Offshoring and Inflation

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Questions

1. Has globalization (trade integration) suppressed inflation?

   Corollary: will deglobalization let the inflation genie out of the bottle?

2. How has the rise of offshoring shaped the answer to question 1?

Has globalization suppressed inflation?

Policymakers think so: *"The integration of low-cost producers into the global economy has imparted a steady disinflationary bias."* [Carney (2019)]

Existing theory and evidence is incomplete (more in a bit).

We study trade & inflation in a New Keynesian framework with:

1. Offshoring: imported intermediate inputs.
2. Persistent (permanent?) changes in trade, phased in over time.
3. Trade shares as "sufficient statistics."
   - Changes in domestic sourcing proxy for relative price changes.
   - In data: domestic sourcing shares $\rightarrow$ producer and consumer prices.
   - In model: domestic sourcing shares = shocks $\rightarrow$ inflation.

We deploy the framework to study how rising trade has influenced inflation in the United States from mid-1990s to present.

Road Map

1. Motivation: linking trade to inflation in US data.
   - Output price inflation is lower for industries exposed to offshoring.
   - Accounting: consumer price level is 2-8% lower due to trade.

   But, data alone can't answer macro-counterfactual question.

2. In NK model with offshoring and imported final goods, **observed historical trade integration raises inflation**.
   - Reason 1: Trade *dynamics* shape inflation.
     Integration is persistent and phased-in over time.
   - Reason 2: In the US, offshoring is an important shock.

3. Three extensions to baseline model:
   (a) Financial shocks & US trade deficits.
   (b) Variable markups & pro-competitive effects of trade.
   (c) Multisector model to revisit motivating evidence.

Abbreviated Tour of Literature

Import Competition & Industry Prices

- Diff-in-diff design: import penetration $\uparrow \rightarrow$ sector-level prices $\downarrow$.
- Consumer Prices: Bai and Stumpner (2019), Jaravel and Sager (2019).
  Producer Prices: Auer and Fischer (2010), Auer et al. (2013).

Monetary Literature on Globalization & Inflation

- Phillips Curve: slope/shifts, 'global slack', inflation synchronization.
  Romer (1993), Rogoff (2003), Ball (2006), IMF WEO (2006), Rogoff (2007), Bianchi and Civelli (2015), Carney (2017), Auer et al. (2019), Forbes (2019).
- Existing work studies temporary shocks, mostly without input trade.

Trade Dynamics & Policy

- Real models with perfect foresight dynamics: Eaton et al. (2011), Reyes-Heroles (2016), Kehoe et al. (2018), Ravikumar et al. (2019).
- Trade in NK Models: Barbiero et al. (2018), Erceg et al. (2018), Barattieri et al. (2019), Rodríguez-Clare et al. (2020).

From Trade to Consumer Prices

Consumer prices $\leftrightarrow$ bundle of domestic and imported final goods.

1. The "Old" Channel: Trade in Consumption Goods
   - Falling prices for imported consumption goods, and substitution of imports for domestic goods, lowers consumer price level.
   - Import competition may also lower markups on domestic goods.
2. The "New" Channel: Offshoring and Trade in Inputs
   - Falling prices for imported inputs reduce domestic production costs. Substitution from domestic to foreign suppliers amplifies decline.
   - Lower production costs $\Rightarrow$ lower prices for domestic goods.
   - Exposure to offshoring: imported inputs + network linkages.

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   - Exposure to offshoring: imported inputs + network linkages.

For motivation, let's go look for these in US data...

Production-Side Prices

Two countries (H/F) and many industries ($s \in S$).

Output Price: $P_{Ht}(s) = \mu_t(s) MC_t(s)$

Marginal Costs: $MC_t(s) = Z_t(s)^{-1} W_t^{1-\alpha(s)} P_{Mt}(s)^{\alpha(s)}$

Composite Input: $P_{Mt}(s) = \prod_s P_t(s', s)^{\alpha(s',s)/\alpha(s)}$

Sourcing: $P_t(s',s) = \left[\gamma_H(s',s) P_{Ht}(s')^{1-\eta(s')} + \gamma_F(s',s) \left(\tau_{Mt}(s') P_{Ft}(s')\right)\right]^{\frac{1}{1-\eta(s')}}$

Domestic Sourcing Share: $\Lambda^M_{Ht}(s', s) = \frac{P_{Ht}(s') M_{Ht}(s',s)}{P_t(s',s) M_t(s',s)} = \left(\frac{P_{Ht}(s')}{P_t(s',s)}\right)^{1-\eta(s')}.$

Comment 1: We'll discuss complete multisector model with nominal rigidities later.
Comment 2: Cobb-Douglas assumptions simplify argument, but neither is necessary.

