Inflation in Distorted Economies: Evidence from India

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  - Persistently high inflation may reduce price stickiness
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  - Persistently high inflation may reduce price stickiness
  - Production technologies affect the shape of marginal cost curves
  - Severe misallocation of resources interacting with inefficient price dispersion due to inflation
- Policy implications:
  - Monetary policy framework
  - Aggregate demand stimulus

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- Bottom-up approach using micro-data on input costs and product prices and quantities

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Model: New Keynesian model

- Non-constant RTS, roundabout production, variable markups, and input wedges
- Aggregate Demand shifts induce two conceptually different inflationary pressures
  - Slope of the Phillips curve: Shift of the AD curve holding the location of the AS curve
  - Endogenous cost-push shocks: driven by changes in allocative efficiency after AD shifts

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Empirics: Representative sample of Indian manufacturing firms over 1998-2017

- Degree of price rigidity
- Passthrough of input cost shocks into prices
- Slope of marginal cost curves

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✓ Identification: circumvent identification challenges in aggregate correlations & IRF-matching

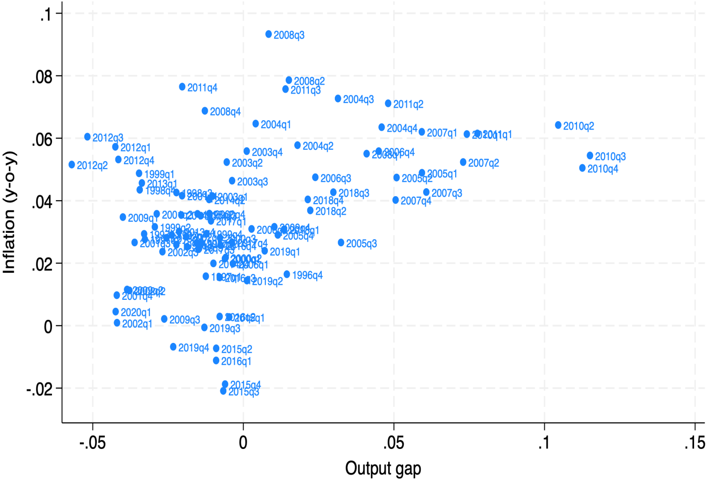
✓ Mechanisms: separately identify components of the Phillips curve

Roadmap

- Model
- Estimation of the slope of the Phillips curve
- Effects on allocative efficiency

Summary of Findings | Literature Review

Phillips correlation for India



Note: inflation is % change in manufacturing Wholesale Price Index, output gap is cyclical component of manufacturing quantity index using Hamilton (2018)

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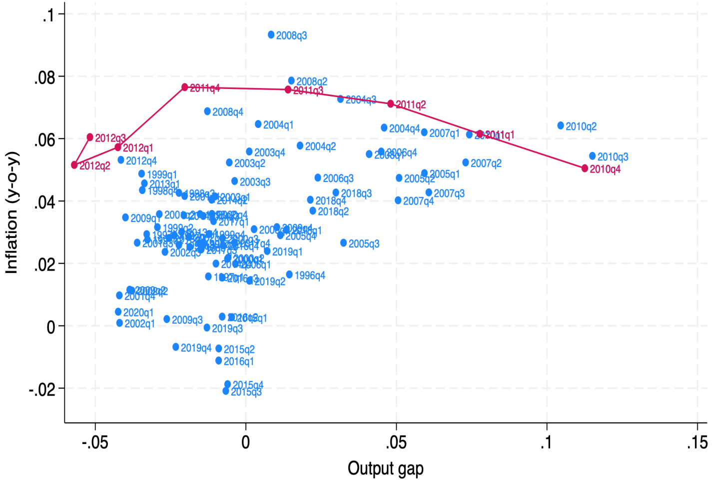

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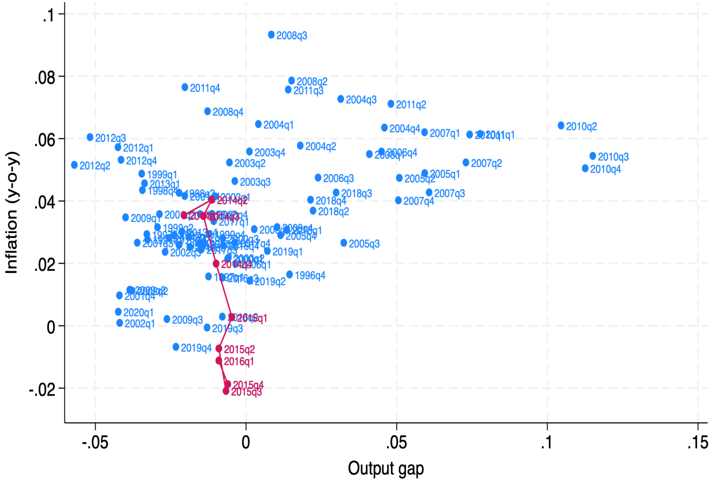

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Environment

Households: $\max \mathbb{E}_0 \sum_{t=0}^{+\infty} \beta^t u(C_t, L_t)$ subject to $P_t^Y C_t + Q_t B_t = B_{t-1} + w_t L_t + T_t$

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- Calvo pricing: can reset price with probability 1-α
- $y_{it} = e^{z_i} v_{it}^a$; $v_{it} = l_{it}^{\phi} x_{it}^{1-\phi}$
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$$\left.\begin{matrix} \\ \\ \end{matrix}\right\} mc_{it} = \frac{1}{a}(1+\tau_i) w_t^v e^{-\frac{1}{a} z_i} y_{it}^{\frac{1-a}{a}}$$

Materials: $X_t = (Y_t^X)^{\frac{\eta}{1+\eta}}$

Equilibrium & Log-linearization

Equilibrium:

- Consumers choose consumption and labor to maximize utility taking prices and wage as given
- Firms with flexible prices set prices to maximize their value taking the price index and their residual demand curves as given; firms with sticky prices meet demand at fixed prices
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Log-linearization around zero-inflation steady state:

- Zero-inflation steady-state:
  - Steady-state distribution of firm size depends on joint distribution (z_i, τ_i).
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Notations: $\lambda_{it} = \frac{p_{it} y_{it}}{P_t^Y Y_t}$ and $\mathbb{E}_\lambda [X_{it}] = \int_0^1 \lambda_{it} X_{it} di$

