The Missing Inflation Puzzle: The Role of the Wage-Price Pass-Through[1]

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[1]The views expressed in this paper are those of the author(s) and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

Sluggish price inflation in the aftermath of the Great Recession

- Inflation remained subdued following the Great Recession
  - below the Fed's 2% target despite historically low unemployment

- What explains this *missing* inflation?
  - Slack beyond unemployment: Moscarini and Postel-Vinay (2017), Abraham et al. (2020), Faberman et al. (2020)
  - Anchored expectations: Del Negro et al. (2015), Carvalho et al. (2017), Coibion et al. (2019)
  - Anchored expectations and low u*: Crump et al. (2019)
  - Boehm and Pandalai-Nayar (2020): Convex supply curves and declining capacity utilization

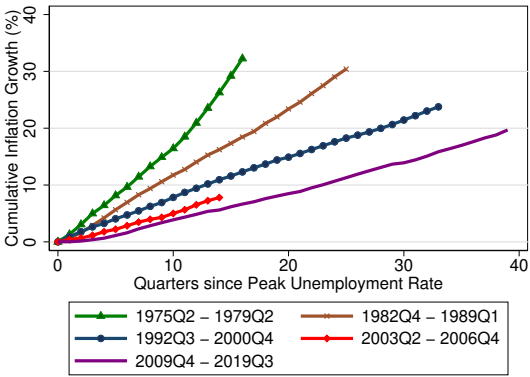
This paper: focus on *declining* pass-through from wages to prices in the goods sector

What we do (and find)

- Analyze aggregate data on unemployment, wages, and inflation
  - show that *missing* inflation is mostly due to core goods inflation
  - which is due to declining pass-through from wages to prices
- Propose two explanations for low pass-through
  - increase in import competition
  - increase in market concentration
- Set up a theoretical framework à la Atkeson and Burstein (2008)
- Analyze pass-through at the industry-level
  - significant pass-through of wage changes to producer prices in services but no pass-through in manufacturing after 2003
- Find lower pass-through in industries with higher import competition and concentration
  - both could reflect the same underlying mechanism as argued in Amiti and Heise (2020)

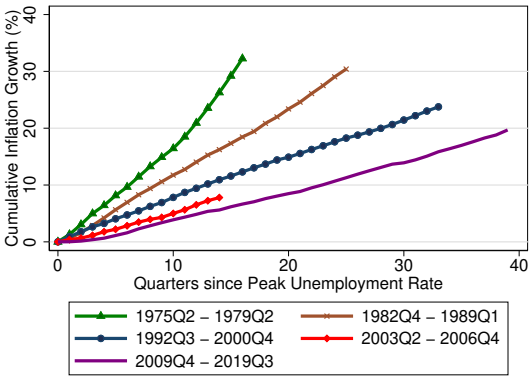
Aggregate Facts

Inflation in Economic Expansions



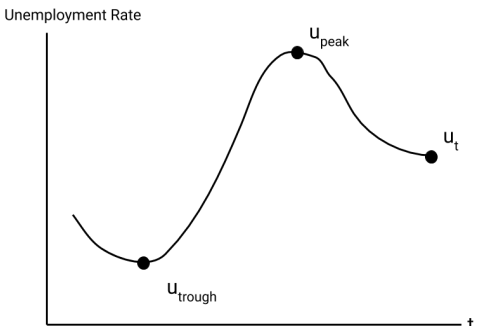
- Inflation has become slower to pick up over time

Inflation in Economic Expansions



- Inflation has become slower to pick up over time
- Speed of labor market recoveries vary across expansions

Was inflation slow to pick up because the labor market was slow to recover?

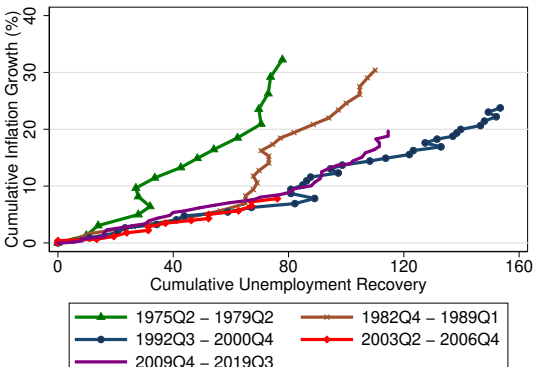


- Define *cumulative unemployment recovery*

$$URecovery_t = \frac{u_{peak} - u_t}{u_{peak} - u_{trough}}$$

- It is the share of the rise in u during the recession that has been reversed during the expansion
- Study the evolution of prices and labor costs relative to $URecovery_t$