Price Changes for Domestic Output

$$\hat{\mathbf{p}}_{Ht} = [\mathbf{I} - \mathbf{A}']^{-1} [\mathbf{I} - \alpha] \hat{\mathbf{p}}_{Vt} + \left(\frac{1}{\eta - 1}\right) \underbrace{[\mathbf{I} - \mathbf{A}']^{-1} \left[\mathbf{A}' \circ \left(\hat{\lambda}^{M}_{Ht}\right)'\right] \iota}_{\text{Offshoring Shock}}.$$

where $\hat{x}_t = \ln X_t / X_0$, $\hat{\lambda}_{Ht}$ is a matrix with elements $\hat{\lambda}^{M}_{Ht}(s, s')$, and $\mathbf{A}$ is the IO matrix. $\hat{\mathbf{p}}_{Vt}$ is vector of sector-level GDP deflators. We set $\eta(s) = \eta$, for simplicity.

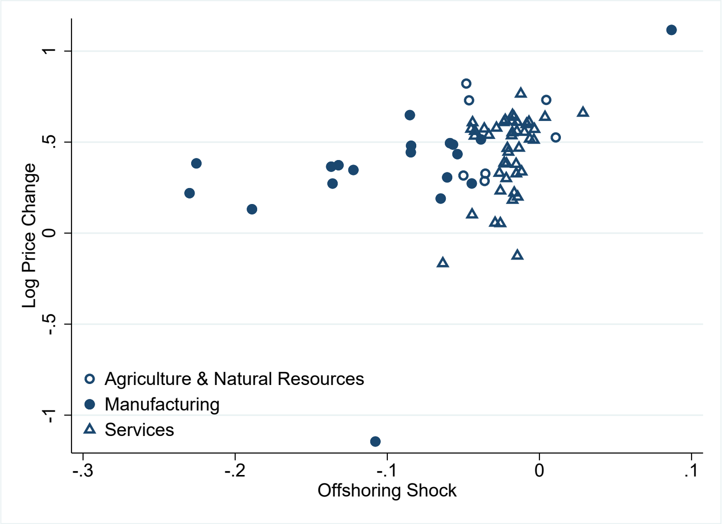
Plot $\hat{\mathbf{p}}_{Ht}$ vs. Offshoring Shock from 1997-2018 by industry.

Data from BEA Industry Economic Accounts

- Price of Gross Output by Industry.
- Annual Input-Output data for 71 industries.
  Includes data to compute $\mathbf{A}$ and $\hat{\lambda}^{M}_{Ht}$.

Producer Price Changes

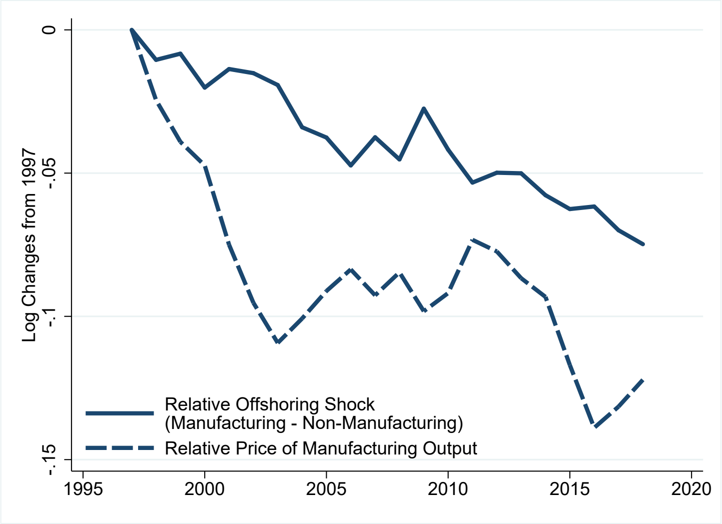
Plot $\hat{\mathbf{p}}_{Ht}$ vs. Offshoring Shock by industry in long differences (1997-2018).



