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., 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: Curvature of residual demand.

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  - When costs increase 10%, firms raise prices $<$10%.
  - Incomplete even at long horizons and after accounting for input cost share.
  - Prevailing explanation: Curvature of residual demand.
- Today: Measure pass-through on a dollars-and-cents basis.
- Result: Firms exhibit complete pass-through in levels.
  - For persistent, common shocks: $1/unit cost increase leads to $1/unit higher prices.
  - Explains incomplete “log pass-through” and variation across products/firms.
  - Pattern spans many markets (gas stations, food products, manufacturing industries).

Explaining Pass-Through in Levels

- Workhorse macro models predict pass-through in levels equals markup, $\mu > 1$.
  - For CES demand.
  - For any homothetic industry demand system given common cost shock.
    (E.g., Kimball 1995; Atkeson and Burstein 2008; HSA from Matsuyama and Ushchev 2022.)
  - Reason: These demand systems are **scale invariant**.

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    (E.g., Kimball 1995; Atkeson and Burstein 2008; HSA from Matsuyama and Ushchev 2022.)
  - Reason: These demand systems are **scale invariant**.

- Alternative: **shift invariant** demand systems that yield pass-through in levels.
  - Many demand systems familiar from IO literature.
    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: Why Switch to Shift Invariant Demand?

1. Asymmetry, size-dependence, and heterogeneity in "log pass-through."
2. In industry model: Dynamics of industry gross margins, profits, and entry.
3. In model with outside goods: 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), Minton and Wheaton (2022), Miravete et al. (2023).
  - In paper: Appendix Table A1 collects studies measuring pass-through in levels and logs.
  - Focus on long-run pass-through of industry-wide ("common") 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

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

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

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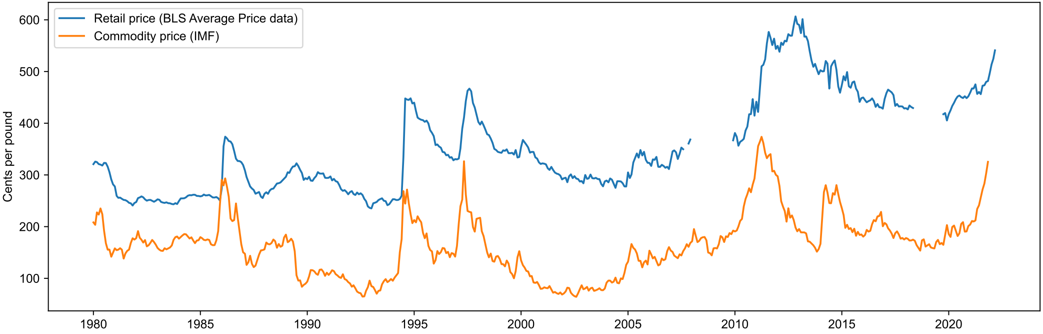
Pass-through for six staple food products

- 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 Δc to Δp and show that leads of Δc do not predict Δp).

Example: Pass-through of coffee commodity costs to CPI

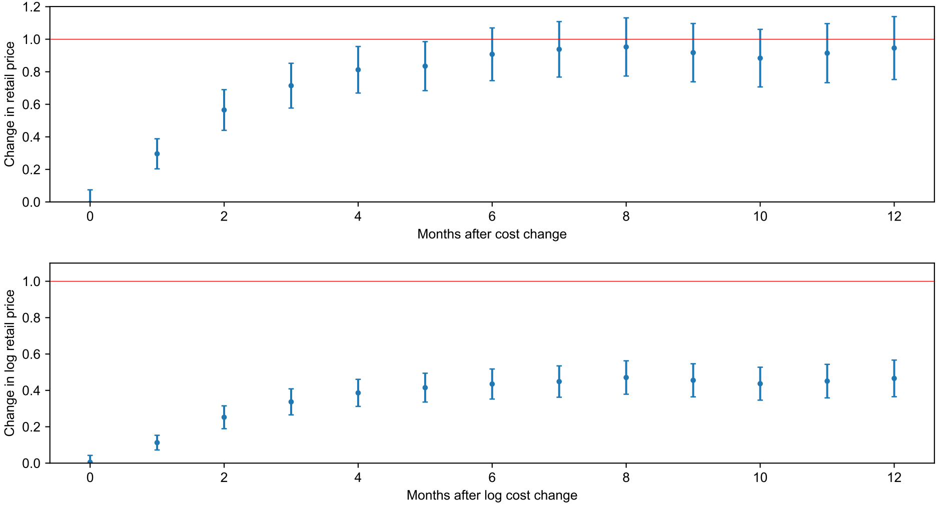


Figure: Passthrough in levels (top) and in logs (bottom).

