $\eta = 0$, log pass-through is (1) asymmetric, and (2) size-dependent.
   - Log pass-through declines with firm size or product quality if markups $\uparrow$ in both.

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

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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.

  Asymmetry: E.g., Peltzman (2000). Big vs. small: Cavallo et al. (2024), Gagliardone et al. (2025). Size: Berman et al. (2012), Amiti et al. (2019), Gupta (2020). Quality: Chen and Juvenal (2016), Auer et al. (2018).

- 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.

# Macro Implications

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

2. In industry model: Dynamics of industry gross margins, profits, and entry.
   - Under homothetic demand, input cost fluctuations should lead to fluctuations in entry/exit or operating profits. Neither appears in the data!
   - With $\eta = 0$, adjustment instead in gross margins: borne out in the data.

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.

# Industry model: Response of margins and entry to input cost changes

- Embed demand systems 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.
  - $\zeta$ is elasticity of entry to economic profits ($\zeta = 0$: fixed mass, $\zeta \to \infty$: free entry).

| *Response to cost increase, $dc > 0$* | | | Gross margins $dm^{\text{gross}}$ | Operating margins $dm^{\text{op}}$ | 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) | $< 0$ | $\leq 0$ | 0 |
| $\eta = 0$ | $\zeta \in (0, \infty)$ | | $< 0$ | $\leq 0$ | $\leq 0$ |
| $\eta = 0$ | $\zeta \to \infty$ | (Free entry) | $< 0$ | 0 | $\leq 0$ |

# Gross margins exhibit strong negative correlation with input costs
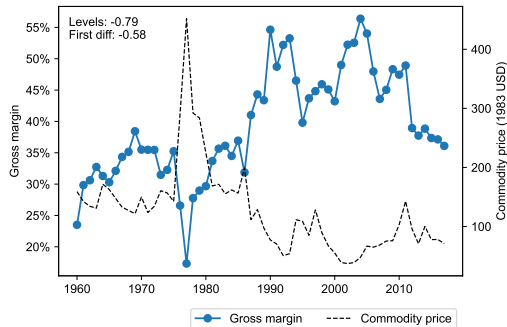


(a) Roasted coffee mfg vs. coffee.
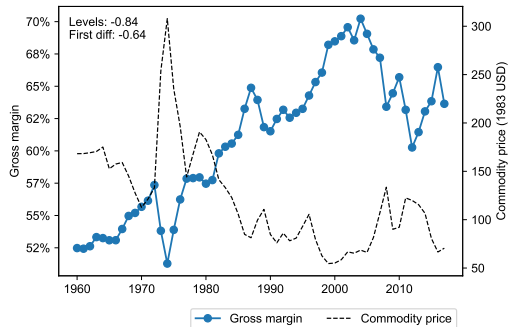


(b) Bread, cake & related products mfg vs. wheat.

- 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: | $\Delta$ *Log Gross Margin* | | $\Delta$ *Log Oper. Margin* | | $\Delta$ *Log Num. Estabs* | |
|---|---|---|---|---|---|---|
| | ARTS | IRS | ARTS | IRS | BDS | SUSB |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta$ 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* | $\Delta$ *Log Gross Margin* | | $\Delta$ *Log Oper. Margin* | | $\Delta$ *Log Num. Estabs* | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\Delta$ 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) |
| $\Delta$ Log Input Price$_t$ $\times$ 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 |

# 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).

   - If marginal consumption from labor-intensive sectors, wage pins down the numeraire.

   - Empirically, correcting for effect on numeraire restores equal pass-through in levels for labor, materials.

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

5. Fluctuations in inflation inequality over commodity cost cycle.

# 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 $\omega$, 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 $\omega$.