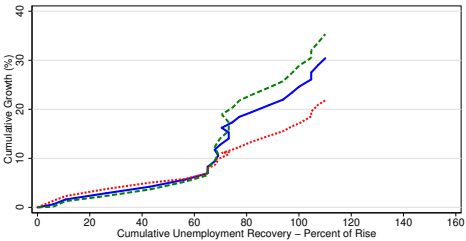
Inflation During Expansions



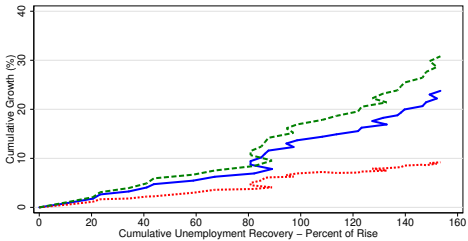
- Inflation has become slower to pick up over time
- Speed of labor market recoveries account for part of the change
- Inflation expectations important

Inflation vs. Unemployment in the Last Four Expansions

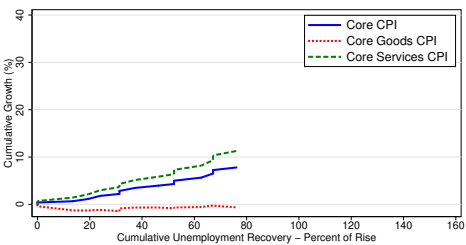
1982-1990



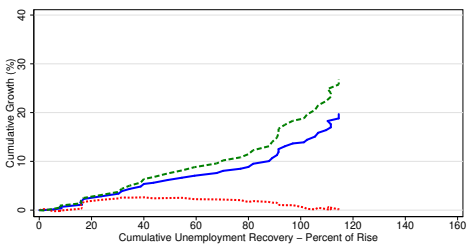
1991-2000



2003-2007



2009-2020



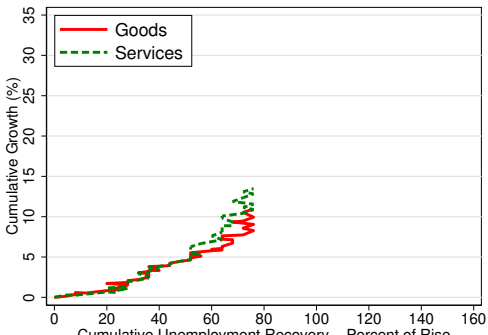
Inflation vs. Unemployment in the Last Four Expansions

- Inflation in services picks up as the unemployment recovery gap closes
- Weakening of inflation/unemployment relationship largely due to goods prices
  - Counterfactual that applies the 1982-1990 path for core goods inflation to the 2009-2020 period closes more than half of the inflation gap between these two expansions
- Changing nature of goods vs. services inflation is important in understanding *missing inflation*
- Evolution of wages (and unit labor costs) in the last two expansions suggests that it is pass-through

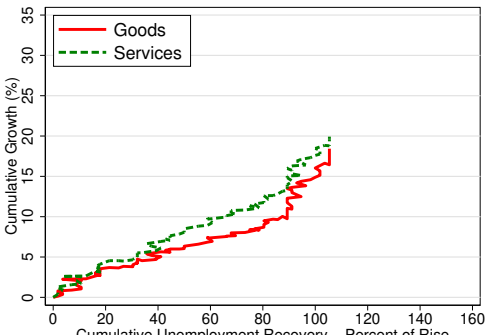
Counterfactual E-to-Pop Ratio Over Time

Wages in Goods and Services: 2003-2007 and 2009-2020

2003-2007



2009-2020



Unit Labor Costs

Aggregate Pass-Through

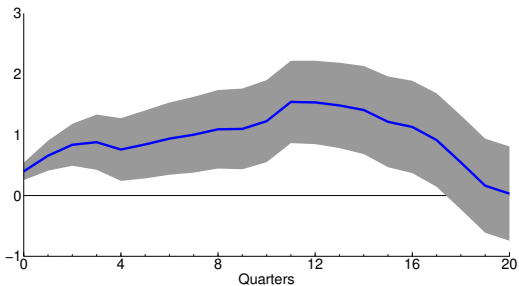
Estimate Jordà's local projections for each quarter $h = 0, ..., 20$

$$\boldsymbol{\pi}^{\mathbf{price}}_{\boldsymbol{t+h}} = \alpha + \boldsymbol{\beta_h}\boldsymbol{\pi}^{\mathbf{wage}}_{\boldsymbol{t}} + \sum_{j=1}^{8} \delta_j \pi^{\text{price}}_{t-j} + \sum_{j=1}^{8} \zeta_j \pi^{\text{wage}}_{t-j} + \eta z_t + \epsilon_t,$$