Firms' pricing problem

Problem: $\max_{p_{it}} \mathbb{E}_t \left[\sum_{s=0}^{+\infty} \alpha^s \Lambda_{t,t+s} \left[p_{it} y_{it+s} - (1+\tau_i) w_{t+s}^{v} e^{-\frac{1}{a} z_i} y_{it+s}^{\frac{1}{a}} \right] \right]$ s.t.: $y_{it+s} = \Upsilon'^{-1}\left(\frac{p_{it}}{\mathcal{P}_{t+s}}\right) Y_{t+s}$

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Optimal reset price:

$$\hat{p}^{new}_{it|t} = (1-\beta\alpha)\mathbb{E}_t \left[\sum_{s=0}^{+\infty} (\beta\alpha)^s (\hat{\mu}^f_{it+s|t} + \hat{mc}_{it+s|t}) \right]$$ with $\mu^f_{it} = \frac{\theta_{it}}{\theta_{it}-1}$ flexible price markup

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$$\hat{mc}_t - \hat{P}_t^Y = \underbrace{\left(\gamma + \frac{\psi + 1 - a}{a}\right)}_{\Omega = \text{ Slope of mc curve}} \hat{Y}_t - \Xi \hat{Z}_t$$

where $\psi = \frac{\phi\nu^{-1} + (1-\phi)\eta^{-1} + \nu^{-1}\eta^{-1}}{1 + \nu^{-1}(1-\phi) + \phi\eta^{-1}}$, ν^{-1} inverse labor supply elasticity, η^{-1} inverse material supply elasticity

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Special case: if $\tau_i = 0\ \forall i,\ \ \hat{Z}_t \propto -\hat{D}_t$

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Law of motions for $\hat{D}_t$ and $\hat{Z}_t$:

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$$\hat{Z}_t = \frac{\varphi\kappa_Z\left(\Omega\hat{Y}_t + \hat{D}_t\right)}{1+\beta+\varphi(1+\Xi\kappa_Z)} + \frac{\hat{Z}_{t-1}+\beta\hat{Z}_{t+1}}{1+\beta+\varphi(1+\Xi\kappa_Z)} \quad \text{with } \kappa_Z = \mathbb{E}_\lambda[\theta_i\zeta_i\rho_i]\left(\mathrm{Cov}_\lambda\left[\frac{m_i^{-1}}{\mathbb{E}_\lambda[m_i^{-1}]}, \frac{\theta_i\zeta_i\rho_i}{\mathbb{E}_\lambda[\theta_i\zeta_i\rho_i]} - \frac{\theta_i}{\mathbb{E}_\lambda[\theta_i]}\right]\right)$$

Proofs

5-equation New Keynesian model

$$\hat{\pi}_t = \varphi \mathbb{E}_\lambda[\zeta_i \rho_i]\Omega \hat{Y}_t - \varphi \mathbb{E}_\lambda[\zeta_i \rho_i]\Xi \hat{Z}_t - \varphi(1 - \mathbb{E}_\lambda[\zeta_i \rho_i])\hat{D}_t + \beta \mathbb{E}_t[\hat{\pi}_{t+1}] \tag{NKPC}$$

$$\hat{D}_t = -\frac{\varphi \kappa_D \left(\Omega \hat{Y}_t - \Xi \hat{Z}_t\right)}{1 + \beta + \varphi(1 + \kappa_D)} + \frac{\hat{D}_{t-1} + \beta \hat{D}_{t+1}}{1 + \beta + \varphi(1 + \kappa_D)} \tag{LOM for D}$$

$$\hat{Z}_t = \frac{\varphi \kappa_Z \left(\Omega \hat{Y}_t + \hat{D}_t\right)}{1 + \beta + \varphi(1 + \Xi \kappa_Z)} + \frac{\hat{Z}_{t-1} + \beta \hat{Z}_{t+1}}{1 + \beta + \varphi(1 + \Xi \kappa_Z)} \tag{LOM for Z}$$

$$c\hat{Y}_t - \tilde{c}\left(\hat{Y}_t - \hat{Z}_t\right) = \mathbb{E}\left[c\hat{Y}_{t+1} - \tilde{c}\left(\hat{Y}_{t+1} - \hat{Z}_{t+1}\right)\right] - \sigma\left(\hat{i}_t - \mathbb{E}_t\left[\hat{\pi}_{t+1}\right]\right) \tag{Euler equation}$$

$$\hat{i}_t = \phi_\pi \hat{\pi}_t + \phi_y \hat{Y}_t + \varepsilon_t^{MP} \tag{MP rule}$$

Estimating the slope of the Phillips curve

Exploit decomposition of the slope of the Phillips curve

$$\hat{\pi}_t = \kappa_y \hat{Y}_t + \beta \mathbb{E}_t[\hat{\pi}_{t+1}] \qquad \longrightarrow \qquad \begin{cases} \hat{\pi}_t = \kappa_{mc}(\hat{mc}_t - \hat{P}^Y_t) + \beta \mathbb{E}_t[\hat{\pi}_{t+1}] \\ \qquad \kappa_{mc} = \varphi \mathbb{E}_\lambda[\zeta_i \rho_i] \\ (\hat{mc}_t - \hat{P}^Y_t) = \Omega\, \hat{Y}_t \end{cases}$$

$$\kappa_y = \varphi \mathbb{E}_\lambda[\zeta_i \rho_i]\Omega$$

(Omitting terms in $\hat{D}_t$ and $\hat{Z}_t$)

- Separate empirical exercise in two steps:
  - Estimation of the pass-through of changes in costs into prices
  - Estimation of the elasticity of marginal costs to changes in quantities
- Galí-Gertler decomposition of the Phillips curve in wide class of NK models

Data: Indian Annual Survey of Industries

- Representative sample of manufacturing establishment over 1998-2017
  - Organized sector, $>$20 employees (or $>$10 employees & use electricity)
- Product-level data:
  - Product-level sales, quantities sold, and unit values
  - 5-digit product codes: 1182 distinct products
  - Change in price and quantity of good j sold by firm i: $\Delta \ln p_{ijt}$ and $\Delta \ln q_{ijt}$
    → Avg price of goods sold by firm i: $\Delta \ln p_{it} = \sum_{j \in \mathcal{J}} \bar{s}_{ijt} \Delta \ln p_{ijt}$
- Input-level data
  - Input-level purchase value, quantities purchased, and unit values
  - Materials (1195 distinct inputs), energy (electricity, oil, coal), labor
  - Change in price and quantity of input k purchased by firm i: $\Delta \ln w_{ikt}$ and $\Delta \ln x_{ikt}$
    → Avg price of variable inputs purchased by firm i: $\Delta \ln w_{it} = \sum_{k \in \mathcal{K}} \bar{s}_{ikt} \Delta \ln w_{ikt}$

Example classification | Example observation | Quality checks

What is the pass-through of input cost shocks into output prices?