- 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 $\omega$: 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

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

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

# Revisiting Okun (1981): Empirical evidence

|  | $\Delta$ Log Output Price$_t$ | | |
|---|---|---|---|
|  | (1) Cost Shares | (2) Sales Shares | (3) Sales Shares |
| $\Delta$ Log Material Price$_t$ × Material Share$_{t-1}$ | 0.798** | 1.046** | 1.049** |
|  | (0.085) | (0.108) | (0.109) |
| $\Delta$ Log Energy Price$_t$ × Energy Share$_{t-1}$ | 0.715** | 0.859** | 0.997** |
|  | (0.271) | (0.378) | (0.362) |
| $\Delta$ Log Production Wage$_t$ × Labor Share$_{t-1}$ | 1.070** | 2.095** |  |
|  | (0.217) | (0.281) |  |
| $\Delta$ Log Production Wage$_t$ × (Labor + Variable Profits) Share$_{t-1}$ |  |  | 0.951** |
|  |  |  | (0.209) |
| Industry FEs | Yes | Yes | Yes |
| Year FEs | Yes | Yes | Yes |
| $N$ | 27 374 | 27 374 | 27 374 |
| $R^2$ | 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.

# Macro Implications

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

   - Given commodity price movements, standard BEA I-O model with Calvo frictions and CES ($\eta = 1$) implies too much volatility in consumer price inflation relative to data.

   - $\eta = 0$ reduces volatility of CPI inflation, while allowing for reasonable markups.

5. Fluctuations in inflation inequality over commodity cost cycle.

# 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.

- 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.

| | 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
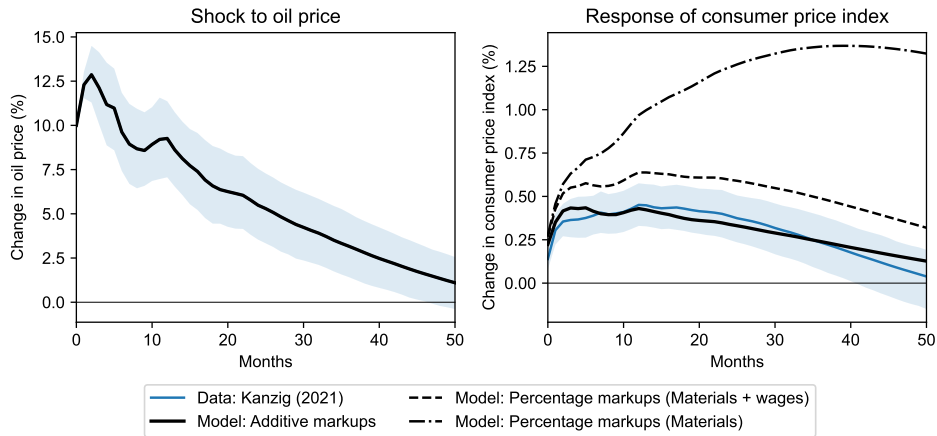


*Note:* Impulse responses to an oil supply news shock from Känzig (2021). The solid line is the point estimate and the shaded areas are 68 percent confidence bands. The changes in the oil price in the left panel are treated as exogenous changes in the oil price in the model. The model lines in the right 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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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.
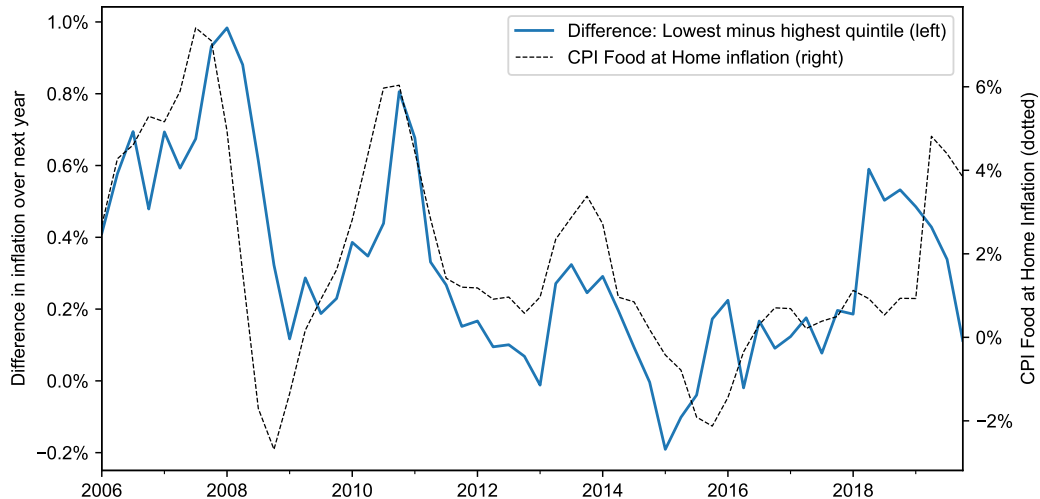
# Inflation inequality moves with commodity costs within category (e.g. coffee)

