Decomposing the (In)Sensitivity of CPI to Exchange Rates

Marco Errico

Introduction

- The response of domestic prices to fluctuations in exchange rates matters for:
  - Monetary and exchange rate policy; Cross-border shocks transmission.
    Corsetti et al. (2008), Benigno & Benigno (2003), Corsetti et al. (2010)
  - Redistribution and inequality dynamics, Jaravel (2021), Cravino & Levchenko (2017)

Introduction

- The response of domestic prices to fluctuations in exchange rates matters.
- Stylized fact: **low CPI sensitivity**, $\Delta e = 1\% \rightarrow \Delta CPI \approx 0.05\% - 0.1\%$.

  Campa & Goldberg (2010), Gopinath (2015)

Introduction

- The response of domestic prices to fluctuations in exchange rates matters.
- Stylized fact: low CPI sensitivity, $\Delta e = 1\% \rightarrow \Delta CPI \approx 0.05\% - 0.1\%$.
- Natural candidates: low pass-through into border price and import exposure.

$$\underbrace{\Delta e = 1\% \rightarrow \Delta p^{border} \approx 0.75\%}_{\text{Incomplete Pass-Through into Border Prices}} \quad \& \quad \underbrace{\Delta p^{border} \rightarrow \Delta CPI}_{\text{Import Exposure} \approx 20\% - 30\%}$$

Introduction

- The response of domestic prices to fluctuations in exchange rates matters.
- Stylized fact: low CPI sensitivity, $\Delta e = 1\% \rightarrow \Delta CPI \approx 0.05\% - 0.1\%$.
- Majority of literature focus on pass-through into border price and import exposure.

$$\underbrace{\Delta e = 1\% \rightarrow \Delta p^{border} \approx 0.75\%}_{\text{Incomplete Pass-Through into Border Prices}} \quad \& \quad \underbrace{\Delta p^{border} \rightarrow \Delta CPI}_{\text{Import Exposure} \approx 20\% - 30\%}$$

- Back-of-the-envelope-calculations: implied CPI sensitivity $\times \mathbf{3}$ than estimated.

$$\Delta CPI \approx \text{Import Exposure} \times \Delta p^{border} \approx 0.15\% - 0.3\%$$

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- Majority of literature focus on pass-through into border price and import exposure.

$$\underbrace{\Delta e \rightarrow \Delta p^{border}}_{\substack{\text{Incomplete} \\ \text{Pass-Through}}} \quad \& \quad \underbrace{\Delta p^{border} \rightarrow \Delta CPI}_{\substack{\text{Import Exposure} \\ \text{Domestic Frictions}}}$$

- This paper: role of **domestic frictions** for the (in)sensitivity of CPI.
  - Domestic frictions: variable markups, nominal rigidities, and distribution costs.
  - Insensitivity vs Sensitivity.

This Paper

- Pricing model of domestic CPI. Campa & Goldberg (2010)
  - Unified framework to connect exchange rate, frictions and border price dynamics.
  - Derive a **measurement equation** for the exchange rate pass-through into CPI.

$$\Delta CPI = (I - \underbrace{\Phi}_{\text{Distribution}} \underbrace{\Delta}_{\text{Nominal}} \underbrace{\Gamma}_{\text{Markup}} S_d)^{-1} \underbrace{S_m}_{\text{Import Exposure}} \Delta p^{border}$$

- Discipline at product level using detailed micro data.
  - Input-output tables → IO network, distribution costs, consumption shares.
  - Balance-sheet data → PF estimation and markup elasticity.
  - Import transaction data → Incomplete and heterogeneous ERPT into border prices.

  Model matches the (*untargeted*) estimated CPI sensitivity.

What curbs/drives the response of domestic prices?

1. 60% of insensitivity due to domestic frictions.
   - Focus on incomplete border pass-through largely overestimates CPI sensitivity.
   - All mechanisms are individually relevant, reduce sensitivity by 20% - 35%.
2. 75% of CPI sensitivity due to imported final goods:
   - Conflicting with previous literature, abstracting from frictions. Campa & Goldberg (2010)
   - Heterogeneity: Composition + Identity.

→ Optimal monetary policy and inflation targeting; Redistribution dynamics.

Roadmap

Measuring Pass-Through into Domestic Prices

Calibration and Estimation

Results

Model Overview

- Pricing model of domestic CPI.

  Campa and Goldberg (2010)

- Key features:
  1. Domestic frictions for exchange rate transmission into CPI.
     - Distribution margin: retail prices include marketing/service costs;
     - Variable markups: adjust markups instead of prices;
     - Nominal rigidities: possibility to adjust prices;
  2. Natural candidate: import exposure and border prices dynamics.
     - Direct + indirect import exposure: sparse network + spillover/amplification;
     - Incomplete ERPT into border prices + heterogeneity.
  3. Static, partial equilibrium setting.
     - Short-run view: firms take as given wages and sectoral prices, no GE effects.