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

		Pass-through (12 mos.)			
Commodity (IMF)	Final Good (BLS)	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)**

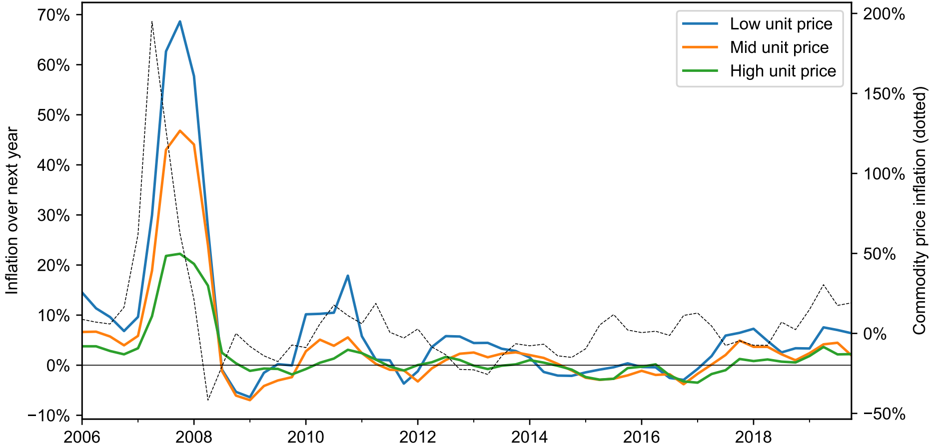
- Monthly commodity prices (IMF), retail prices (BLS Average Price Data), 1990–2020.
- Match units (e.g., lbs flour per bushel of wheat) using USDA conversion tables.
- **Cannot reject complete pass-through in levels for 5 of 6.** (Reject in logs for all.)

Exploiting cross-sectional variation

- Complete pass-through in levels across different products.
- Explains heterogeneity in log pass-through across products (UPCs):
  - High-priced products in rice/coffee/flour have lower “log pass-through.”
  - Explained by same pass-through in levels across products.
- Explains heterogeneity in log pass-through across retailers selling same UPC:
  - Retailers selling same UPC at higher price have lower “log pass-through.”
  - Explained by same pass-through in levels across all retailers.
  - Holds for universe of food products in NielsenIQ data (1M UPCs across 200 retail chains).

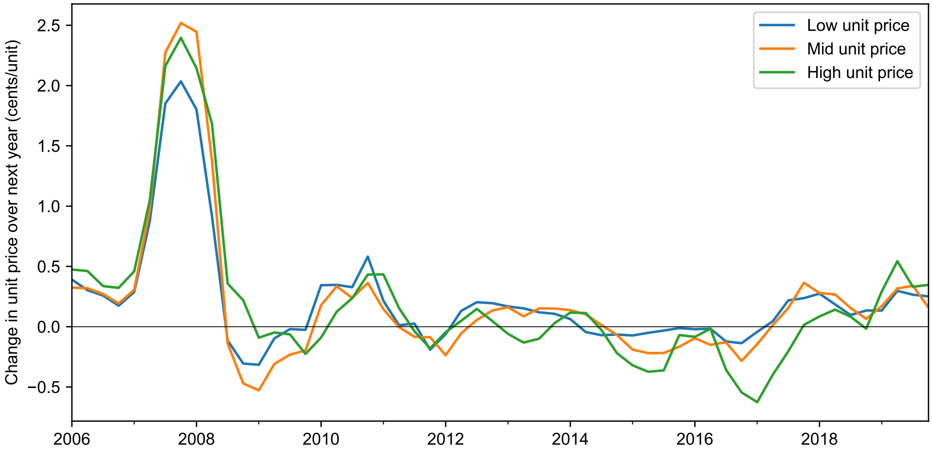
High-price products within category lower “log pass-through”

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 × Mid Unit Price	−0.075**	−0.007	−0.064**
	(0.014)	(0.009)	(0.015)
Commodity Inflation × 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

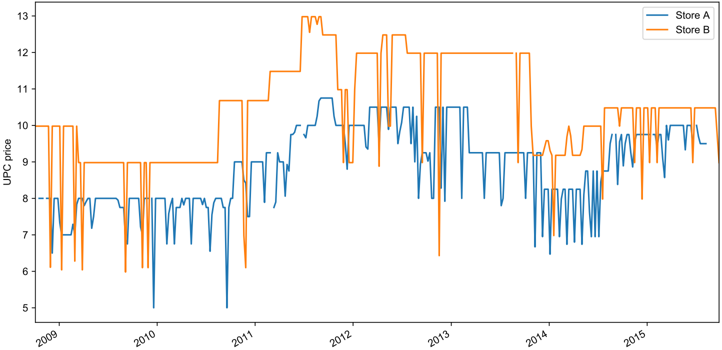
	Δ Retail price		
	Rice	Flour	Coffee
Δ Commodity Price $\times$ Mid Unit Price	0.059	0.027	-0.069
	(0.052)	(0.040)	(0.046)
Δ Commodity Price $\times$ High Unit Price	0.042	-0.067	-0.099*
	(0.100)	(0.044)	(0.058)
UPC FEs	Yes	Yes	Yes
N (thousands)	399.4	101.4	1570.0
R^2	0.07	0.05	0.14