Slope yields naive estimate $\eta \approx 1.5$.

The Relative Price of Manufacturing

Plot relative price and relative offshoring shock for manufacturing over time.



Relative price: $\frac{1}{|M|}\sum_{s\in M}\hat{\mathbf{p}}_{Ht}(s) - \frac{1}{|N|}\sum_{s\in N}\hat{\mathbf{p}}_{Ht}(s)$. Relative offshoring defined similarly.

Consumer Prices

Consumers have nested CES preferences.

Price Level: $\hat{p}_{Ct} = \sum_s \gamma(s)\hat{p}_{Ct}(s)$.

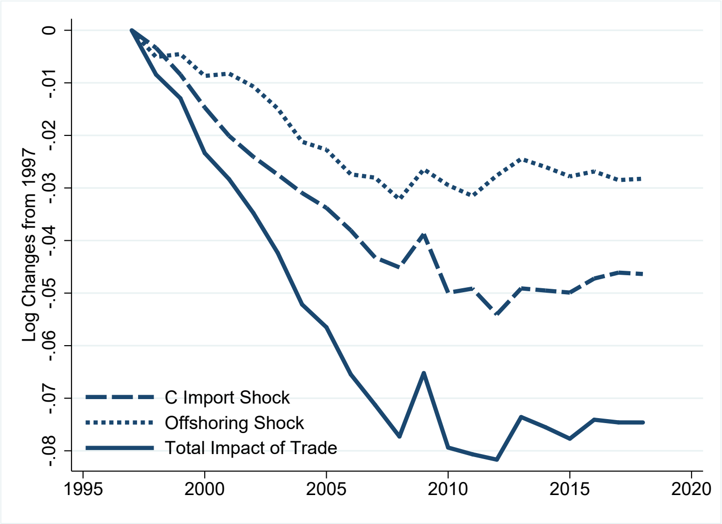
Sector-Level Prices: $\hat{p}_{Ct}(s) = \hat{p}_{Ht}(s) + \left(\frac{1}{\eta(s)-1}\right)\hat{\lambda}^C_{Ht}(s)$.

Combine and substitute for $\hat{\mathbf{p}}_{Ht}$:

$$\hat{p}_{Ct} = \gamma\left[\mathbf{I} - \mathbf{A}'\right]^{-1}\left[\mathbf{I} - \alpha\right]\hat{\mathbf{p}}^v_t + \underbrace{\left(\frac{1}{\eta-1}\right)\gamma\left[\mathbf{I} - \mathbf{A}'\right]^{-1}\left[\mathbf{A}' \circ \left(\hat{\lambda}^M_{Ht}\right)'\right]\iota}_{\text{Offshoring}} + \underbrace{\left(\frac{1}{\eta-1}\right)\gamma\hat{\lambda}^C_{Ht}}_{\text{C Imports}},$$

where γ is a row vector with elements $\gamma(s)$ and $\hat{\lambda}^C_{Ht}$ is a column vector with elements $\hat{\lambda}^C_{Ht}(s)$. Use industry CEX shares from IO data for γ. Set $\eta_C(s) = \eta_M(s) = 2$.

Trade & the Consumer Price Level



Offshoring $\approx$ 40% of total impact of trade.

Beyond Accounting

All together, results *suggest* imports restrain inflation.
Plus, both trade in inputs and final goods matter.

Big Caveat: this is accounting, not counterfactual analysis.

Two major threats to interpretation:

1. Domestic costs (value-added deflator) are endogenous to trade.
2. Inflation depends on monetary policy!

We need a model...

Model Sketch

Small Open Economy with:

- Continuum of producers under monopolistic competition (1 sector).
- CES production and demand structure.
- Representative consumer; separable consumption/leisure preferences.
- Complete international financial market.
- Pricing rigidities: Rotemberg adj. costs for domestic producers.
  Note: no assumption about currency invoicing of imports.
- Inflation targeting central bank.

Given historical trade shares, we can characterize retrospective impact of trade on inflation $\rightarrow$ sufficient statistics in the model.

Log-linear approximation to solve the model.

Production and Consumption

Let $\hat{x}_t = \ln X_t - \ln X_0$, where X_0 is initial steady state value.