- **From the model.** $\Rightarrow$ Regression of $\Delta \ln p_{it}$ on $\Delta \ln w_{it}$ instrumented by exog. cost shifter ϑ_{it}^{obs}:
  $\beta_{p,w}^{\mathrm{IV}} = (1-\alpha)(1-\beta\alpha)\mathbb{E}_{\lambda}[\rho_i \zeta_i]$

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In the data. Partial equilibrium pass-through of firm-specific input cost shock into prices:

$$\Delta \ln p_{ijt} = \alpha_{jt} + \beta \Delta \ln w_{it} + \varepsilon_{ijt}$$

- $\Delta \ln p_{ijt}$: change in the price of good j sold by firm i
- $\Delta \ln w_{it}$: change in the price index of variable inputs used by firm i
- α_{jt}: controls for product-specific shocks and competitors' prices
- Identification concern: demand shocks & upward-sloping supply curves for some inputs
  - Instrument: Changes in the price of materials and fuels $\times$ firm-specific input shares (Amiti et al. 2019)

Details | Adj. for persistence | mc passthrough

What is the pass-through of input cost shocks into output prices?

	$\Delta \ln p$					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln w$	0.139^{***}	0.111^{***}	0.111^{***}	0.291^{***}	0.223^{***}	0.222^{***}
	(0.008)	(0.008)	(0.008)	(0.019)	(0.017)	(0.017)
Year FE	✓			✓		
Year × Product FE		✓	✓		✓	✓
Controls			✓			✓
Observations	356,162	353,568	353,568	355,530	352,934	352,934
F-stat				5195.8	5272.9	5280.9

- Average elasticity of 0.22

Dynamic | Non-linear | Robustness | Firm-level | Heterogeneity

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Dynamic Non-linear Robustness Firm-level Heterogeneity

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- Adjusting for α and the persistence of input cost shocks $\Rightarrow \kappa_{mc} = .095$ (quarterly)
- $\mathbb{E}_\lambda[\rho_i \zeta_i] = 0.25 \rightarrow$ inconsistent with canonical NK model with CRS and constant markups

Dynamic Non-linear Robustness Firm-level Heterogeneity

What is the slope of the marginal cost curve?

From the model. $\hat{mc}_{it} = \frac{1-a}{a}\hat{y}_{it} + (\hat{mc}_t - \frac{1-a}{a}\hat{Y}_t)$

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In the data. Partial equilibrium effect of quantity change on marginal cost:

$$\Delta \ln mc_{it} = \alpha_{s(i)t} + \beta \Delta \ln q_{it} + \varepsilon_{it}$$

- $\Delta \ln q_{it}$: change in the quantity sold by firm i
- $\Delta \ln mc_{it}$: change in the marginal cost of firm i: $\Delta \ln mc_{it} = \Delta \ln \mathcal{C}_{it} - \Delta \ln q_{it}$
  - $\Delta \ln \mathcal{C}_{it}$: change in total variable costs (materials, fuels & labor)
- $\alpha_{s(i)t}$: 3-digit industry of firm $i \times$ year fixed effects
- Identification concern: firm-specific supply shocks
  - Instrument: Changes in product-specific demand $\times$ firm-specific product shares

Details

What is the slope of the marginal cost curve?

	Baseline		Excl. labor	
	Δ ln mc	Δ ln C	Δ ln mc	Δ ln C
Δ log q	0.184***	1.106***	0.253***	1.192***
	(0.062)	(0.062)	(0.066)	(0.067)
Year × Ind. FE	✓	✓	✓	✓
N	258,238	258,238	258,237	258,237
F-Stat	247.18	247.18	247.18	247.18
Returns to scale	0.84	0.90	0.80	0.84

- When quantities go up by 1%, marginal cost goes up by 0.2%
- Inconsistent with constant returns to scale (in the short run)

Robustness Heterogeneity

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- Inconsistent with constant returns to scale (in the short run)
- Short-run firm level returns to scale $a = 0.83$

Robustness Heterogeneity

What is the slope of the marginal cost curve?

- What about cost curves at a more aggregate level?

$$\hat{mc}_t = \Omega \hat{Y}_t - \Xi \hat{Z}_t + \hat{P}_t^Y \qquad \text{with } \Omega = \gamma + \frac{\psi + 1 - a}{a}$$

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→ Aggregate product-specific demand shock at the district or industry level

	District		Industry	
	$\Delta \ln \text{mc}$	$\Delta \ln \text{C}$	$\Delta \ln \text{mc}$	$\Delta \ln \text{C}$
$\Delta \ln \text{q}$	0.583***	1.487***	0.703**	1.704***
	(0.144)	(0.140)	(0.310)	(0.311)
Year FE	✓	✓	✓	✓
F Stat	103.08	103.08	26.83	26.83
N	7,707	7,707	1,211	1,211

- When quantities go up by 1%, marginal cost goes up by 0.6% to 0.7%

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N	7,707	7,707	1,211	1,211

- When quantities go up by 1%, marginal cost goes up by 0.6% to 0.7%
- The slope of the short-run marginal cost curve is $\Omega = 0.695$

Slope of the Phillips curve

$$\hat{\pi}_t = \underbrace{\frac{(1-\alpha)(1-\beta\alpha)}{\alpha}\mathbb{E}_\lambda[\zeta_i\rho_i]}_{\kappa_{mc}=.095}\Big(\underbrace{\Omega}_{\Omega=.695}\hat{Y}_t - \frac{\nu^{-1}}{a}\hat{Z}_t + \vartheta_t\Big) - \varphi(1-\mathbb{E}_\lambda[\zeta_i\rho_i])\hat{D}_t + \beta\mathbb{E}_t[\hat{\pi}_{t+1}]$$

- **Slope of the Phillips curve:** $\kappa_y = .066$ at the quarterly horizon. The Phillips curve is steep.

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- Why?