- 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

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

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

- 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	Flour	Coffee	All
	(1)	(2)	(3)	(4)
$\Delta \bar{p}_{kt} \times \text{RelativePrice}_{ikt}$	-0.022	0.058	0.192	-0.001
	(0.141)	(0.209)	(0.170)	(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	Flour	Coffee	All	Rice	Flour	Coffee	All
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta \bar{p}_{kt} \times \text{RelativePrice}_{ikt}$	-0.022	0.058	0.192	-0.001				
	(0.141)	(0.209)	(0.170)	(0.839)				
$\Delta \log \bar{p}_{kt} \times \text{RelativePrice}_{ikt}$					-1.004^{**}	-1.014^{**}	-1.261^{**}	-1.043^{**}
					(0.125)	(0.184)	(0.084)	(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. ($\beta^{\log} \approx -1$.)
- 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

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

- 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)
$(\text{InputCost}/\text{Sales})_{t-1}$		0.004		0.008		0.023**
		(0.011)		(0.011)		(0.011)
Δ Log Input Price$_t$ $\times$ $(\text{InputCost}/\text{Sales})_{t-1}$		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 common cost 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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Perfect Competition?

- One candidate explanation for pass-through in levels is perfect competition.
  - Gross markup $\mu = 1$, so both complete pass-through in both levels and logs.
- However, perfect competition at odds with other features of the data.
  - Substantial price dispersion for identical products.
  - Sluggish price adjustment.
  - Finite firm-level demand elasticities.
  - Firms' prices elevated over available measures of cost.
- Can we reconcile price *dynamics* that resemble perfect competition with price *levels* that don't?

Environment

- Set of goods partitioned into $J \geq 1$ *inside* goods and $K \geq 0$ *outside* goods.
- Prices for inside goods $\boldsymbol{p} = (p_1, ..., p_J)$. Outside goods vector $\boldsymbol{p}_0$.
- $D(\boldsymbol{p}, \boldsymbol{p}_0, Y)$ gives quantities demanded as function of prices, income Y.
- Each inside good produced with constant marginal cost c_j.

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- $D(\boldsymbol{p}, \boldsymbol{p}_0, Y)$ gives quantities demanded as function of prices, income Y.
- Each inside good produced with constant marginal cost c_j.
- **Assumption 1** (Nash-in-prices). For each $j \in \{1, ..., J\}$, price p_j set to maximize firm j's profits, taking all other prices and demand system D as given.
- **Assumption 2.** Given outside prices $\boldsymbol{p}_0$, income Y, and marginal costs $\boldsymbol{c}$, (1) an equilibrium exists (2) in which $\partial \log D_j / \partial \log p_j \in (-\infty, 0)$ for all j.

Sufficient Conditions For Pass-Through

- $D(\boldsymbol{p}, \boldsymbol{p}_0, Y)$ is scale invariant in $\boldsymbol{p}$ if there exists functions $\varphi_1, ..., \varphi_J$ s.t. for any $\lambda > 0$,

$$D_j(\lambda \boldsymbol{p}, \boldsymbol{p}_0, Y) = \lambda^{\varphi_j(\boldsymbol{p}, \boldsymbol{p}_0, Y, \lambda)} D_j(\lambda \boldsymbol{p}, \boldsymbol{p}_0, Y), \qquad \forall j.$$

  and $\partial \varphi_j / \partial p_j = 0$ for all j.

- $D(\boldsymbol{p}, \boldsymbol{p}_0, Y)$ is shift invariant in $\boldsymbol{p}$ if there exists functions $\psi_1, ..., \psi_J$ s.t. for any λ,

$$D_j(\boldsymbol{p} + \lambda, \boldsymbol{p}_0, Y) = (1 + \lambda \psi_j(\boldsymbol{p}, \boldsymbol{p}_0, Y, \lambda))\, D_j(\lambda \boldsymbol{p}, \boldsymbol{p}_0, Y), \qquad \forall j.$$

  and $\partial \psi_j / \partial p_j = 0$ for all j.

Sufficient Conditions For Pass-Through

Proposition (Complete log pass-through)

Consider a shock that increases marginal costs by $d\log c_j = d\log c$ *for all* $j \in \{1, ..., J\}$*, holding fixed* $\boldsymbol{p}_0$ *and* Y*. If demand is scale invariant in* $\boldsymbol{p}$*, then* $d\log p_j = d\log c$ *for all* j*.*

Proposition (Complete pass-through in levels)

Consider a shock that increases marginal costs by $dc_j = dc$ *for all* $j \in \{1, ..., J\}$*, holding fixed* $\boldsymbol{p}_0$ *and* Y*. If demand is shift invariant in* $\boldsymbol{p}$*, then* $dp_j = dc$ *for all* j*.*

Sufficient Conditions For Pass-Through

Proposition (Complete log pass-through)

Consider a shock that increases marginal costs by $d\log c_j = d\log c$ for all $j \in \{1, ..., J\}$, holding fixed $\boldsymbol{p}_0$ and Y. If demand is scale invariant in $\boldsymbol{p}$, then $d\log p_j = d\log c$ for all j.

Proposition (Complete pass-through in levels)

Consider a shock that increases marginal costs by $dc_j = dc$ for all $j \in \{1, ..., J\}$, holding fixed $\boldsymbol{p}_0$ and Y. If demand is shift invariant in $\boldsymbol{p}$, then $dp_j = dc$ for all j.