Domestic Sourcing Shares:

$$\hat{\lambda}^C_{Ht} = (1-\eta)\left(\hat{p}_{Ht} - \hat{p}_{Ct}\right)$$
$$\hat{\lambda}^M_{Ht} = (1-\eta)\left(\hat{p}_{Ht} - \hat{p}_{Mt}\right)$$

Consumption & Input Use:

$$\hat{c}_{Ht} = \frac{\eta}{\eta-1}\hat{\lambda}^C_{Ht} + \hat{c}_t$$
$$\hat{m}_{Ht} = \frac{\eta}{\eta-1}\hat{\lambda}^M_{Ht} + \hat{m}_t$$
$$\hat{m}_t = \left(\widehat{mc}_t - \hat{p}_{Ht}\right) + \hat{y}_t - \frac{1}{\eta-1}\hat{\lambda}^M_{Ht}$$
$$\widehat{mc}_t - \hat{p}_{Ht} = (1-\alpha)\left[\hat{w}_t - \hat{p}_{Ht}\right] + \frac{\alpha}{\eta-1}\hat{\lambda}^M_{Ht} - \hat{z}_t$$

Labor and Goods Markets

Labor Market:

$$\hat{l}_t = -\frac{\rho}{\psi}\hat{c}_t + \frac{1}{\psi}\left(\hat{w}_t - \hat{p}_{Ht}\right) - \frac{1}{\psi(\eta-1)}\hat{\lambda}^C_{Ht}$$

$$\hat{l}_t = -\alpha\left[\hat{w}_t - \hat{p}_{Ht}\right] + \frac{\alpha}{\eta-1}\hat{\lambda}^M_{Ht} + \hat{y}_t - \hat{z}_t$$

Goods Market:

$$\hat{y}_t = \left(\frac{C_{H0}}{Y_0}\right)\hat{c}_{Ht} + \left(\frac{M_{H0}}{Y_0}\right)\hat{m}_{Ht} + \left(\frac{X_0}{Y_0}\right)\hat{x}_t$$

$$\hat{x}_t = \frac{\eta}{\eta-1}\hat{\lambda}^C_{Ht} + \eta\hat{q}_t + \hat{c}^*_t$$

Closing the Model

Euler Equation: $\hat{c}_t = E_t \hat{c}_{t+1} - \frac{1}{\rho} \left(\hat{r}_t - E_t \pi_{Ct+1} \right)$

Monetary Policy Rule: $\hat{r}_t = \omega \pi_{Ct}$

Domestic Phillips Curve: $\pi_{Ht} = \left(\frac{\epsilon - 1}{\phi} \right) \left(\widehat{mc}_t - \hat{p}_{Ht} \right) + \beta E_t \left(\pi_{Ht+1} \right)$

Consumer Price Inflation: $\pi_{Ct} = \pi_{Ht} + \frac{1}{\eta - 1} \left(\hat{\lambda}^C_{Ht} - \hat{\lambda}^C_{Ht-1} \right)$

Risk Sharing: $\hat{c}_t = \hat{c}^*_t + \frac{1}{\rho} \hat{q}_t$

Equilibrium: Given $\{\hat{\lambda}^C_{Ht}, \hat{\lambda}^M_{Ht}, \hat{z}_t, \hat{c}^*_t\}$, an equilibrium is a collection of prices $\{\hat{q}_t, \pi_{Ct}, \pi_{Ht}, \hat{r}_t, \hat{w}_t - \hat{p}_{Ht}, \widehat{mc}_t - \hat{p}_{Ht}\}$ and quantities $\{\hat{c}_t, \hat{c}_{Ht}, \hat{l}_t, \hat{m}_t, \hat{m}_{Ht}, \hat{x}_t, \hat{y}_t\}$ that satisfies the previous equations.

The Experiment

Domestic sourcing shares change permanently.