Model Overview

- Unit-elastic consumption bundle over domestic and imported sectoral goods.

$$\eta^{P,e} = \boldsymbol{\beta} \times \boldsymbol{\eta}^{\mathbf{p},e} = \underbrace{\boldsymbol{\beta}^{D} \times \boldsymbol{\eta}^{\mathbf{p}^{D},e}}_{\text{Indirect exposure}} + \underbrace{\boldsymbol{\beta}^{F} \times \boldsymbol{\eta}^{\mathbf{p}^{F},e}}_{\text{Direct exposure}}.$$

Model Overview

- Unit-elastic consumption bundle over domestic and imported sectoral goods.
- Domestic sectoral goods aggregate sectoral varieties and distribution costs.
  1. Varieties produced by monopolistically symmetric competitive firms.
     Domestic + imported intermediate inputs, together with labor. Variable markups + Calvo.

$$\widetilde{p_i} = \mu_i mc_i \qquad \text{with } mc_i = w^{\alpha_{i,l}} \prod_{j=1}^{N} p_j^{\alpha_{i,j}} \qquad \text{and } \mu_i \equiv \frac{\varepsilon(\widetilde{p_i})}{\varepsilon(\widetilde{p_i}) - 1}.$$

  2. Local competitive distributor aggregates differentiated varieties - VES technology.

$$\sum_k A_i \mathcal{K}_i \left(\frac{y_{i,k}}{y_i} \right) = 1, \qquad \mathcal{K}(\cdot) > 0, \mathcal{K}'(\cdot) > 0, \mathcal{K}''(\cdot) < 0 \qquad \Longrightarrow \Gamma_i \equiv -\frac{d \log \mu_i}{d \log \widetilde{p_i}} > 0.$$

  3. Combine varieties with distribution services paid in labor with unit-elastic technology.

$$p_i = \widetilde{p_i}^{1-\phi_i} w^{\phi_i} \qquad \text{with } \phi_i \leqslant 1.$$

Model Overview

- Unit-elastic consumption bundle over domestic and imported sectoral goods.
- Domestic sectoral goods aggregate sectoral varieties and distribution costs.
  1. Varieties produced by monopolistically symmetric competitive firms.
     Domestic + imported intermediate inputs, together with labor.
     Competition within sectors (variable markups) + nominal rigidities (one-period Calvo rigidity).
  2. Local competitive distributor aggregates differentiated varieties.
  3. Combine varieties with distribution services paid in labor with unit-elastic technology.
- Imported sectoral goods purchased and sold locally by distributor.
  1. Retail price of imported goods = border price + local distribution costs.
  2. Reduced form border price sensitivity.

Pass-through into CPI - $\eta^{P,e}$

- ERPT into CPI: $\eta^{P,e} = \boldsymbol{\beta} \times \boldsymbol{\eta}^{\mathbf{p},e} = \underbrace{\boldsymbol{\beta}^{D} \times \boldsymbol{\eta}^{\mathbf{p}^{D},e}}_{\text{Indirect exposure}} + \underbrace{\boldsymbol{\beta}^{F} \times \boldsymbol{\eta}^{\mathbf{p}^{F},e}}_{\text{Direct exposure}}$.

- Direct exposure: PT into imported final consumption.

$$\boldsymbol{\eta}^{\mathbf{p}^{F},e} = \underbrace{\Phi}_{\substack{\text{Domestic} \\ \text{distribution}}} \quad \underbrace{\Psi}_{\text{Border price ERPT}} .$$

- Indirect exposure: PT into domestic final consumption.

$$\boldsymbol{\eta}^{\mathbf{p}^{D},e} = \underbrace{\left(I - \Phi\Delta\Gamma S_{d}\right)^{-1} \Phi\Delta\Gamma S_{m}}_{\substack{\text{Domestic network} \\ \text{\& frictions}}} \times \quad \underbrace{\boldsymbol{\eta}^{\mathbf{p}^{F},e}}_{\substack{\text{ERPT into} \\ \text{imported inputs}}} .$$

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Calibration - Summary

- Several data sources from Chile, 2000-2019.