- **Coffee**: Same $\Delta p$ across products → higher % inflation for low-price products.
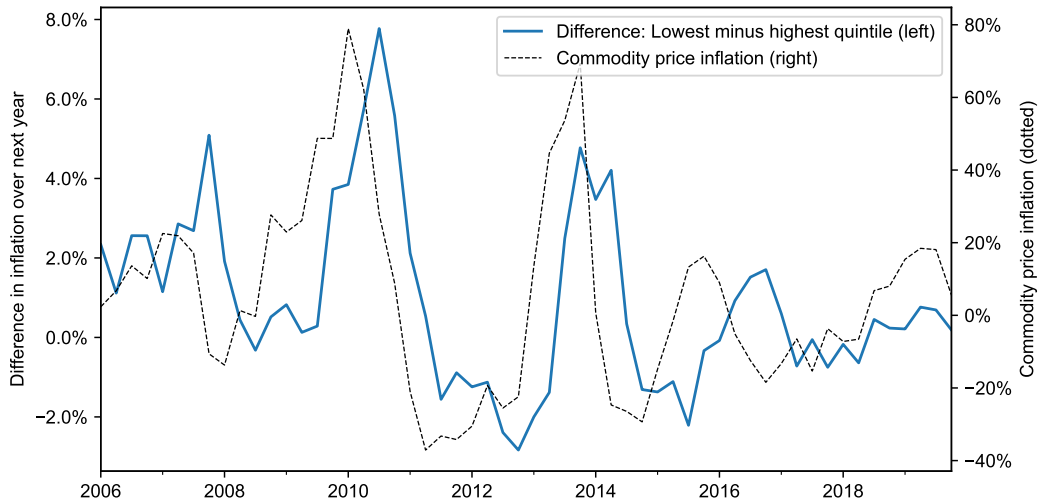
# Cycles in inflation inequality over entire food-at-home bundle