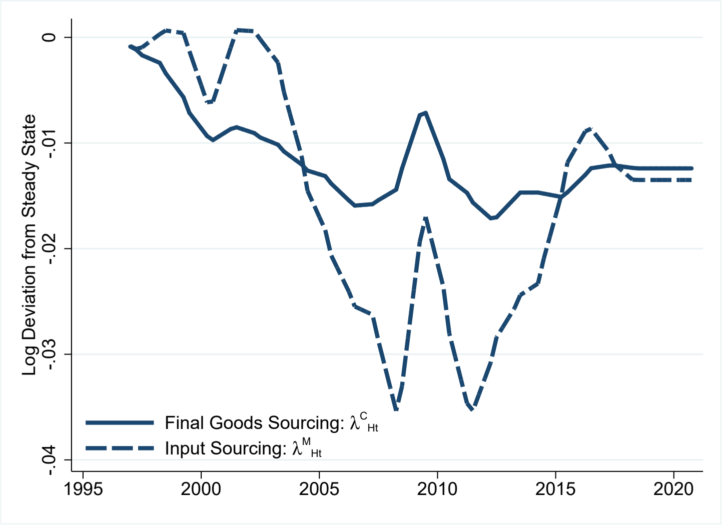
$\Rightarrow$ the equilibrium is non-stationary.

We will solve for linear dynamics under perfect foresight.

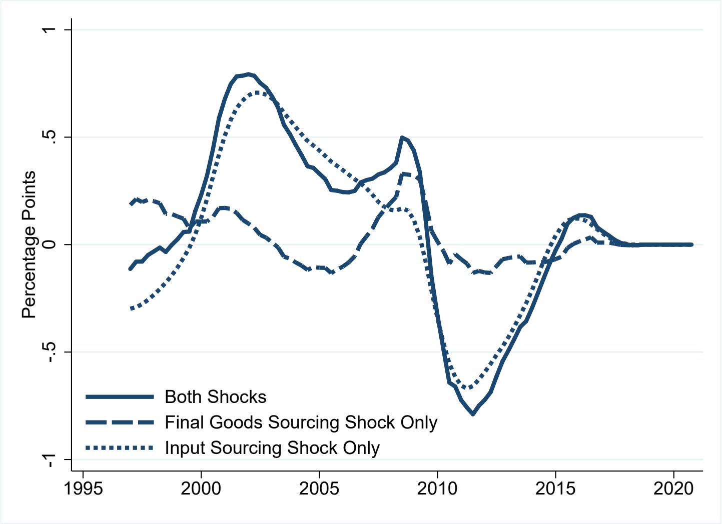
- Date 0 in initial steady state.
  Agents assume domestic sourcing shares will remain constant.
- Date 1 agents learn that globalization is happening
  i.e., they learn future path for domestic sourcing shares.
- Reoptimize and converge to new long run equilibrium.

For reference: $\eta = 3$, which scales the size of the shocks.
Macro-parameters are standard; others set to match US in 1996Q4.

The Shocks: Domestic Sourcing Shares



Inflation



Cumulatively, price level rises by 8% (40bps/yr).

Model vs. Conventional Wisdom

In the model:

Pre-Great Recession: globalization triggers inflation.

Post-Great Recession: retreat of globalization dampens inflation.

Model results $\neq$ conventional wisdom:

Carney (2017) "The integration of lower-cost producers into the global economy acts like an increase in potential supply for advanced economies. . . The series of positive shocks from increased. . . integration cause parallel shifts down in the **Phillips Curve**."

See also IMF WEO (2006), Yellen (2006), Bean (2007).

The Supply Side: Phillips Curve

Consumer Price Inflation: $\pi_{Ct} = \pi_{Ht} + \frac{1}{\eta-1} \Delta \hat{\lambda}_{Ht}^{C}$.

Domestic Price Inflation: $\pi_{Ht} = \Gamma \left(\hat{y}_t - \hat{y}_t^n \right) + \beta E_t \left(\pi_{Ht+1} \right)$.

Phillips Curve: $\pi_{Ct} = \Gamma \left(\hat{y}_t - \hat{y}_t^n \right) + \beta E_t \pi_{Ct+1} + \frac{1}{\eta-1} \left(\Delta \hat{\lambda}_{Ht}^{C} - \beta E_t \Delta \hat{\lambda}_{Ht+1}^{C} \right)$.

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Expected result for domestic sourcing for *consumer goods*.

- $\Delta\hat{\lambda}^{C}_{Ht} < 0$ shifts Phillips Curve down.
- This is manifestation of supply shock (terms of trade) story.

Unexpected result: Input sourcing doesn't matter.