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- Ω: macro-level real rigidities

  Rotemberg Woodford 1997: $\Omega = 0.47$; Shea 1993: $\Omega = 0.18$; Boehm Pandalai-Nayar 2022: $\Omega = 0.24$; Gagliardone Gertler Lenzu Tielens 2024: $\Omega = 0.27$

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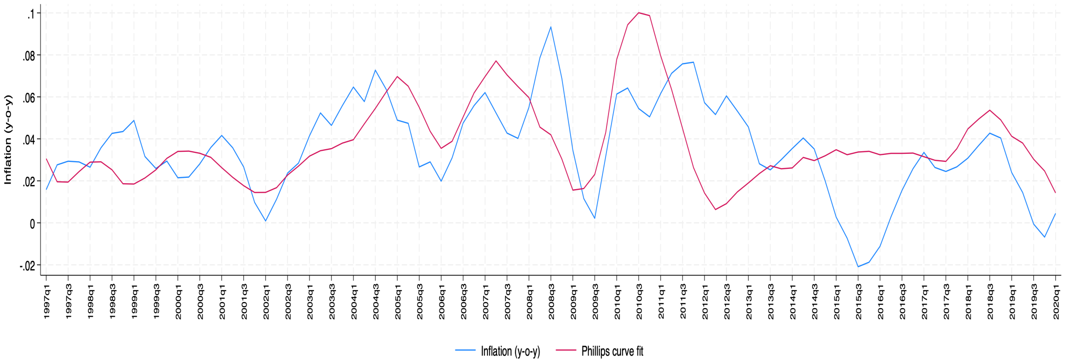
  - Slope of mc curve : if India had the same Ω as the U.S., $\kappa^y = 0.023$

Aggregate Phillips curve fit for India

$$\pi_t = \kappa_y \varpi \tilde{y}_t + \bar{\pi} \text{ with } \varpi \text{ estimated to fit } \sum_{j=0}^{5} \beta^j \tilde{y}_{t+j} = a_0 + \varpi \tilde{y}_t + e_t$$



PV computation

Resid. oil price

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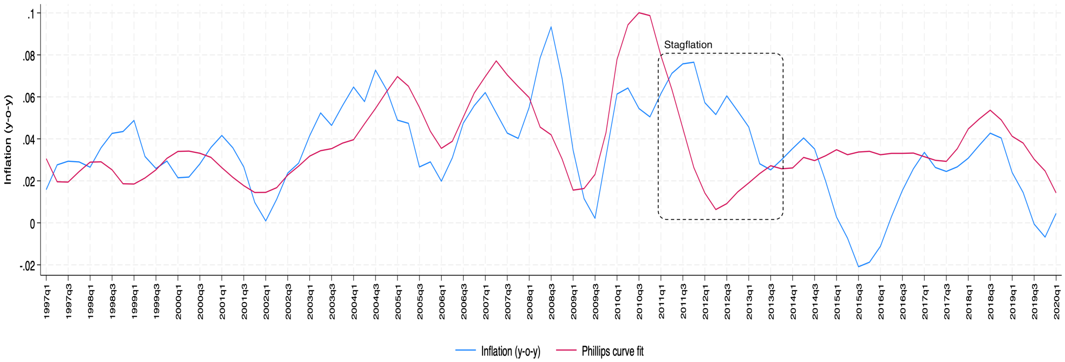

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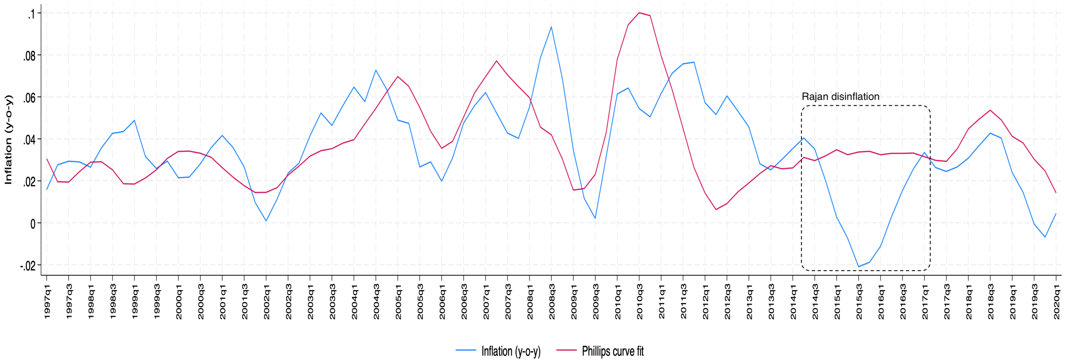

PV computation

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Allocative Efficiency

Endogenous shifters

Law of motion of $\hat{D}_t$:

$$\hat{D}_t = -\frac{\varphi \kappa_D}{1+\beta+\varphi(1+\kappa_D)}\left(\Omega \hat{Y}_t - \Xi \hat{Z}_t\right) + \frac{\hat{D}_{t-1} + \beta \hat{D}_{t+1}}{1+\beta+\varphi(1+\kappa_D)}$$

Law of motion of $\hat{Z}_t$:

$$\hat{Z}_t = \frac{\varphi \kappa_Z}{1+\beta+\varphi(1+\Xi\kappa_Z)}\left(\Omega \hat{Y}_t + \hat{D}_t\right) + \frac{\hat{Z}_{t-1} + \beta \hat{Z}_{t+1}}{1+\beta+\varphi(1+\Xi\kappa_Z)}$$

where

$$\kappa_D = \mathbb{E}_\lambda[\zeta_i \rho_i]\,\mathrm{Cov}_\lambda\left[\frac{\theta_i}{\mathbb{E}_\lambda[\theta_i]}, \frac{\zeta_i \rho_i}{\mathbb{E}_\lambda[\zeta_i \rho_i]}\right]$$

$$\kappa_Z = \mathbb{E}_\lambda[\theta_i \zeta_i \rho_i]\left(\mathrm{Cov}_\lambda\left[\frac{m_i^{-1}}{\mathbb{E}_\lambda[m_i^{-1}]}, \frac{\theta_i \zeta_i \rho_i}{\mathbb{E}_\lambda[\theta_i \zeta_i \rho_i]}\right] - \mathrm{Cov}_\lambda\left[\frac{m_i^{-1}}{\mathbb{E}_\lambda[m_i^{-1}]}, \frac{\theta_i}{\mathbb{E}_\lambda[\theta_i]}\right]\right)$$

Non-parametric identification

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  - m_i: $m_i \propto \mathrm{TFPR}_i$ (Hsieh Klenow 2009)
  - θ_i: Estimate markups (production approach w/ materials flexible input) & invert Lerner formula
    - Requires estimation of output elasticity + assumes input wedge on materials is priced

Results [Preliminary]