Proposition (Disjoint properties)

*If $D(\boldsymbol{p}, \boldsymbol{p}_0, Y)$ is scale invariant in $\boldsymbol{p}$, it is **not** shift invariant in $\boldsymbol{p}$, and vice versa.*

Scale Invariant Demand: Examples

Example (Homothetic preferences)

Suppose a representative consumer solves

$$\max_{\boldsymbol{q}} U(q_1, ..., q_J) \qquad \text{s.t.} \qquad \boldsymbol{p}'\boldsymbol{q} = Y.$$

If U is homothetic, then $\boldsymbol{q} = D(\boldsymbol{p}, \boldsymbol{p}_0, Y)$, where D is scale invariant in $\boldsymbol{p}$, with $\boldsymbol{p}_0 = \emptyset$ and $\varphi_j = -1$ for all j.

- E.g., CES, Kimball, HSA demand.
- Incomplete pass-through of firm-specific shocks, but complete log pass-through of common shocks.

Scale Invariant Demand: Examples

Example (Nested homothetic preferences)

Suppose a continuum of industries $n \in [0,1]$, each with J firms. Rep. consumer maximizes

$$U = \left(\int_0^1 Q_n^{\frac{\sigma-1}{\sigma}} dn \right)^{\frac{\sigma}{\sigma-1}} \qquad \text{s.t.} \qquad \int_0^1 \sum_j p_{nj} q_{nj} dn = Y.$$

where $Q_n = Q_n(q_{n1}, ..., q_{nJ})$ is a homothetic aggregate over firms in industry n.

For each industry n, $\boldsymbol{q_n} = D(\boldsymbol{p}, \boldsymbol{p}_0, Y)$, where D is scale invariant in $\boldsymbol{p} = (p_{n1}, ..., p_{nJ})$, with $\varphi_j = -\sigma$ for all j.

- E.g., nested CES (Atkeson and Burstein 2008), nested Kimball (Amiti et al. 2019).
- Complete log pass-through of industry-wide shocks.

Shift Invariant Demand: Examples

- If these demand systems are not consistent with pass-through in levels, which are?
- Answer: Quite a few shift invariant demand systems!

Shift Invariant Demand: Examples

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- Answer: Quite a few shift invariant demand systems!

Example (Log-linear demand)

Suppose the demand for good j follows

$$D_j(p_j, \boldsymbol{p}_0, Y) = \exp\left(a_j(\boldsymbol{p}_0, Y) - b_j(\boldsymbol{p}_0, Y)p_j\right).$$

Then D is shift invariant in p_j with $\psi_j = \left(\exp(-b_j\lambda) - 1\right)/\lambda$.

- Log-linear demand curves lead to pass-through in levels of firm-specific shocks.

  See e.g., Bulow and Pfleiderer (1983), Weyl and Fabinger (2013), Mrázová and Neary (2017).

Shift Invariant Demand: Examples

Example (Discrete choice with quasilinear preferences)

Suppose unit mass of consumers $i \in [0,1]$, each with income Y. Chooses one firm $j \in \{1, ..., J\}$

$$U_i = \max_j \{u_{ij}\} \qquad \text{s.t.} \qquad \begin{cases} u_{ij} = \delta_{ij} + q_{i0}, \\ p_j + p_0 q_{i0} = Y. \end{cases}$$

Demand system $D(\boldsymbol{p}, p_0, Y)$ from aggregating over all i is shift invariant in $\boldsymbol{p}$ with $\psi_j = 0$.

- E.g., logit, nested logit, mixed logit (Nevo 2001), multinomial probit.
- “Address models” like competition on a line (Hotelling 1929), unit circle (Salop 1979).

Takeaway: Class of Alternative Demand Systems Consistent with Evidence

- Large class of demand systems (but not homothetic demand) can match pass-through.
- Integrating these demand systems into workhorse models can explain other patterns.
- **Neutrality.**
  - Any Marshallian demand system must obey $D(\lambda \boldsymbol{p}, \lambda \boldsymbol{p}_0, \lambda Y) = D(\boldsymbol{p}, \boldsymbol{p}_0, Y)$.
  - Can also impose $D(\lambda \boldsymbol{p}, \lambda \boldsymbol{p}_0, Y) = D(\boldsymbol{p}, \boldsymbol{p}_0, Y)$ (not inconsistent with shift invariance).
- **Evidence on quantities.**
  - Homothetic demand predicts reallocation away from products with larger $\Delta \log p$.
  - Test using quantity shares of low vs. high-priced rice / flour / coffee.
  - No quantity response or if anything trading down.

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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 model with outside goods: 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."
   - Shift invariant demand $\Rightarrow$ log pass-through is asymmetric and 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.
3. In model with outside goods: Pass-through of labor vs. material costs. (Okun 1981).
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Asymmetry, size-dependence, and heterogeneity

- Suppose $D(\boldsymbol{p}, \boldsymbol{p}_0, Y)$ is shift invariant, and denote initial markup $\mu_j = p_j / c_j$.
  In response to common cost shock dc,

$$\rho_j^{\log} = \frac{\Delta \log p}{\Delta \log c} \approx \frac{1}{\mu_j} \left(1 + \frac{1}{2} \frac{\mu_j - 1}{\mu_j} \Delta \log c_j \right).$$

  - **Asymmetry**: Positive shocks appear to have higher pass-through:
    $\rho^{\log}(\Delta \log c) > \rho^{\log}(-\Delta \log c)$.
    E.g., Peltzman (2000)

  - **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 $\Delta \log c_H > \Delta \log c_L$.
    Cavallo et al. (2024), Gagliardone et al. (2025).