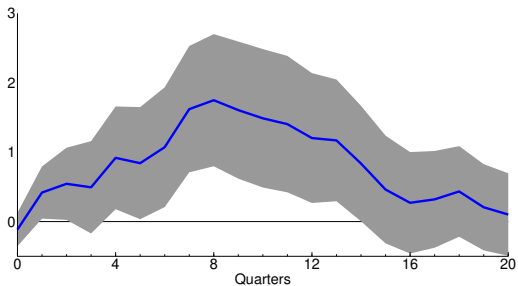
- Use Core CPI (1964-2019) and *Core* goods PPI (1974-2019)
- Use average hourly earnings of production and supervisory workers
- Control for the CBO unemployment gap, z_t
- Interpret $\boldsymbol{\beta_h}$ as conditional correlations

Aggregate pass-through has on average been high...

Impulse Response of Core CPI to Earnings

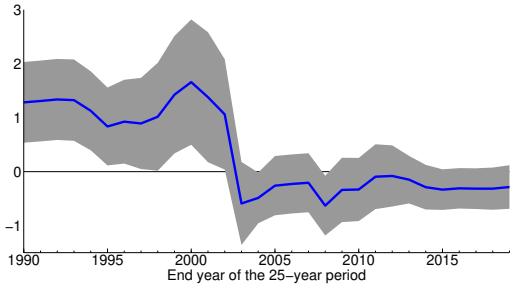


Impulse Response of Core PPI to Earnings

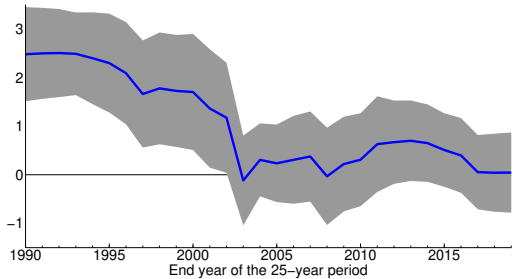


...but disappeared in the early 2000s

Pass-Through to Core CPI



Pass-Through to Core PPI



- Peak pass-through from wages to prices disappeared
- Consider rising import competition and increasing concentration

PPI to CPI

Pass-through from Wages to Prices
Theoretical Framework

Economic Environment

- Imperfect competition with variable markups as in Atkeson and Burstein (2008)
- Two sectors, indexed by s, goods and services, populated by a continuum of industries, indexed by k
- Finite number of firms indexed by i in industry k, each face the demand curve for its variety

$$y_s(k,i) = p_s(k,i)^{-\eta} p_s(k)^{\eta-\sigma} P_s^{-\sigma} Y_s$$

  - η: elasticity of substitution across varieties
  - σ: elasticity of substitution between industries
  - Assume $\eta > \sigma > 1$
  - $p_s(k) = \left(\sum_{i=1}^{N_s(k)} p_s(k,i)^{1-\eta}\right)^{1/(1-\eta)}$ is industry k's price index

Price Setting

- Production using capital and labor at marginal cost of

$$mc = \frac{1}{A} w^{\alpha} r^{1-\alpha}$$

- Optimal price setting implies

$$p_s(k,i) = \underbrace{\frac{\mathcal{E}_s(k,i)}{\mathcal{E}_s(k,i)-1}}_{\mathcal{M}_s(k,i)=markup} \frac{1}{A} w^{\alpha} r^{1-\alpha}$$

- Demand elasticity depends on firm i's market share $\varphi_s(k,i)$ in industry k

$$\mathcal{E}_s(k,i) = \eta(1-\varphi_s(k,i)) + \sigma\varphi_s(k,i)$$

- Firms take into account their effect on the industry's price index
  $\longrightarrow$ firms with a larger market share set higher markups since $\eta > \sigma > 1$

Pass-through from Wages to Prices

Pass-through of shocks into prices

$$d \log p_s(k,i) = d \log \mathcal{M}_s(k,i) - d \log A + \alpha d \log w_i + (1-\alpha) d \log r$$

- Increases in the factor prices pass through in proportion to their shares
- Productivity growth allows the firm to lower its price
- Pass-through depends on the adjustment of firm's markup

Linking Changes in Market Structure to Pass-through

Theorem

Consider an industry populated by $N_D \geq 1$ domestic firms and $N_F \geq 1$ foreign firms with symmetric market shares. Consider a wage shock which only affects domestic firms.