- Foreign sourcing lowers costs, but doesn't directly change π_{Ht}.
- Phillips Curve logic is incomplete: globalization $\leftrightarrow$ offshoring.

The Demand Side: IS Curve

IS Curve: $(\hat{y}_t - \hat{y}_t^n) = -\frac{1}{\theta\rho}\left(\hat{\tilde{r}}_t - \hat{\tilde{r}}_t^n\right) + E_t\left(\hat{y}_{t+1} - \hat{y}_{t+1}^n\right)$.

Real Interest Rate: $\hat{\tilde{r}}_t \equiv \hat{r}_t - E_t \pi_{Ct+1}$.

Real Natural Interest Rate: $\hat{\tilde{r}}_t^n \equiv -E_t\left(\Upsilon_M \Delta\hat{\lambda}_{Ht+1}^M + \Upsilon_C E_t \Delta\hat{\lambda}_{Ht+1}^C\right)$.

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Trade shocks are embedded in the real natural interest rate.

- Expected declines in domestic sourcing raise real natural rate. Mechanics run through consumption: $\Delta\hat{c}_{t+1}^n > 0 \Rightarrow \hat{\hat{r}}_t^n \uparrow$.
- $\hat{\hat{r}}_t^n \uparrow \Rightarrow$ raises "aggregate demand." Think: shifts the IS curve right, raising output gap.

<u>Punchline</u>: expected future globalization raises aggregate demand today, raising output gap and triggering inflation.

Three Extensions

1. Financial Inflow Shocks (with incomplete markets).
2. Variable Markups & Pro-Competitive Effects of Trade.
3. Multisector Model: Revisiting stylized facts about prices.

Financial Inflow Shocks

Motivation: Global Savings Glut.

We have shown that trade integration raises the real natural interest rate; most think that global savings glut forces drove it down.

Does adding shocks to match US trade deficits alter π-results?

Short answer: **no**.

In fact, anticipated increases in the trade deficit drive up inflation.

See the paper for concise explanation in three equation model.

Pro-Competitive Effects of Trade

Motivation: imports lower domestic markups & sector-level price growth.

[Auer and Fischer (2010), Feentra and Weinstein (2017), Jaravel and Sager (2019)]

Do pro-competitive effects lower inflation? How much?

Allow variable (flex price) markups via Kimball Demand.

Consumption: $\nu \int_0^1 \Upsilon\left(\frac{C_{Ht}(i)}{\nu C_t}\right) di + (1-\nu)\int_0^1 \Upsilon\left(\frac{C_{Ft}(i)}{(1-\nu)C_t}\right) di = 1.$

Inputs: $\xi \int_0^1 \Upsilon\left(\frac{M_{Ht}(i)}{\xi M_t}\right) di + (1-\xi)\int_0^1 \Upsilon\left(\frac{M_{Ft}(i)}{(1-\xi)M_t}\right) di = 1.$

Assume $\Upsilon(\cdot)$ is incomplete gamma function.

- $\sigma \leftrightarrow$ steady-state elasticity.
- $\epsilon \leftrightarrow$ elasticity of demand elasticity.
- See Klenow and Willis (2016) and Gopinath et al. (2020).

Three Insights

1. Sufficient statistic approach to model analysis goes through.
   - Why? Log-linear approximation to demand has constant elasticity.
   - Nonetheless, markups are variable.

2. Trade integration "looks like" a markup shock in Phillips Curve.

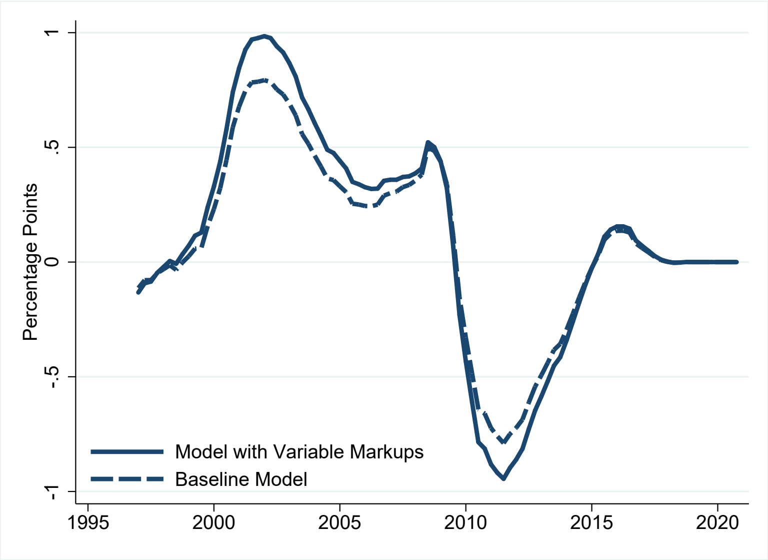
$$\pi_{Ht} = -\frac{1}{\phi}\hat{\epsilon}_{Ht} + \left(\frac{\epsilon_{H0}-1}{\phi}\right)\widehat{rmc}_t + \beta E_t\left(\pi_{Ht+1}\right),$$