# 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).
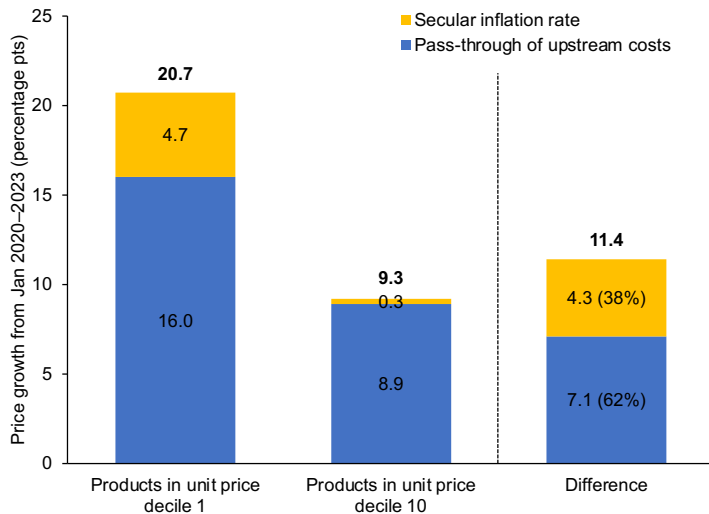
# Conclusion

- 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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# Pass-through in Atkeson and Burstein (2008) nested CES model
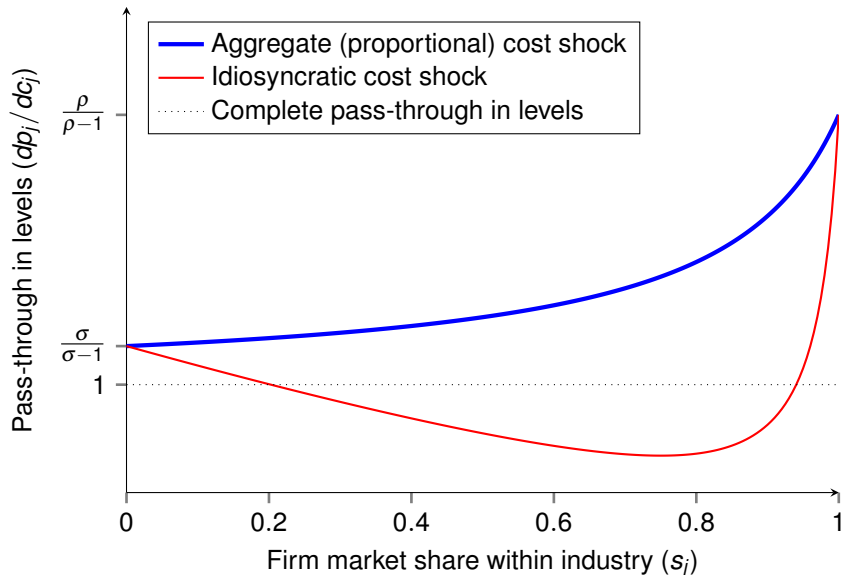
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# Station-level panel dataset of gas prices in Perth, Australia

- 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
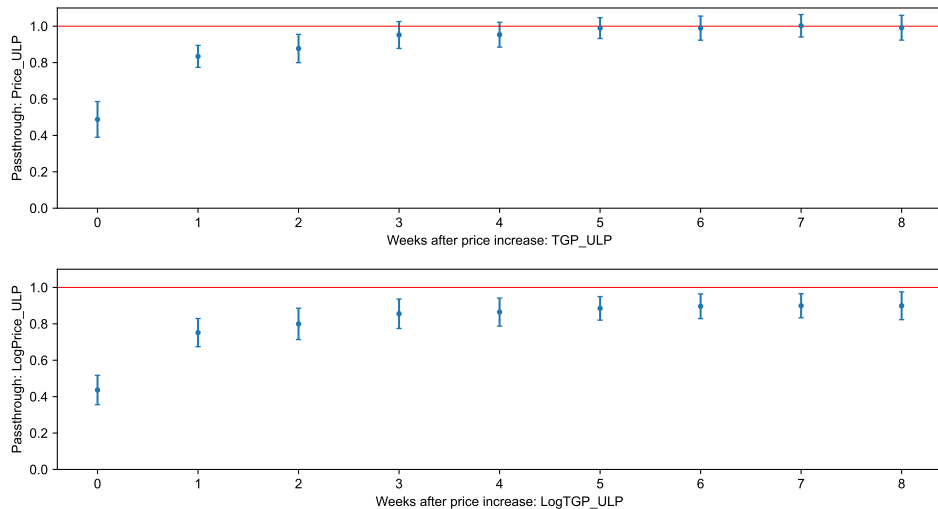


Figure: Passthrough in levels (top) and in logs (bottom). SEs two-way clustered by postcode $\times$ year.

## Summary of retail gasoline pass-through estimates

|  | Pass-through (8 weeks) | | | |
| Description | 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 $\text{AvgMarkup}_{it}$, with IVs to isolate markups.

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

# Exploiting variation in markups

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

# Exploiting variation in markups

| $\Delta$Price$_{it}$ | (1) (OLS) | (2) (OLS) | (3) (IV1) | (4) (OLS) | (5) (IV2) |
|---|---|---|---|---|---|
| $\Delta$Cost$_t$ | 0.950** | 0.989** | | | |
| | (0.021) | (0.037) | | | |
| $\Delta$Cost$_t \times$ Avg. Station Markup$_i$ (Net %) | | -0.005 | | | |
| | | (0.003) | | | |
| $\Delta$Cost$_t \times$ 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