Parameter(s)	Description	Data
S_m & S_d	Import and domestic Leontief matrices	IO tables
β	Consumption share	IO tables
Φ	Distribution margin	IO tables
Γ	Markup elasticity	ENIA Survey
Ψ	ERPT into Border Price	Customs Data
Δ	Calvo parameter	Arouba et al. (2022)

Roadmap

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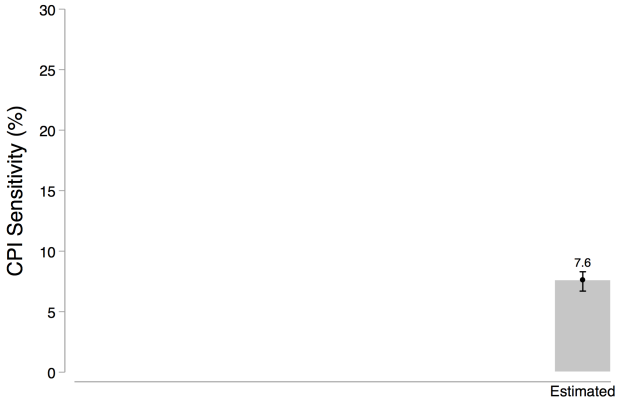
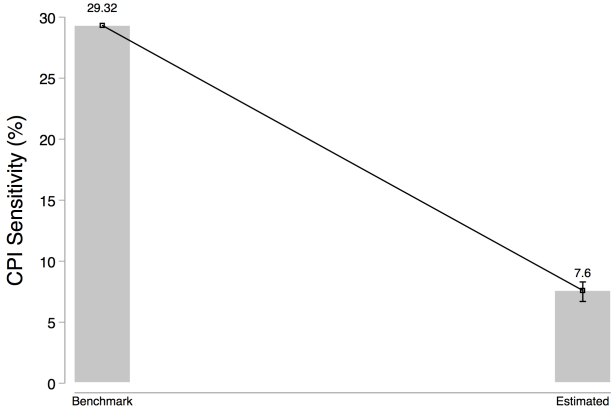
Decomposing CPI (In)Sensitivity



- Estimated average CPI sensitivity over 2009-2019: 7.6%

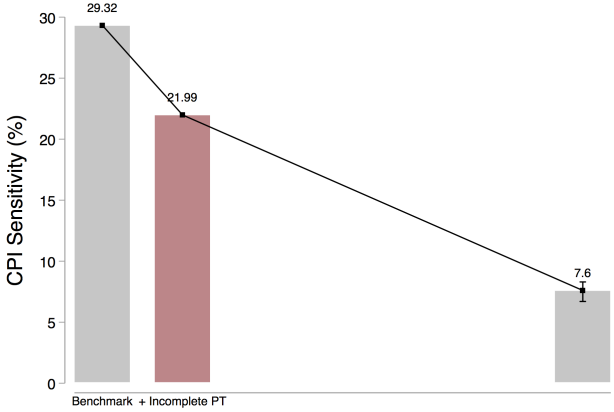
Estimated Sensitivity

Decomposing CPI (In)Sensitivity



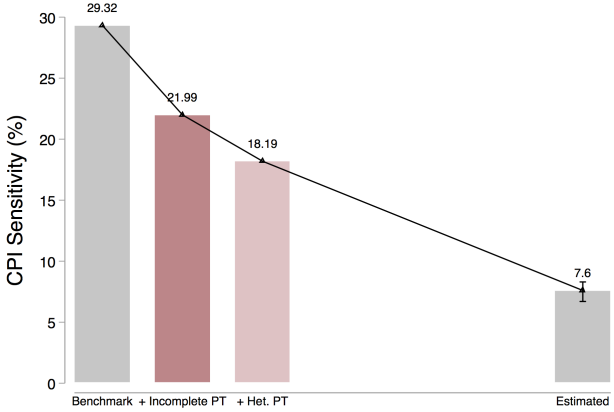
Benchmark: $\eta^{p^F,e} = 1$ $\eta^{p^D,e} = (I - S_d)^{-1}\ S_m\ \eta^{p^F,e}$ $\approx$ 4x Estimated.

Decomposing CPI (In)Sensitivity



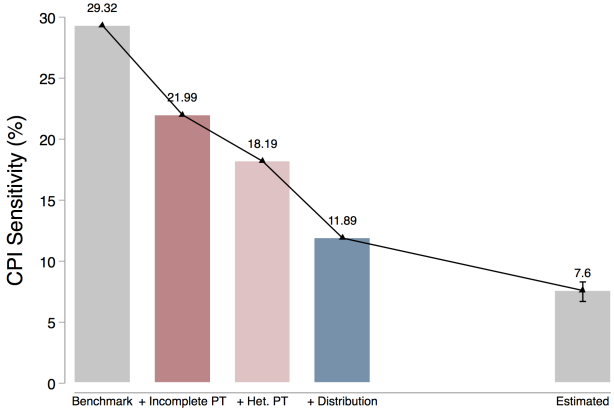
+ Incomplete PT: $\eta^{p^F,e} = \mathbf{\Psi}$ $\eta^{p^D,e} = (I - S_d)^{-1}\ S_m\ \eta^{p^F,e}$ $\approx$ 25% lower.