  - **Heterogeneity**: If markups increase with firm size / quality, $\rho^{\log}$ falls with both.
    Size: Amiti et al. (2019), Gupta (2020). Quality: Chen and Juvenal (2016), Auer et al. (2018).

Macro Implications

1. Asymmetry, size-dependence, and heterogeneity in "log pass-through."
2. In industry model: Dynamics of industry gross margins, profits, and entry.
   - Scale invariant demand $\Rightarrow$ input cost fluctuations should lead to fluctuations in entry/exit or operating profits. Neither appears in the data!
   - Shift invariant demand $\Rightarrow$ adjustment instead in gross margins.
3. In model with outside goods: Pass-through of labor vs. material costs. (Okun 1981).
4. In input-output model: Low volatility of consumer inflation relative to commodity prices.
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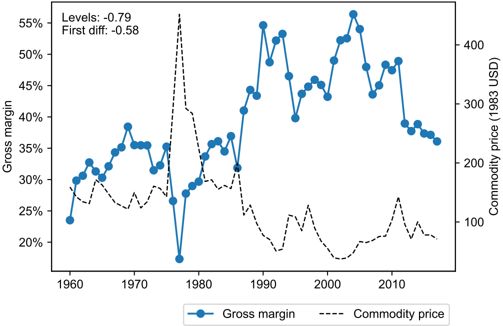
Industry model: Response of margins and entry to input cost changes

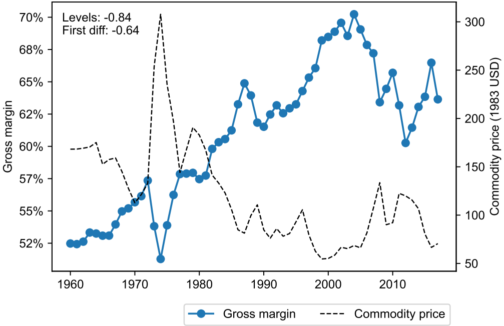
- Embed demand systems in standard monopolistic competition setup.
  - Mass N of symmetric firms, marginal cost c. Fixed entry cost f_e. Overhead cost f_o.
  - Aggregate industry demand inelastic, $Q = p^{-\theta}$, with $\theta < 1$.
  - Gross and operating margins = variable / operating profits as % of sales.
  - 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}	Oper. margins dm^{op}	Mass of firms $d \log N$
Scale invariant	$\zeta = 0$	(Fixed mass)	0	> 0	0
	$\zeta \in (0, \infty)$		0	> 0	> 0
	$\zeta \to \infty$	(Free entry)	0	0	> 0
Shift invariant	$\zeta = 0$	(Fixed mass)	< 0	≤ 0	0
	$\zeta \in (0, \infty)$		< 0	≤ 0	≤ 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 with scale invariant demand, gross margins are not constant.
- Exhibit strong negative correlation with commodity input prices.

Shift invariant demand explains dynamics of gross, oper. margins, entry

Panel A: Retail Gasoline	Δ *Log Gross Margin*		Δ *Log Oper. Margin*		Δ *Log Num. Estabs*	
Source:	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$_t$ $\times$ 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	27381	27381	27305	27305	18201	18201
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 model with outside goods: Pass-through of labor vs. material costs. (Okun 1981).
   - Additive markups under shift invariance can be set relative to outside goods.
   - Empirically, can explain pass-through in levels of labor, materials costs.
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 differential pass-through

- J identical inside firms that produce using materials and labor, with cost

$$C(y) = (\beta c + (1-\beta)w)\,y.$$

- Outside good produced from labor by competitive firms, so that $p_0 = w/A_0$.

- Suppose demand shift invariant in $\boldsymbol{p}$, and further $D(\lambda \boldsymbol{p}, \lambda p_0, Y) = D(\boldsymbol{p}, p_0, Y)$.

Stylized multi-sector model with differential pass-through

- J identical inside firms that produce using materials and labor, with cost

$$C(y) = (\beta c + (1-\beta)w)\,y.$$

- Outside good produced from labor by competitive firms, so that $p_0 = w/A_0$.

- Suppose demand shift invariant in $\boldsymbol{p}$, and further $D(\lambda \boldsymbol{p}, \lambda p_0, Y) = D(\boldsymbol{p}, p_0, Y)$. Then:
  - Complete pass-through in levels of materials costs, $\rho_c^{\text{level}} = 1$, $\rho_c^{\log} < 1$.
  - Complete log pass-through of labor costs, $\rho_c^{\text{level}} \geq \mu$, $\rho_c^{\log} \geq 1$.
  - "Adjusted pass-through in levels" of labor costs $\rho_w^{\text{adj}} = 1$, where

$$\frac{d\log p}{d\log w} = \rho_w^{\text{adj}} \frac{\text{LaborCosts} + \text{VariableProfits}}{py}.$$

- Intuition: Additive markup set relative to outside good, and hence wage.