- $\kappa_D = .00035$
  - $\kappa_D > 0$ because firms with larger demand elasticities have a larger price passthrough $\rho_i \zeta_i$
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- Effects are small: $\uparrow$ 1% in $\hat{Y}_t \Rightarrow \downarrow$ 0.01% in $\hat{Z}_t$

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  - $\hat{Z}_t \propto \mathrm{Cov}_\lambda(\theta_i, \rho_i) \propto \mathrm{Cov}_\lambda(size_i, \rho_i)$ sufficient statistic for productivity effect
- However: non-CRS + input wedges $\Rightarrow \mathrm{Cov}_\lambda(size_i, \rho_i)$ is not a sufficient statistic
  - $\hat{D}_t \propto \mathrm{Cov}_\lambda(\theta_i, \rho_i \zeta_i)$ can have a different sign
  - $\hat{Z}_t$ also depends on on joint distribution of θ_i and m_i^{-1}

Conclusion

- Estimate the slope of the Phillips curve in India over 1998-2017
  - Bottom-up approach using micro-data on prices and quantities
- The slope of the Phillips curve is large
  - Relatively high frequency of price changes and steep marginal cost curves
  - Domestic demand factors contribute significantly to the dynamics of inflation
- Monetary shocks do not seem to have large effects on allocative efficiency (preliminary)
- Next steps:
  - More dimensions of heterogeneity (price stickiness, returns to scale)
  - Implications for welfare costs of high steady-state inflation

Main findings

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- Domestic output gap & estimated slope rationalize well aggregate inflation dynamics
- (Preliminary) Effects of monetary shocks on allocative efficiency quantitatively small

Literature review

1. **Slope of the Phillips curve: US & OECD**: time series (Rotemberg Woodford 1997, Mavroeidis et al. 2014), cross-sectional (Beraja et al. 2019, Hazell et al. 2022, Cerrato Gitti 2022, Gagliardone et al. 2024). **EMDEs**: cross-country (Mohanty Klau 2001, Filardo Lombardi 2014), India (Ball Chari Mishra 2016).
   - Estimate slope from Indian micro-data → significantly larger than existing empirical estimates
   - Portable framework to estimate slope of Phillips curve & isolate mechanisms

2. **Monetary shocks & allocative efficiency:** Meier Reinelt 2020, Mongey 2021, Baqaee Fahri Sangani 2024
   - Augment Baqaee Fahri Sangani 2024 with arbitrary RTS and input wedges
   - Quantification of this channel for a highly distorted economy

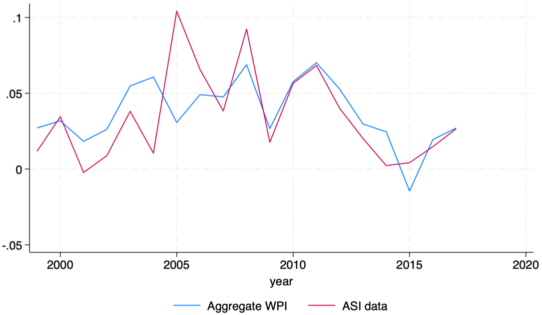
3. **Pricing decisions in developing countries:** Gagnon 2009, Alvarez et al. 2019, Drenik Perez 2020
   - Persistent and moderately high levels of inflation as opposed to extreme episodes
   - Focus on estimating effect of domestic demand on inflation

4. **Passthrough of input cost shocks** (Gopinath Rigobon 2008, Gopinath Itskhoki 2012, Amiti Itskhoki Konings 2019) & **slope of cost curves** (Shea 1993, Bresnahan Ramey 1994, Boehm Pandalai-Nayar 2022)
   - Map estimates to slope of Phillips curve

Data quality checks

- Coverage: comparing value added in ASI vs. manufacturing GDP from national accounts
  - Manufacturing GDP from national accounts includes organized sector firms not covered by ASI ($<$10 employees or $<$20 employees & no electricity) + informal sector (estimated from census of informal manufacturing every $\approx$7 years)
  - On average, ASI covers 61% of total manufacturing value added

Data quality checks



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Example of NPC-MS 11 5 Digits Classification

Code	Description
35	Other chemical products; man-made fibres
351	Paints and varnishes and related products; artists' colours; ink
35110	Paints and varnishes and related products
35120	Artists', students' or signboard painters' colours, modifying tints, amusement colours and the like
35130	Printing ink
35140	Writing or drawing ink and other inks
352	Pharmaceutical products
353	Soap, cleaning preparations, perfumes and toilet preparations
354	Chemical products n.e.c.
355	Man-made fibres
36	Rubber and plastics products
361	Rubber tyres and tubes
36111	New pneumatic tyres, of rubber, of a kind used on motor cars
36112	New pneumatic tyres, of rubber, of a kind used on motorcycles or bicycles
36113	Other new pneumatic tyres, of rubber
36114	Inner tubes, solid or cushion tyres, interchangeable tyre treads and tyre flaps, of rubber
36115	Camel back strips for retreading rubber tyres
36120	Retreaded pneumatic tyres, of rubber
362	Other rubber products
36210	Reclaimed rubber
36220	Unvulcanized compounded rubber, in primary forms or in plates, sheets or strip; unvulcanized rubber in forms other than primary forms or plates, sheets or strip
36230	Tubes, pipes and hoses of vulcanized rubber other than hard rubber
36240	Conveyor or transmission belts or belting, of vulcanized rubber
36250	Rubberized textile fabrics, except tyre cord fabric
36260	Articles of apparel and clothing accessories (including gloves) of vulcanized rubber other than hard rubber
36270	Articles of vulcanized rubber n.e.c.; hard rubber; articles of hard rubber
363	Semi-manufactures of plastics
364	Packaging products of plastics
369	Other plastics products

Note: For codes other than 351, 361 & 362, the 5-digit classifications are not shown.