1. *If $N < \infty$, pass-through is less than α. As $N = N_D + N_F$ declines and firms' market share increases, pass-through of the shock declines.*

2. *A higher share of domestic firms in the industry, N_D/N, increases pass-through.*

Implications

Rising market concentration ⟶ reduces pass-through

- firms become more sensitive to strategic interaction with competitors
- they adjust markups more to maintain market share

Foreign competition ⟶ reduces pass-through

- fewer competitors experience the cost shock
- firms absorb more of the shock into their markups to keep market share

Intuition

Industry-level Analysis

Empirical Framework

Empirical specification:

$$\boldsymbol{\Delta \ln(p_{it})} = \boldsymbol{\beta \Delta \ln(w_{it})} + \zeta \ln A_{it} + \gamma X_{it} + \delta_i + \rho_t + \epsilon_{it}$$

p_{it}: producer price index in industry i and period t

Δw_{it}: change in industry i's wage index

- **Period:** 2003-2016
- **Prices:** Industry-level Producer Price Index (PPI) for 255 5-digit NAICS industries (148 in manufacturing)
- **Wages:** Weekly earnings from QCEW
- **TFP:** Multifactor productivity (MFP) from the BLS/KLEMS
- **Controls:** Age, gender, and education composition from the QCEW

Pass-Through in Services and Manufacturing: 2003-2016

	(1) All	(2) Manuf/Serv
Δ Wage	0.0616***	
	(0.0167)	
Δ Wage Manuf		0.0216
		(0.0186)
Δ Wage Services		0.0917***
		(0.0286)
Δ TFP	-0.0793***	-0.0757***
	(0.0149)	(0.0141)
Time Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
R2	0.0184	0.0197
Observations	12727	12727

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- Positive pass-through driven by services
- Negligible pass-through in manufacturing
- IV strategy using newly available job-to-job transitions data confirms these findings
- Impulse responses show that pass-through is negligible at most horizons in manufacturing but positive in services

IV Impulse Responses

Pass-Through Controlling for the Labor Share: 2003-2016

	(1) All	(2) Manuf/Serv
Δ Wage × LS	0.182**	
	(0.0760)	
Δ Wage × LS Manuf		0.0581
		(0.108)
Δ Wage × LS Services		0.197**
		(0.0852)
Δ TFP	-0.0788***	-0.0778***
	(0.0155)	(0.0155)
Time Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
R2	0.0169	0.0170
Observations	12727	12727

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- Manufacturing has a lower labor share and experienced a more pronounced decline in its labor share
- Lack of pass-through in manufacturing is not due to its declining labor share
- 20% pass-through for services

Disappearing Pass-through in Manufacturing: 1993-2003 vs. 2003-2016

	(1) All	(2) Pre/Post
Δ Wage × LS	0.1402	
	(0.1055)	
Δ Wage × LS × $Pre-2003$		0.311**
		(0.138)
Δ Wage × LS × $Post-2003$		-0.0607
		(0.155)
Δ TFP	-0.179***	-0.177***
	(0.0196)	(0.0195)
Time Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
R2	0.0431	0.0418
Observations	12913	12913

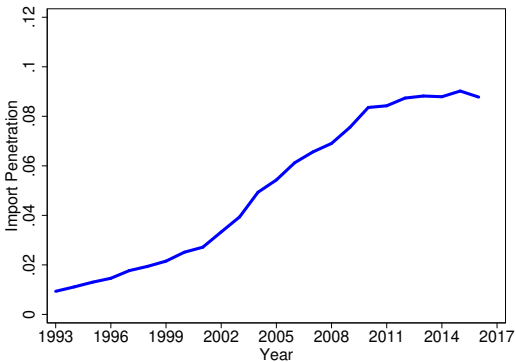
Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- Can estimate pass-through for the 1993-2003 period for manufacturing
- Positive pass-through in manufacturing in the pre-2003 period
- The disappearance of pass-through coincides with the flattening of core goods inflation

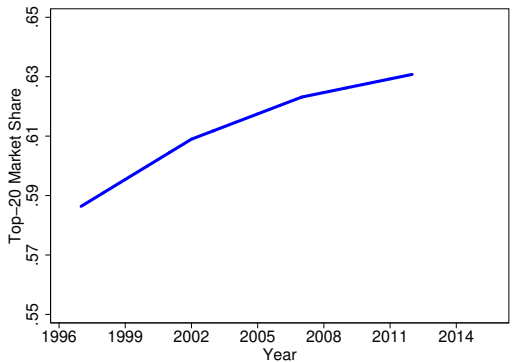
Why did Pass-through Disappear in Manufacturing?