Decomposing CPI (In)Sensitivity



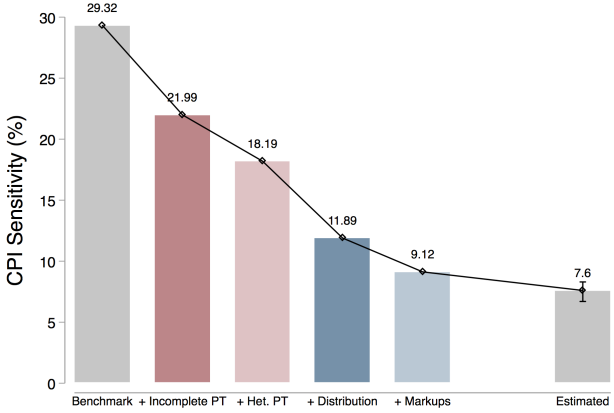
+ Het. PT: $\eta^{p^F,e} = \mathbf{\Psi_i}$ $\eta^{p^D,e} = (I - S_d)^{-1} \; S_m \; \eta^{p^F,e}$ $\approx$ 20% lower.

Decomposing CPI (In)Sensitivity



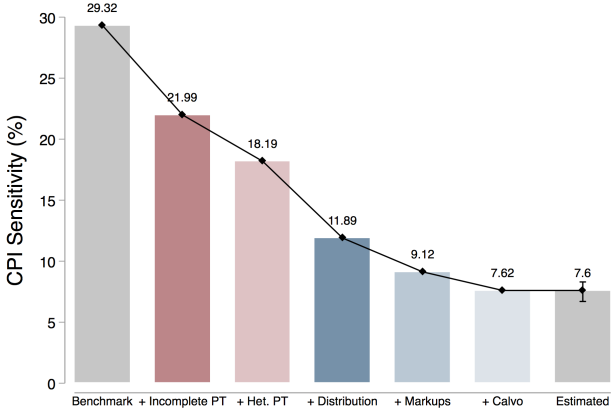
+ Distribution: $\eta^{p^F,e} = \mathbf{\Phi}\ \Psi_i \qquad \eta^{p^D,e} = (I - \mathbf{\Phi} S_d)^{-1}\ \mathbf{\Phi}\ S_m\ \eta^{p^F,e}$ $\approx$ 35% lower.

Decomposing CPI (In)Sensitivity



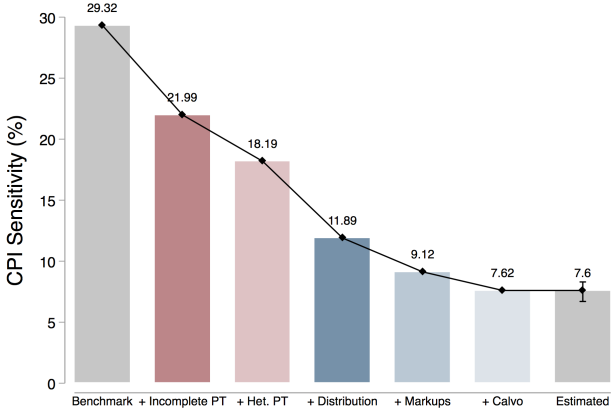
+ Markup: $\eta^{p^F,e} = \Phi\ \Psi_i$ $\eta^{p^D,e} = (I - \mathbf{\Gamma}\Phi S_d)^{-1}\ \mathbf{\Gamma}\ \Phi\ S_m\ \eta^{p^F,e}$ $\approx$ 25% lower.

Decomposing CPI (In)Sensitivity



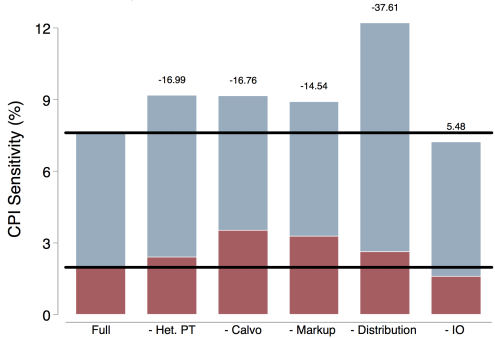
+ Calvo: $\eta^{p^F,e} = \Phi\ \Psi_i$ $\eta^{p^D,e} = (I - \mathbf{\Delta}\Gamma\Phi S_d)^{-1}\ \mathbf{\Delta}\ \Gamma\ \Phi\ S_m\ \eta^{p^F,e}$ $\approx$ 17% lower.