| $\Delta$Price$_{it}$ | (1) (OLS) | (2) (OLS) | (3) (IV1) | (4) (OLS) | (5) (IV2) |
|---|---|---|---|---|---|
| $\Delta$Cost$_t$ | 0.950** | 0.989** | 0.952** | | |
| | (0.021) | (0.037) | (0.044) | | |
| $\Delta$Cost$_t \times$ Avg. Station Markup$_i$ (Net %) | | -0.005 | -0.000 | | |
| | | (0.003) | (0.005) | | |
| $\Delta$Cost$_t \times$ 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

| $\Delta\text{Price}_{it}$ | (1) (OLS) | (2) (OLS) | (3) (IV1) | (4) (OLS) | (5) (IV2) |
|---|---|---|---|---|---|
| $\Delta\text{Cost}_t$ | 0.950** | 0.989** | 0.952** | 0.987** | 0.971** |
| | (0.021) | (0.037) | (0.044) | (0.034) | (0.043) |
| $\Delta\text{Cost}_t \times$ Avg. Station Markup$_i$ (Net %) | | -0.005 | -0.000 | | |
| | | (0.003) | (0.005) | | |
| $\Delta\text{Cost}_t \times$ 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.

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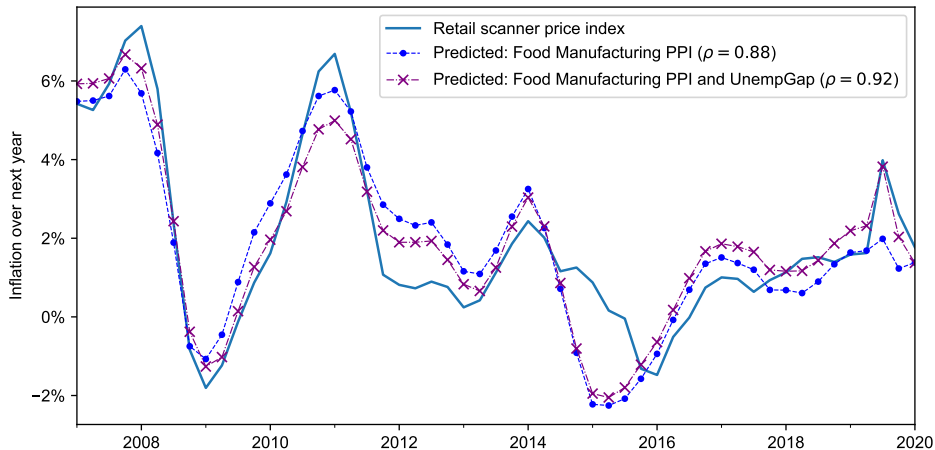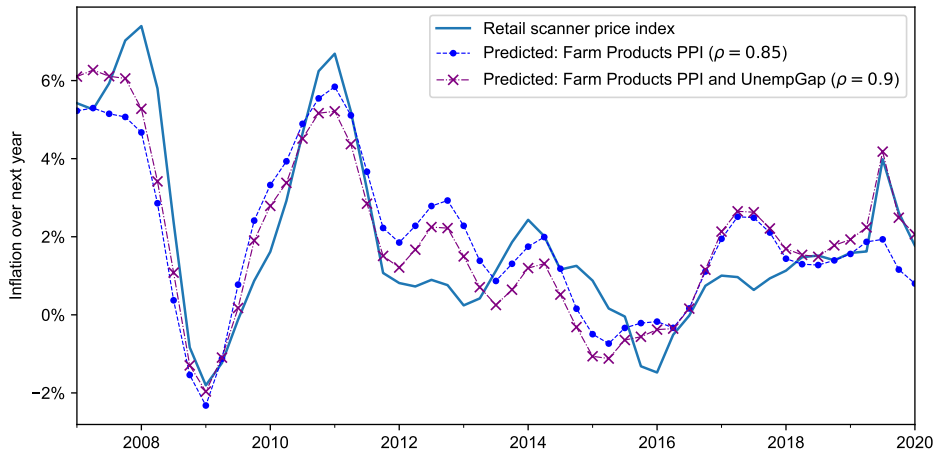
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# Backup: Upstream PPI explains food-at-home inflation well

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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