Revisiting Okun (1981): Empirical evidence

	Δ Log Output Price$_t$		
	(1)	(2)	(3)
	Cost Shares	Sales Shares	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	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

	Δ Log Output Price$_t$		
	(1)	(2)	(3)
	Cost Shares	Sales Shares	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.

Macro Implications

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3. In model with outside goods: Pass-through of labor vs. material costs. (Okun 1981).
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 implies too much volatility in consumer price inflation relative to data.
   - Shift invariance 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 CES demand 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%		
Scale invariant, 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 CES demand compared to the data.
- Reduce volatility by assuming more costs variable. But need low markups.

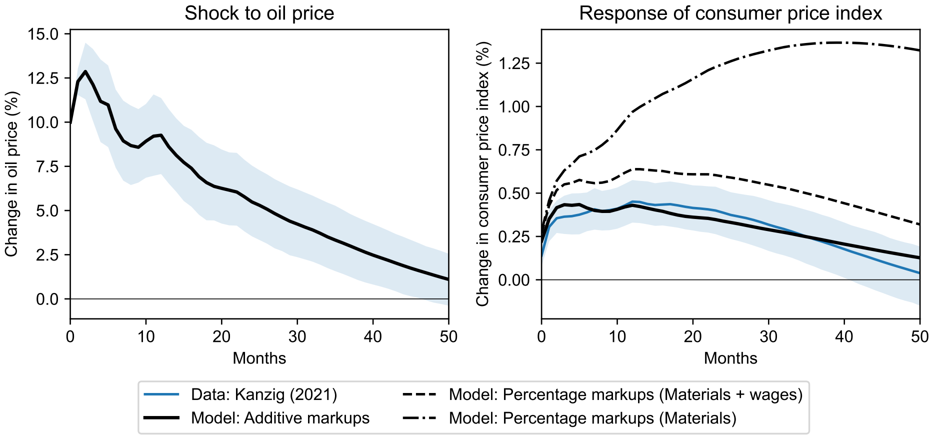
	Std. deviation of annual inflation, 1982–2018	Cost-weighted average markup	
		Mfg.	All
Personal Consumption Expenditures (PCE) Price Index	1.1%		
Consumer Price Index for All Urban Consumers	1.3%		
Scale invariant, Variable costs (VC) $=$ Materials	2.5%	1.48	2.19
Scale invariant, VC $=$ Materials $+$ wages	1.7%	1.19	1.31
Scale invariant, VC $=$ Materials $+$ wages $+$ cons. 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 CES demand compared to the data.
- Reduce volatility by assuming more costs variable. But need low markups.
- Additive markups 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%		
Scale invariant, Variable costs (VC) $=$ Materials	2.5%	1.48	2.19
Scale invariant, VC $=$ Materials $+$ wages	1.7%	1.19	1.31
Scale invariant, VC $=$ Materials $+$ wages $+$ cons. of fixed capital	1.6%	1.11	1.17
Shift invariant, 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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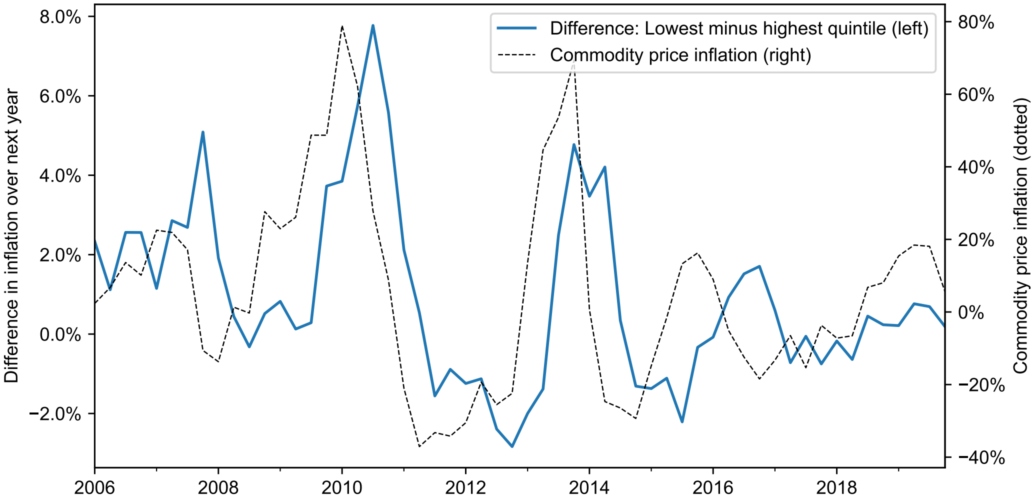
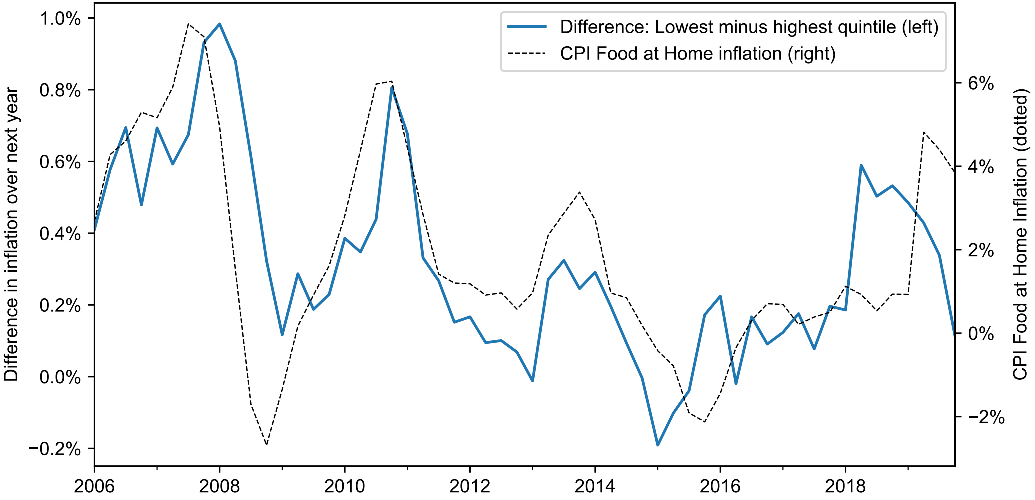
4. In input-output model: Low volatility of consumer inflation relative to commodity prices.
5. Fluctuations in inflation inequality over commodity cost cycle.
    - Explains “cheapflation” during recent inflation without price gouging / excess demand.
    - Absent this channel, inflation inequality from 2020–2023 would have been 1/3 as large.