Decomposing CPI (In)Sensitivity



- Full model closely reproduces estimated level of CPI insensitivity.
- Domestic frictions more relevant than the response of border prices. ▸ Order

Decomposing CPI Sensitivity



- Main source of sensitivity: Direct exposure/imported consumption, $\approx$ 75%.
  Conflicting evidence with previous literature.
  Campa and Goldberg (2010), Burnstein et al. (2005), Gopinath (2015)
- Intuition: Frictions stronger on n_D $\quad (\eta^{p^D,e} = (I - \Delta\Gamma\Phi S_d)^{-1}\ \Delta\ \Gamma\ \Phi\ S_m\ \eta^{p^F,e})$.

Decomposing CPI Sensitivity

- Not just about domestic frictions:

1. Heterogeneous frictions reduces transmission – Composition effect. ▸ Details
2. Presence of domestic frictions reduces IO effects/amplification. ▸ Details
3. Heterogeneity in consumption shares – Composition effect. ▸ Details
4. Network centrality and imported inputs negatively correlated. ▸ Details

- Previous literature overlook domestic frictions (heterogeneity) and sparse network.
- Reconcile: Direct = Indirect in Benchmark case. ▸ Benchmark

Discussion - Implications

- (In)Sensitivity of domestic prices to ER key in open economy macroeconomics.
  ERPT to CPI: fear of floating vs misalignment → Determines optimal index (PPI vs CPI).
  Benigno and Benigno (2003), Corsetti et al. (2008)

- Predominant role of direct exposure and domestic frictions; Heterogeneity.
  → Inflation targeting: CPI/PPI weights might not coincide with optimal weights.
  Rubbo (2020), Pasten et al. (2022)
  → Redistribution: low income consumers more exposed (higher direct exposure).
  Jaravel (2020)

Conclusion

- I decompose CPI (in)sensitivity:
  - Expression for pass-through rate into CPI with usual and unusual suspects.
  - Discipline it with multiple, granular data sources.
  - Focus on heterogeneity across sectors/products.
- Main results:
  1. Predominant role of domestic frictions and direct exposure.
  2. Disaggregation and heterogeneities key to understand role of each element.
- Implications for:
  1. Policy: Monetary policy and inflation targeting debate in open economy; Inequality dynamics.
  2. Future modelling and calibrations: need (heterogeneity in) frictions.

Appendix

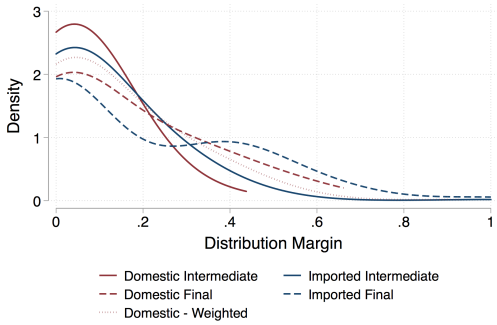
Distribution Margins

- Source: 2013 IO tables from Central Bank of Chile.
- Distribution margin:

$$\phi_i = \frac{\text{Value at purchaser prices - value at basic prices}}{\text{Value at purchaser prices}},$$

  corresponding to retail, wholesale, and transportation costs.
- For each i, compute ϕ_i separately for
  - imported vs domestic goods;
  - final vs intermediate consumption.
- For domestic products, ϕ_i weighted average of final and intermediate margins.

Distribution Margins



- Rich heterogeneity across products and use: Final > intermediate; imported > domestic.

▸ Summary Statistics ▸ Back

Distribution Margin

	Intermediate Goods		Final Goods	
	Domestic	Imported	Domestic	Imported
Farms	0.0701	0.0778	0.258	0.183
Fishing and Forestry	0.0135	0.000166	0.113	0.0224
Oil, Coal and Gas Extraction	0.0000500	0.0236	0	0
Mining	0.000593	0.0216	0	0
Food, Beverages and Tobacco	0.0896	0.207	0.265	0.366
Textile and Apparel	0.128	0.248	0.342	0.529
Wood, Paper and Printing	0.103	0.142	0.181	0.257
Petroleum and Chemical Products	0.150	0.172	0.307	0.386
Plastic Rubber and Construction	0.0580	0.146	0.146	0.401
Fabricated Metal Products	0.0577	0.133	0.0309	0.0809
Machinery and Equipment	0.0918	0.194	0.134	0.336
Motor Vehicles	0.0335	0.0988	0.0744	0.333
Furniture	0.112	0.225	0.312	0.369
Utilities	0.0310	0.000800	0.106	0
Construction	0.00269	0	0	0
Wholesale and Retail Trade	0.00384	0.00180	0.0229	0
Transportation	0.0107	0.00803	0.0183	0
Health Care and Education	0.00190	0	0.0250	0
Accomodation and Recreation	0.0381	0.0216	0.0894	0
Professional Services	0.0208	0.0157	0.0525	0.0226
Communication	0.0451	0.0153	0.149	0
Other Products or Services	0.0908	0.0701	0.0391	0.118

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Markup Elasticity

- Assume Klenow-Willis (2016) for distributor's VES technology. In steady-state:

$$\Gamma_i = \frac{\epsilon_i}{\sigma_i - 1},$$

with σ_i and ϵ_i being the elasticity and the super-elasticity of demand.