Rising Import Competition and Increasing Concentration

Import penetration from China



Market share of top 20 firms



Import Penetration Channel

Recall that foreign competition $\longrightarrow$ reduces pass-through in our framework

- fewer competitors experience the cost shock and firms absorb more of the shock into their markups to keep market share

Define industry i's import penetration from China as

$$\boldsymbol{IP_{it}^{CN}} = \frac{\text{Imports}_{it}^{CN}}{\text{Sales}_{it} - \text{Exports}_{it} + \text{Imports}_{it}}$$

Estimate the modified pass-through regression

$$\boldsymbol{\Delta \ln(p_{it})} = \beta_0 \Delta \ln(w_{it}) + \boldsymbol{\beta_1 \Delta \ln(w_{it}) * IP_{it}^{CN}} + \alpha IP_{it}^{CN} + \zeta \ln A_{it} + \gamma X_{it} + \delta_i + \rho_t + \epsilon_{it}$$

where IP_{it}^{CN} is industry i's import penetration from China in year t.

Pass-Through and Import Penetration

	(1) IP	(2) $\Delta \text{IP}_{97,t}$
Δ Wage	0.0247*	0.0245*
	(0.0139)	(0.0137)
Δ Wage × IP	-0.128*	
	(0.0662)	
Δ Wage × $\Delta IP_{97,t}$		-0.115*
		(0.0658)
Δ TFP	-0.169***	-0.170***
	(0.0196)	(0.0196)
Time Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
R2	0.0375	0.0382
Observations	12398	12305

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- Industries that experience high import penetration from China exhibit relatively lower pass-through.
- An industry without imports exhibits a pass-through from wages to prices of about 2.5%.
- Effect is similar in magnitude when considering change in import penetration from China since 1997.

Market Concentration Channel

- Several recent papers have focused on the role of rising market concentration on the aggregate economy (e.g., Gutierrez and Philippon, 2017, Autor et al., 2020)
- Rise in market concentration lowers pass-through from labor costs to prices: firms with higher market share internalize more the effects of price changes on market share $\longrightarrow$ adjust markups more to maintain their competitive position

Estimate the effect of rising market concentration on pass-through:

$$\boldsymbol{\Delta \ln(p_{it})} = \beta_0 \Delta \ln(w_{it}) + \boldsymbol{\beta_1 \Delta \ln(w_{it}) * C_{it}} + \alpha C_{it} + \zeta \ln A_{it} + \gamma X_{it} + \delta_i + \rho_t + \epsilon_{it}$$

where C_{it} is the measure of concentration.

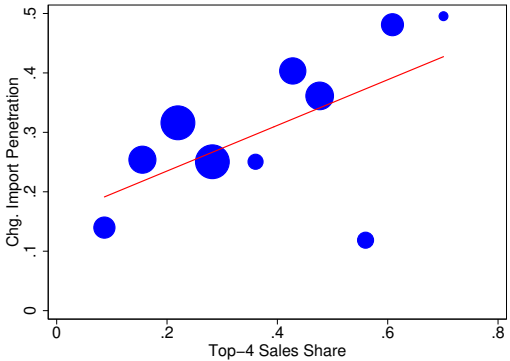
Pass-Through and Sales Concentration

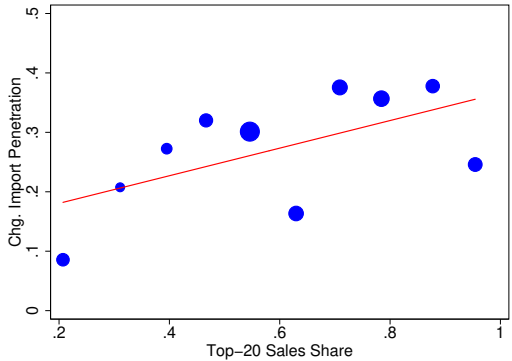
	(1) Top-4	(2) Top-20	(3) HHI
Δ Wage	0.143***	0.177***	0.114***
	(0.0347)	(0.0574)	(0.0279)
Δ Wage × SC 4	-0.205***		
	(0.0566)		
Δ Wage × SC 20		-0.185**	
		(0.0762)	
Δ Wage × Sales HHI			-0.690***
			(0.233)
Δ TFP	-0.181***	-0.182***	-0.182***
	(0.0205)	(0.0204)	(0.0211)
Time Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
R2	0.0626	0.0588	0.0623
Observations	8705	8705	8585