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Sample observation

Raw materials dataset

ID	year	product_code11	purchase_value	uv	qty	
0240008F	2011	2669	48218561	41.97802	865017.8	Other woven fabrics of cotton
0240008F	2011	26710	2649371	30	88312	Woven fabrics of man-made filament yarn, obtained from high tenacity yarn of nylon or other polyamides, of polyesters or of viscose rayon; woven fabrics of synthetic filament yar
0240008F	2012	2669	46018736	49.40823	679527	Other woven fabrics of cotton
0240008F	2012	26710	2845950	36.55	77865	Woven fabrics of man-made filament yarn, obtained from high tenacity yarn of nylon or other polyamides, of polyesters or of viscose rayon; woven fabrics of synthetic filament yar
0240008F	2013	2669	67070993	74.71748	728179.3	Other woven fabrics of cotton
0240008F	2014	2669	62055676	91.82945	330366.6	Other woven fabrics of cotton
0240008F	2015	2669	75771753	91.06703	462286.8	Other woven fabrics of cotton
0240008F	2016	2669	9570270	161.8727	44645.84	Other woven fabrics of cotton
0240008F	2016	26710	43363840	50	868493	Woven fabrics of man-made filament yarn, obtained from high tenacity yarn of nylon or other polyamides, of polyesters or of viscose rayon; woven fabrics of synthetic filament yar
0240008F	2017	26510	11335530	53	212715	Woven fabrics of silk or of silk wastes
0240008F	2017	26590	17726301	82133	216	Woven fabrics of other vegetable textile fibres; woven fabrics of paper yarn
0240008F	2017	2669	2658951	92	28930	Other woven fabrics of cotton
0240008F	2017	26710	20103389	46	440199	Woven fabrics of man-made filament yarn, obtained from high tenacity yarn of nylon or other polyamides, of polyesters or of viscose rayon; woven fabrics of synthetic filament yar

Products dataset

ID	year	product_c...	sales_val...	uv	qty	
0240008F	2011	26710	4.89e+07	173	274768	Woven fabrics of man-made filament yarn, obtained from high tenacity yarn of nylon or other polyamides, of polyesters or of viscose rayon; woven fabrics of synthetic fila
0240008F	2011	27180	2.45e+07	1598	14333	Quilts, eiderdowns, cushions, pouffes, pillows, sleeping bags and the like, fitted with springs or stuffed or internally fitted with any material or of cellular rubber or plastics
0240008F	2011	28250	1.38e+08	1385	92146	Garments made up of felt or nonwovens; garments made up of textile fabrics impregnated or coated with plastics, rubber or other materials
0240008F	2012	26710	4.66e+07	187	245806	Woven fabrics of man-made filament yarn, obtained from high tenacity yarn of nylon or other polyamides, of polyesters or of viscose rayon; woven fabrics of synthetic fila
0240008F	2012	27180	2.73e+07	1795	13933	Quilts, eiderdowns, cushions, pouffes, pillows, sleeping bags and the like, fitted with springs or stuffed or internally fitted with any material or of cellular rubber or plastics
0240008F	2012	28250	1.36e+08	1525	83843	Garments made up of felt or nonwovens; garments made up of textile fabrics impregnated or coated with plastics, rubber or other materials
0240008F	2013	28250	2.15e+08	1209.88	173936	Garments made up of felt or nonwovens; garments made up of textile fabrics impregnated or coated with plastics, rubber or other materials
0240008F	2014	28250	2.57e+08	1392	180980.4	Garments made up of felt or nonwovens; garments made up of textile fabrics impregnated or coated with plastics, rubber or other materials
0240008F	2015	28250	2.84e+08	1358	203525	Garments made up of felt or nonwovens; garments made up of textile fabrics impregnated or coated with plastics, rubber or other materials
0240008F	2016	28250	2.97e+08	1459.64	194318	Garments made up of felt or nonwovens; garments made up of textile fabrics impregnated or coated with plastics, rubber or other materials

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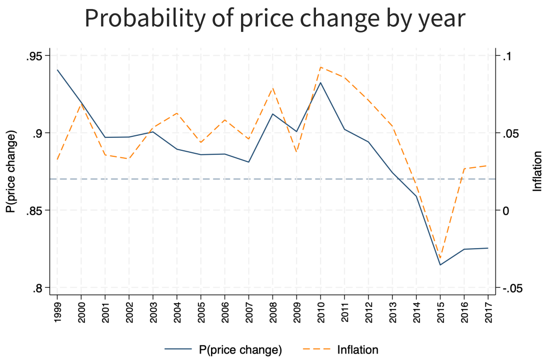
Input prices are also sticky



- P(price change) = 0.85 at annual freq. → 0.38 quarterly, 0.15 monthly

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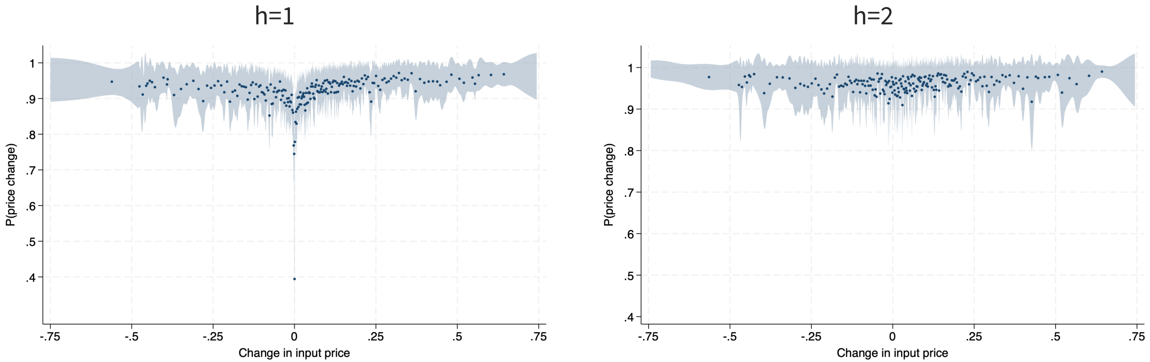
Probability of price change by input cost shock



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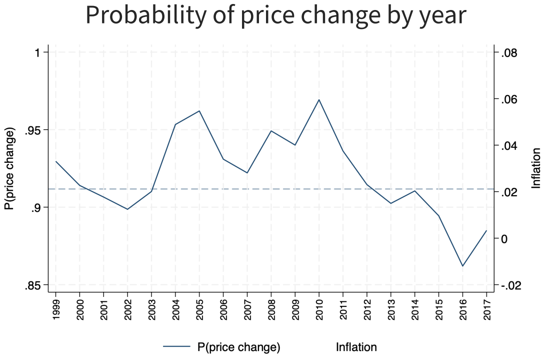
Price stickiness