- Use ENIA dataset to estimate production function and markups at sector level.
  Levinsoohn and Petrin (2003), Ackerberg et al. (2015), De Loecker and Warzynski (2012)
  ▸ Data Description ▸ Markup Estimation

- As robustness, I estimate markups using accounting cost share approach.
  Autor et al. (2020) ▸ Robustness

Markup Elasticity (cont'd)

- Calibrate σ_i to match the estimated average markup, $\bar{\mu}_i$: $\sigma_i = \frac{\bar{\mu}_i}{\bar{\mu}_i - 1}$. ▸ Markup Estimates

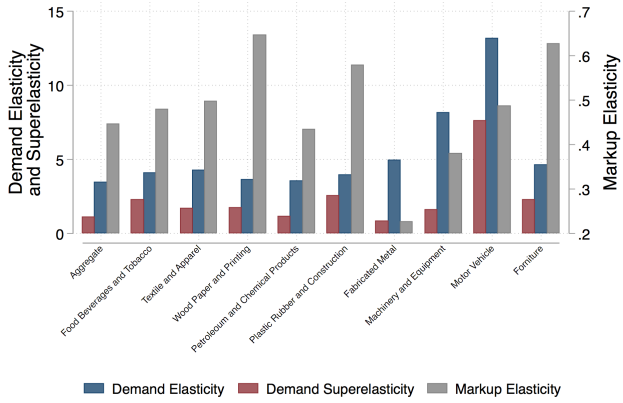
- Estimate ϵ_i using within-industry relationship between markups and market shares implied by Klenow-Willis specification. Edmond et al. (2019)

$$\frac{1}{\mu_{ikt}} + \log\left(1 - \frac{1}{\mu_{ikt}}\right) = a_i + b_i \log \texttt{share}_{ikt} + \iota_k + \iota_t, \qquad b_i = \frac{\epsilon_i}{\sigma_i}.$$

- Retrieve ϵ_i given $\widehat{b}_i$ and σ_i.

- Missing products (mostly services) are calibrated using aggregate estimates.

Markup Elasticity (cont'd)



- Markup elasticities are in line with values used in the literature. Gopinath et al. (2010)
- Large heterogeneity in implied pass-through rates (ranging between 0.5 and 0.9).

▸ Implied Parameters ▸ Robustness ▸ Between Sectors ▸ Back

ENIA - Survey of Manufacturing

- 2000-2007 Annual National Industrial Surveys (ENIA): 5000 plants with > 10 employees.
- Data on sales, inputs expenditures, employment and wage bill, investment, industry.
- Summary Statistics:

	Mean	p25	Median	p75
Sales	5,666,147	151,802	407,989	1,607,334
Wage Bill	438,828.1	37,268	88,067	279,700
Material Expenditure	3,067,797	74,545	209,090	866,560
Capital Stock	3,001,394	31,636	130,379	620,612
Electricity Used (MW)	3,520.978	27	77	357
Observations	31,027			

▸ Back

Markup Estimation - Production Function

- I estimate a Cobb-Douglas production function of the form:

$$\log y_{ik} = \beta_i^k \log k_{ik} + \beta_i^l \log l_{ik} + \beta_i^x \log x_{ik} + \omega_{ik} + \xi_{ik}$$

  where y_{ik}, k_{ik}, l_{ik}, x_{ik}, ω_{ik} and ξ_{ik} represent quantity sold, capital stock, labor, materials, log productivity and the error term, respectively.
- Deflate variables using sectoral output, capital and inputs specific deflators.
- Endogeneity due to unobserved ω_{ik}: control function approach. Ackerberg et al (2015)
- Use electricity consumption in MWs as proxy variable. Treat capital as dynamic input.
- Variable inputs: composite expenditure on labor and material (cost of goods sold). De Looecker et al (2022)
- Compute markups following De Loecker et al. (2012): $\mu_{ik} = \widehat{\beta_i^{\texttt{Cost}}} \frac{\texttt{Sales}_{ik}}{\texttt{Cost}_{ik}}$.