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

- **Coffee**: Same Δp across products $\rightarrow$ higher % inflation for low-price products.

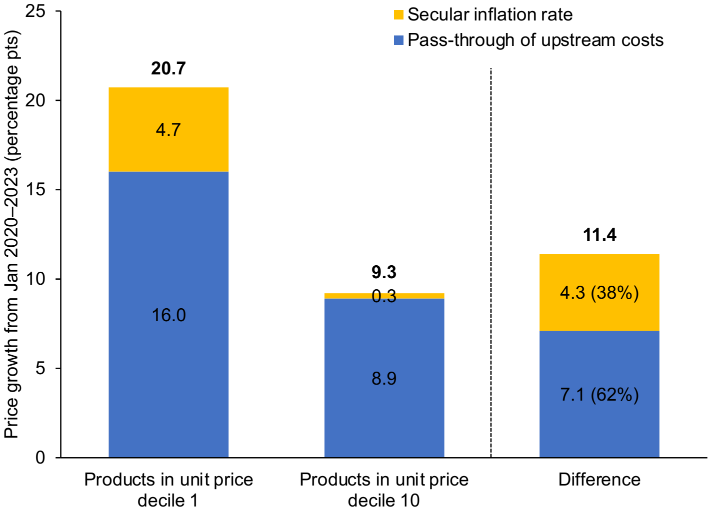


Cycles in inflation inequality over entire food-at-home bundle



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 common cost shocks is complete in *levels*.
- Not consistent with homothetic demand in workhorse models.
- Shift invariant demand systems 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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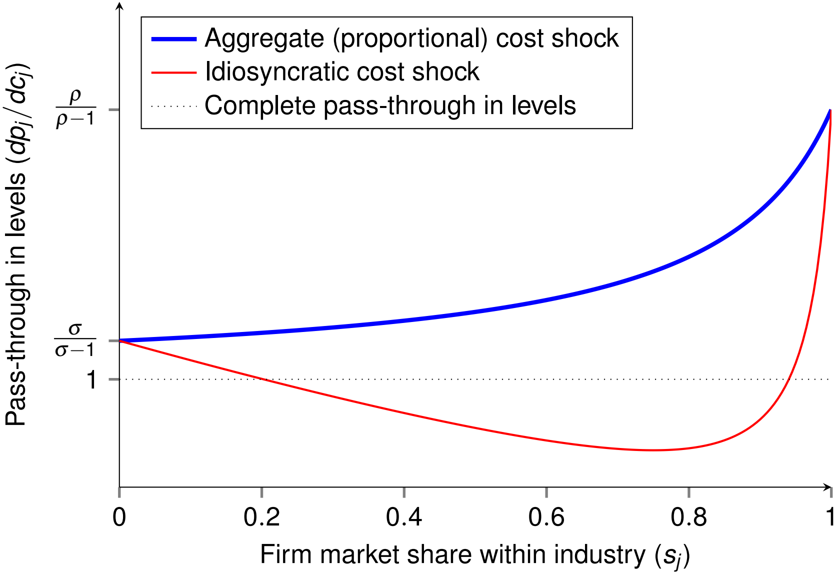
Pass-through in Atkeson and Burstein (2008) nested CES model



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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