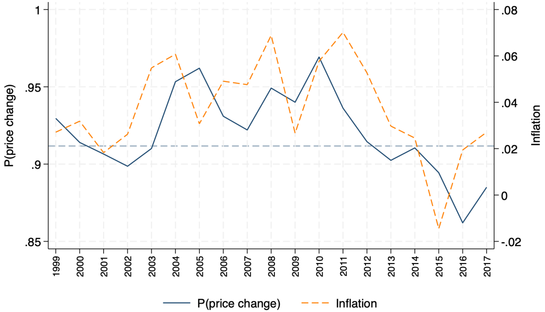
- $\mathbb{P}$(price change) = 0.91 at annual freq. → 0.45 quarterly, 0.18 monthly
  - Comparable to Gagnon 2009 (Mexico), Nakamura Steinsson Sun Villar 2018 (US), Alvarez Beraja Gonzalez-Rozada Neumeyer 2019 (Argentina) for similar inflation ranges
- Quarterly $\alpha = 0.55$

[Alternative estimation using dynamic passthrough] ▸

Heterogeneity | Input prices stickiness | By cost shock | Back

Price stickiness

Probability of price change by year



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[Alternative estimation using dynamic passthrough] ▸

Heterogeneity | Input prices stickiness | By cost shock | Back

Alternative estimation of α

Let us denote β_h^{IV} the IV-local projection coefficient at horizon h for a shock of persistence ρ_ϑ:

$$\beta_0^{IV} = \frac{1-\beta\alpha}{1-\beta\alpha\rho_\vartheta}(1-\alpha)\mathbb{E}_\lambda[\rho_i\zeta_i]$$

$$\beta_1^{IV} = \frac{1-\beta\alpha}{1-\beta\alpha\rho_\vartheta}\mathbb{E}_\lambda[\rho_i\zeta_i](1-\alpha)\left(\rho_\vartheta+\alpha\right)$$

Therefore,

$$\frac{\beta_1^{IV}}{\beta_0^{IV}} = \rho_\vartheta + \alpha \;\Rightarrow\; \alpha = 0.12$$

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Passthrough of cost shocks: Empirical strategy

$$\Delta \ln p_{ijt} = \alpha_{jt} + \beta \Delta \ln w_{it} + \varepsilon_{it}$$

- $\Delta \ln p_{ijt}$: change in the price of good j sold by firm i
- $\Delta \ln w_{it}$: change in the price index of variable inputs used by firm i
  - For observed inputs $\mathcal{K}$, define $\Delta \ln x_{it} = \sum_{k \in \mathcal{K}} \bar{s}_{ikt} \Delta \ln x_{ikt}$
  - $\Delta \ln w_{it} = \Delta \ln \mathcal{C}_{it} - \Delta \ln x_{it}$

- Instrument:
  - Let $\underline{\mathcal{K}}$ the set of inputs considered for the shift-share instrument
  - $\underline{\mathcal{K}} = \{$5-digit materials, coal, oil, electricity$\}$

$$\vartheta_{it} = \sum_{k \in \underline{\mathcal{K}}} s_{ik,t-1} \Delta \log w_{ikt}$$

- Identifying assumption:
  - Firms highly reliant on inputs with large $\Delta \log w_{ikt}$ do not experience systematically different demand shocks

→ Balance on firm characteristics

→ $\vartheta_{it} \perp$ demand shifter

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Passthrough of cost shocks: dynamic effect

	Δ^1 ln p					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Δ ln w	0.148***	0.107***	0.106***	0.375***	0.249***	0.246***
	(0.013)	(0.011)	(0.011)	(0.031)	(0.027)	(0.027)
Year FE	✓			✓		
Year × Product FE		✓	✓		✓	✓
Controls			✓			✓
Observations	205,722	203,140	203,140	205,430	202,849	202,849
F-stat				3324.7	2890.1	2890.4
Rescaled	.174	.125	.124	.441	.293	.29

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Passthrough of cost shocks: non-linearity?

	$\Delta \ln p$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln w$	0.223^{***}	0.223^{***}	0.221^{***}	0.219^{***}	0.222^{***}	0.231^{***}
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.018)
Year × Product FE	✓	✓	✓	✓	✓	✓
Observations	352934	340828	331435	304866	265128	200328
F-stat	5,273	5,223	5,206	5,231	4,836	4,506
Excl. band	None	[-0.005,0.005]	[-0.01,0.01]	[-0.025,0.025]	[-0.05,0.05]	[-0.10,0.10]

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Passthrough of cost shocks: Robustness

	Δ ln p					
Δ ln w	0.244**	0.217***	0.226***	0.237***	0.193***	0.201***
	(0.117)	(0.020)	(0.017)	(0.019)	(0.008)	(0.011)
Product × Year FE	✓	✓	✓	✓	✓	✓
Firm × Product FE		✓				
State × Year FE			✓			
Product × State × Year FE				✓		
Instrument	Alt.	Baseline	Baseline	Baseline	Baseline	Baseline
Weight	Baseline	Baseline	Baseline	Baseline	None	Sampling
Observations	255,331	297,514	352,933	305,623	357,986	357,986
F-stat	133.7	4018.9	5415.6	4521.9	20277.5	12451.7

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Passthrough of cost shocks: Firm-level

	Δ ln p					
	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
(sum) d0ln_me_Tq_qss	0.235^{***}	0.193^{***}	0.193^{***}			
	(0.014)	(0.014)	(0.014)			
Δ ln w				0.270^{***}	0.228^{***}	0.227^{***}
				(0.016)	(0.016)	(0.016)
Year FE	✓			✓		
Year × Ind FE		✓	✓		✓	✓
Controls			✓			✓
Observations	262,854	261,214	261,214	262,837	261,198	261,198
F-stat				5742.0	5470.5	5478.7

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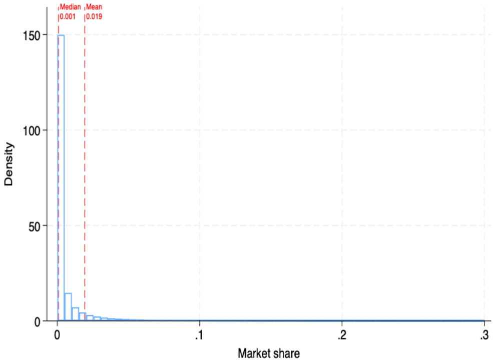
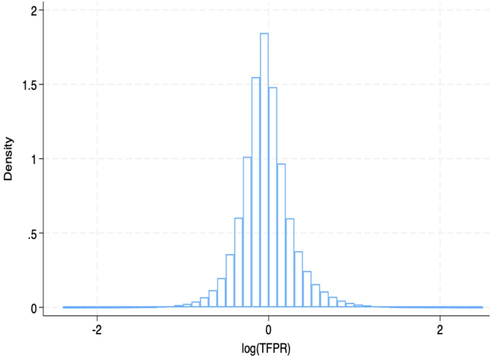
The pass-through of input cost shocks into prices is heterogeneous