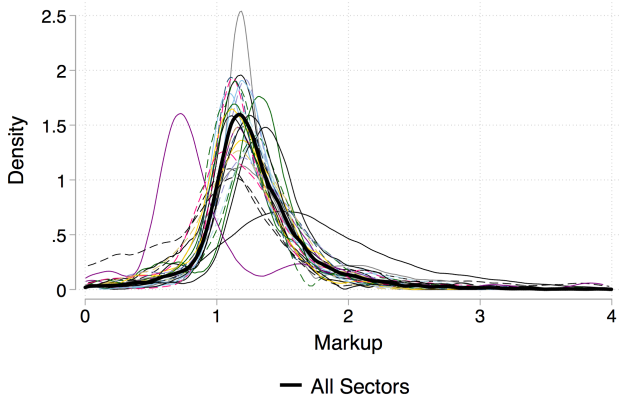
▸ Back

Markup Estimation - Accounting Cost Share

- Weaknesses in estimating markups via production function. Bond et al. (2022)
- Under CRS production function, output elasticity of input i = cost share of input i. Autor et al. (2020), Edmond et al. (2018)
- Assume output elasticity common within each sector across firms.
- Calibrate sectoral output elasticity to the median input share across firms.
- Use Cost of goods sold or labor only as input.
- Compute markups using De Loecker et al. (2012): $\mu_{ik} = \widehat{\beta_i^{\texttt{Cost}}} \frac{\texttt{Sales}_{ik}}{\texttt{Cost}_{ik}}$.

▸ Back

Estimated Markup



- Estimates and distributions in line with previous results.

  Levinsohn and Petrin (2003), Garcia-Marin et al. (2019)

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Estimated Markup and Implied Parameters

	Markup				Implied Parameters		
	Mean	Median	StD	Weighted Mean	σ	ϵ	Γ
Food Beverages and Tobacco	1.343	1.302	0.226	1.415	4.098	2.281	0.479
Textile and Apparel	1.274	1.262	0.186	1.301	4.266	1.672	0.498
Wood Paper and Printing	1.289	1.257	0.201	1.377	3.643	1.712	0.646
Petroleoum and Chemical Products	1.392	1.275	0.410	1.420	3.521	1.139	0.434
Plastic Rubber and Construction	1.292	1.262	0.209	1.391	3.930	2.546	0.578
Fabricated Metal	1.165	1.101	0.263	1.295	4.939	0.810	0.226
Machinery and Equipment	1.201	1.177	0.188	1.152	8.122	1.595	0.380
Motor Vehicle	1.088	1.119	0.265	1.047	13.18	7.582	0.486
Forniture	1.244	1.227	0.172	1.275	4.641	2.283	0.627
Aggregate	1.274	1.237	0.247	1.408	3.453	1.093	0.446

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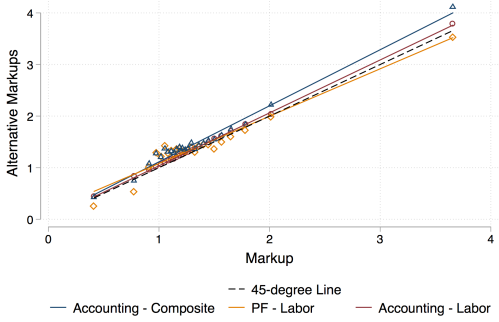
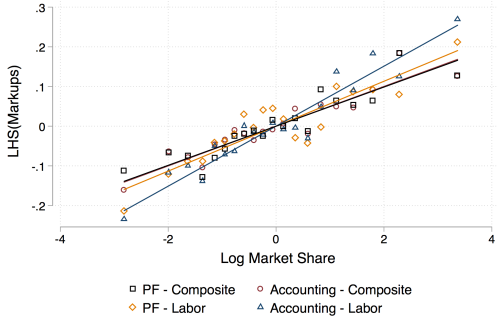
Estimated Markup - Robustness

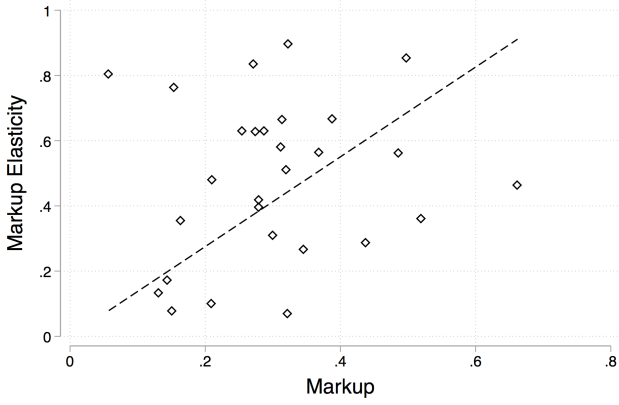




- Highly correlated estimated markups across approaches and variable inputs.
- Similar implied markup elasticities.

▸ Back

Markup Elasticity - Sectors



- Cov$(\mu_i, \Gamma_i) > 0$ also across sectors.