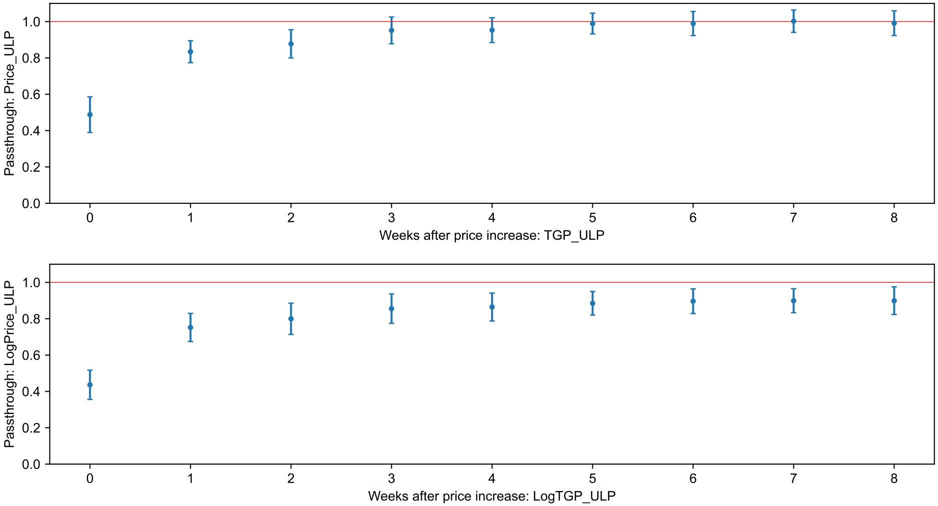

Figure: Passthrough in levels (top) and in logs (bottom). SEs two-way clustered by postcode × year.

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)				
$\Delta\text{Cost}_t \times$ Avg. Station Markup$_i$ (Net %)					
$\Delta\text{Cost}_t \times$ 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)			
$\Delta\text{Cost}_t \times$ Avg. Station Markup_i (Net %)		-0.005			
		(0.003)			
$\Delta\text{Cost}_t \times$ 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

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)
$\Delta \text{Cost}_t \times$ 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$_{i,t} \rightarrow 0$.

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) (1)	(2)	Premium (PULP) (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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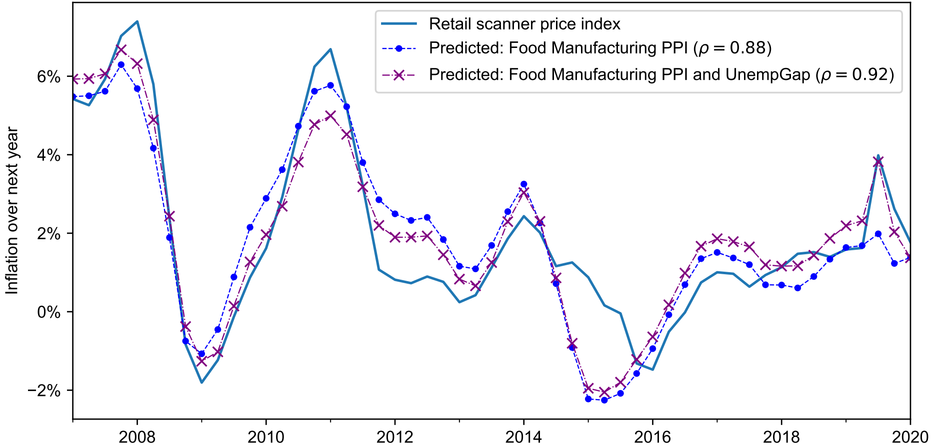
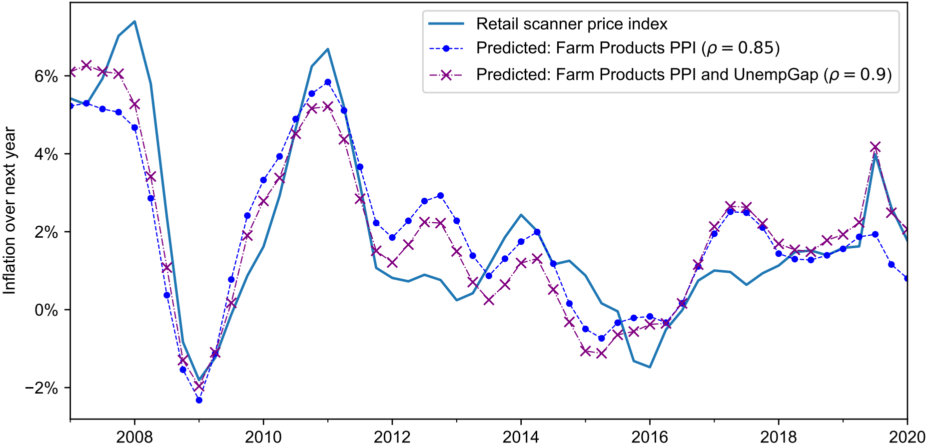
Backup: Upstream PPI explains food-at-home inflation well

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 Total	Matched to UPC With infl.	Matched to retailer-UPC Total	Matched to retailer-UPC 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.

	Food Manufacturing PPI		Farm Products PPI	
Index	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.

	Food Manufacturing PPI		Farm Products PPI	
Index	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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