$$\text{with} \quad \hat{\epsilon}_{Ht} = -\left(\frac{\varepsilon}{\sigma-1}\right)\left[\frac{C_{H0}}{Y_{H0}}\hat{\lambda}^C_{Ht} + \frac{M_{H0}}{Y_{H0}}\hat{\lambda}^M_{Ht}\right]$$

   Think "supply shock" in macro-terminology.

3. Pro-competitive effects manifest as "demand shock" too!
   - Markups distort output down, through supply/use of factors. Thus, reductions in markups have expansionary output effects.
   - Anticipated declines in markups raise real natural interest rate.

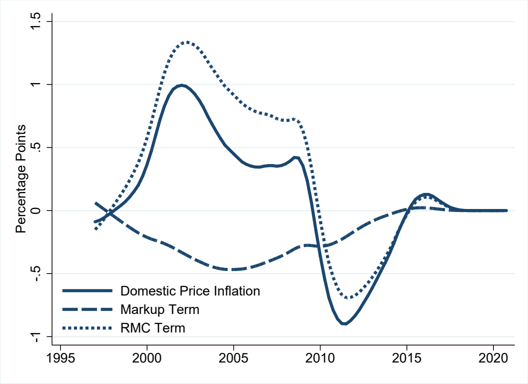
Inflation with Pro-Competitive Trade Integration



Markup Reductions Do Restrain Inflation

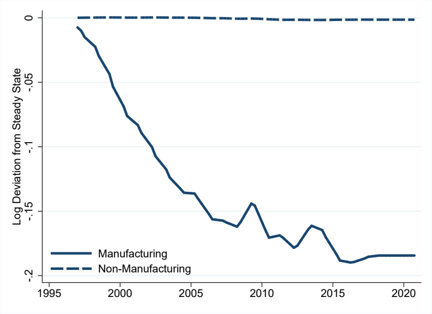
But GE Effects on Real Marginal Costs Dominate

$$\pi_{Ht} = \underbrace{-\frac{1}{\phi}\sum_{s=0}^{\infty}\beta^s E_t\left[\hat{\epsilon}_{Ht+s} - \hat{\epsilon}_{HT}\right]}_{\text{Markup Term}} + \underbrace{\left(\frac{\epsilon_{H0}-1}{\phi}\right)\sum_{s=0}^{\infty}\beta^s E_t\left[\widehat{rmc}_{t+s} - \widehat{rmc}_T\right]}_{\text{RMC Term}}$$

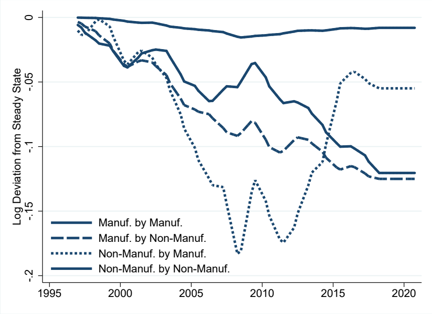


Multisector Model

Motivation: heterogeneous integration across sectors.