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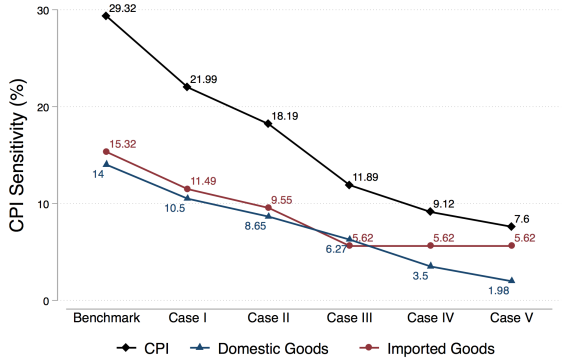
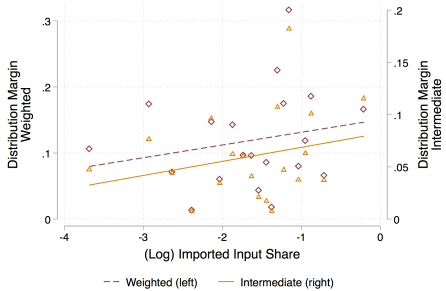
Imported vs Domestic Consumption

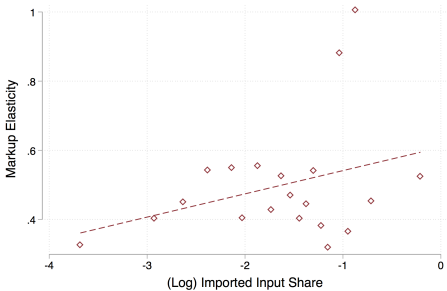


- In full model (Case V): 75% of sensitivity due to consumption of imported goods.
- In benchmark economy: direct vs indirect equally relevant. Back

Not Only Domestic Frictions

1. Heterogeneous frictions reduces transmission – Composition effect.
   Imported intermediate inputs positively related to distribution cost and markup elasticity.



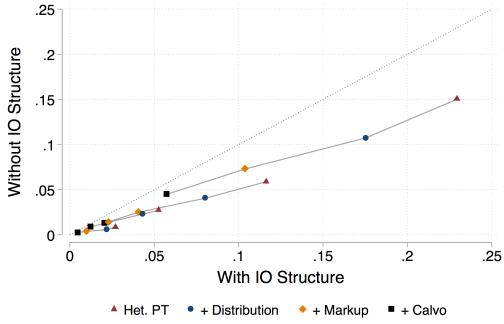


→ Composition effect: lower transmission in most relevant goods ($\approx 10\%$). Pasten et al (2022)

▸ Back

Not Only Domestic Frictions

2. Presence of domestic frictions reduces IO effects/amplification.

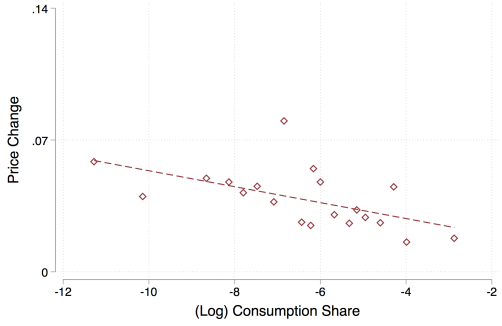


$$\eta^{p^F,e} = \Phi\ \Psi_i \qquad \eta^{p^D,e} = (\mathbf{I} - \mathbf{\Delta\Gamma\Phi S_d})^{-1}\ \Delta\ \Gamma\ \Phi\ S_m\ \eta^{p^F,e}$$

▸ Back

Not Only Domestic Frictions

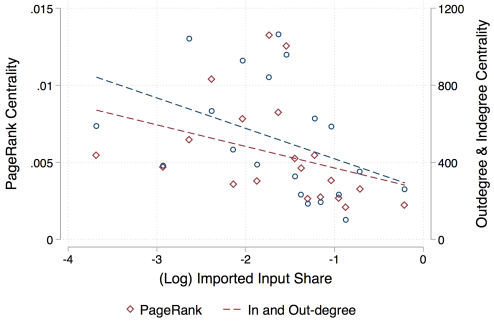
3. Lower consumption shares for goods with more volatile prices – Composition effect.

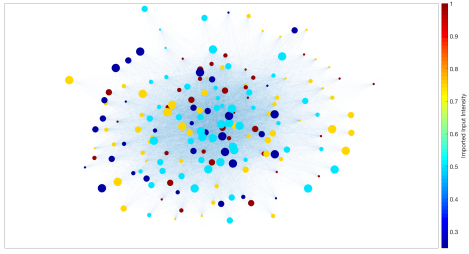


→ Composition effect: smaller relevance of most exposed goods. Chen et al (2022) ▸ Back

Not Only Domestic Frictions

4. Network centrality and imported inputs negatively correlated.





→ Economic structure/Network shape relevant import exposure & amplification. Back