Two relevant dimensions of heterogeneity

Distribution of market shares



Distribution of wedges



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Slope of short-run marginal cost curve: Empirical strategy

$$\Delta \ln mc_{it} = \alpha_{kt} + \beta \Delta \ln q_{it} + \varepsilon_{it}$$

- $\Delta \ln q_{it}$: change in the quantity sold by firm i
- $\Delta \ln mc_{it}$: change in the marginal cost of firm i: $\Delta \ln mc_{it} = \Delta \ln \mathcal{C}_{it} - \Delta \ln q_{it}$
  - Also consider $\Delta \ln \mathcal{C}_{it}$ as dependent variable

- Instrument:
  - $\Delta \ln sales_{jt}$: change in total sales of product j

$$\xi_{it} = \sum_{j \in \underline{\mathcal{J}}} s_{ij,t-1} \Delta \ln sales_{jt}$$

- Identifying assumption:
  - Firms specialized in products with high sales growth do not experience systematically different supply shocks

→ Balance on firm characteristics

→ $\xi_{it} \perp$ cost shifter

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Fact 4: Marginal costs increase fast in quantities

- Is capital really a fixed input?
- Additional controls: longitudinal FE, controlling for the supply shock
- Different weight
- local projections effect

Proofs for the laws of motion of $\hat{D}_t$ and $\hat{Z}_t$

Derivation of $\hat{D}_t$: log-linearizing the definition of the demand index

$$\hat{D}_t = -\mathbb{E}_\lambda[(\theta_i - 1)(\hat{p}_{it} - \hat{\mathcal{P}}_t)]$$

Derivation of $\hat{Z}_t$:

- Define the actual markup as: $\mu_{it}^a \equiv \frac{p_{it}}{mc_{it}}$
- By definition the the aggregate distortion and of the firm-level observed markup we can write (similar to Baqaee Fahri 2020):

$$\hat{Z}_t = a\left[\hat{\mathcal{M}}_t - \mathbb{E}_\lambda[\hat{\mu}_{it}^a]\right]$$

- Log-linearizing the definition of $\mathcal{M}_t$:

$$\hat{Z}_t = -\mathcal{M}\mathrm{Cov}_\lambda[((1+\tau_i)\mu_i)^{-1}, \hat{y}_{it}]$$

- Using the fact that the steady-state markup is given by the Lerner index and using the demand curve:

$$\hat{Z}_t = \mathcal{M}\mathbb{E}_\lambda[(1+\tau_i)^{-1}(\theta_i - 1)(\hat{p}_{it} - \hat{\mathcal{P}}_t)]$$

Obtaining the LOMs: combine with

$$\begin{aligned}
\hat{p}_{it} &= \mathbb{1}_{it}^p \hat{p}_{it|t}^{new} + (1 - \mathbb{1}_{it}^p)\hat{p}_{it-1} \\
\hat{p}_{it|t}^{new} &= (1-\beta\alpha)\left(\zeta_i\rho_i\left(\hat{mc}_t + (1-\phi)\tilde{\vartheta}_{it}^x\right) + (1-\zeta_i\rho_i)\hat{\mathcal{P}}_t\right) + \beta\alpha\mathbb{E}_t[\hat{p}_{it+1|t+1}^{new}]
\end{aligned}$$

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Identification of the slope of the Phillips curve: Case of a persistent shock

- If the input cost shock ϑ_{it}^{obs} is AR1 with persistence ρ_ϑ, then

$$\kappa^{IV} = (1-\alpha)\frac{1-\beta\alpha}{1-\beta\alpha\rho_\vartheta}\mathbb{E}_\lambda[\rho_i\zeta_i]$$

- The $h=1$ and $h=2$ local projection coefficients identify:

$$\kappa^{IV,\,h=1} = \frac{1-\beta\alpha}{1-\beta\alpha\rho_\vartheta}\mathbb{E}_\lambda[\rho_i\zeta_i](1-\alpha)\left(\rho_\vartheta+\alpha\right)$$

$$\kappa^{IV,\,h=2} = \frac{1-\beta\alpha}{1-\beta\alpha\rho_\vartheta}\mathbb{E}_\lambda[\rho_i\zeta_i](1-\alpha)(\rho_\vartheta^2+\alpha\rho_\vartheta+\alpha^2)$$

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Passthrough of marginal cost shocks

- What if we use ϑ_{it}^{obs} as an instrument for $\Delta \ln mc_{it}$?

$$\kappa^{IV} = (1 - \beta\alpha)(1 - \alpha)\frac{\mathbb{E}_\lambda[\rho_i \zeta_i]}{\mathbb{E}_\lambda[\zeta_i + (1 - \zeta_i)\alpha(1 + (1 - \alpha)\beta)]}$$

- Under the assumption of constant returns to scale:

$$\kappa^{IV} = (1 - \beta\alpha)(1 - \alpha)\mathbb{E}_\lambda[\rho_i]$$

- If prices are flexible:

$$\kappa^{IV} = \frac{\mathbb{E}_\lambda[\rho_i \zeta_i]}{\mathbb{E}_\lambda[\zeta_i]}$$

Aggregate Phillips curve for India

$$\pi_t^{ex.oil} = \kappa^y \tilde{y}_t + \beta \bar{\pi}$$

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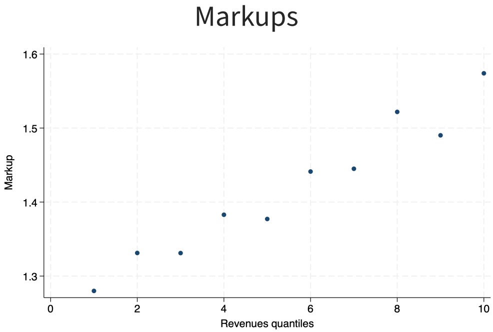
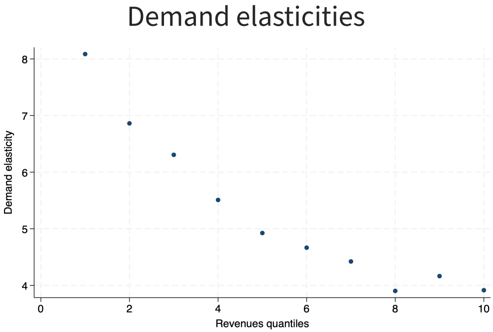
Markups and demand elasticities





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