(a) Domestic Sourcing: Final Goods

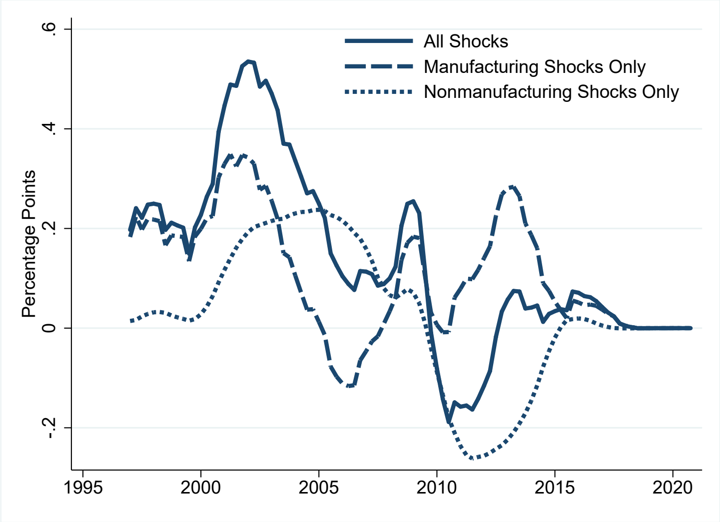


(b) Domestic Sourcing: Inputs

How does heterogeneity influence aggregate π?
Are rel. price and P-level accounting results consistent with $\pi > 0$?

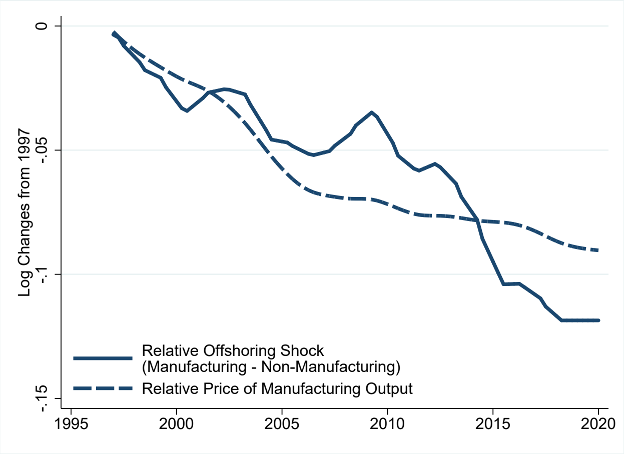
Inflation in Multisector Model

Skipping details . . . model is two sector version of baseline model.



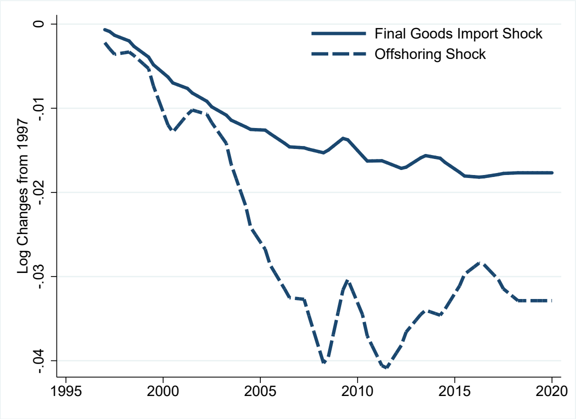
Relative Price of Manufacturing Output

$$\pi_{Ht} = \left[\mathbf{I} - \mathbf{A}'\right]^{-1}\left[\mathbf{I} - \alpha\right]\pi_{Vt} + \left(\frac{1}{\eta - 1}\right)\underbrace{\left[\mathbf{I} - \mathbf{A}'\right]^{-1}\left[\mathbf{A}' \circ \Delta\hat{\lambda}'_{Ht}\right]\iota}_{\text{Offshoring Shock}}$$



Inflation Accounting

$$\pi_t = \gamma \left[\mathbf{I} - \mathbf{A}'\right]^{-1} \left[\mathbf{I} - \alpha\right] \pi_{Vt} + \underbrace{\left(\frac{1}{\eta - 1}\right) \gamma \left[\mathbf{I} - \mathbf{A}'\right]^{-1} \left[\mathbf{A}' \circ \Delta \hat{\lambda}'_{Ht}\right] \iota}_{\text{Offshoring}} + \underbrace{\left(\frac{1}{\eta - 1}\right) \gamma \Delta \hat{\lambda}^{C}_{Ht}}_{\text{Final Goods Imports}}$$



Takeaway: neither relative price changes, nor inflation accounting decompositions are informative about the ultimate impact of trade on inflation.

Final Thoughts

This paper surprised us too!

Offshoring and trade dynamics matter for π-dynamics
...just not the way "we" thought.

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