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- The effect of market concentration is negative and significant for all measures of market concentration.
- Going from the 25th to the 75th percentile of top-4 concentration (20% to 48%) lowers pass-through by about a third (−0.057).

Import Penetration Or Market Concentration?





Reference: Amiti and Heise (2020)

Concluding Remarks

- Change in behavior goods inflation changed in the 2000s
  - due to declining pass-through from wages to prices
- Strong support in the industry-level data for two channels
  - increase in import competition
  - increase in market concentration
- Consistent with a framework with variable markups such as Atkeson and Burstein (2008)
- Open issues:
  - Behavior of markups
  - Interaction of pass-through with inflation expectations
  - Effects of trade policy

IV Regressions

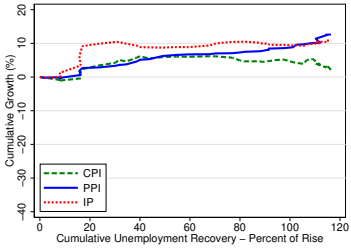
	(1) Δ Wage	(2) Δ Price	(3) Δ Wage	(4) Δ Price
Δ TFP	-0.0622	0.0223	0.0544***	-0.0190
	(0.0522)	(0.0528)	(0.0199)	(0.253)
J2J	1.030**		4.940	
	(0.521)		(7.205)	
Δ Wage Services		1.234**		
		(0.560)		
Δ Wage Manuf				-2.699
				(4.138)
Time Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
R2		-1.087		-7.055
Observations	4994	4994	7730	7730
F-Statistic	15.82		3.49	

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

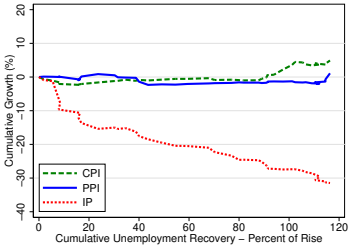
Back

PPI vs CPI for Individual Sectors: 2009 Expansion

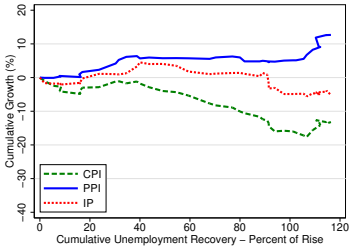
Apparel



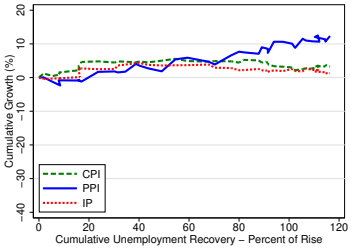
Audio and Telecoms Equipment



Appliances

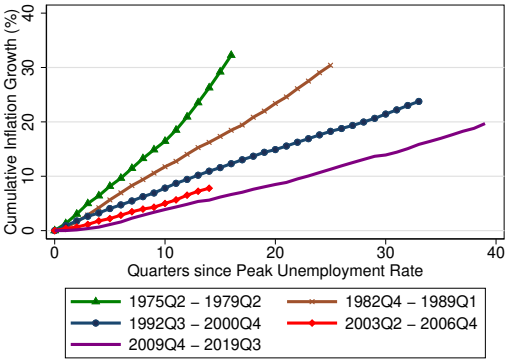


Vehicles

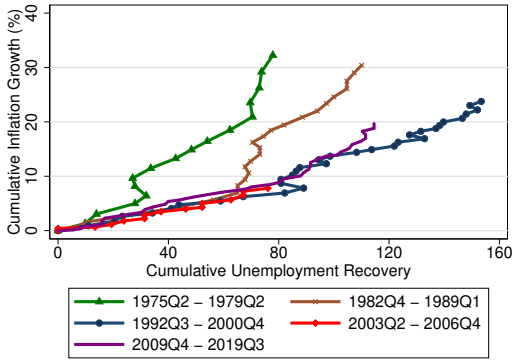


Evolution of CPI Inflation During Economic Expansions

(a) Inflation over Time

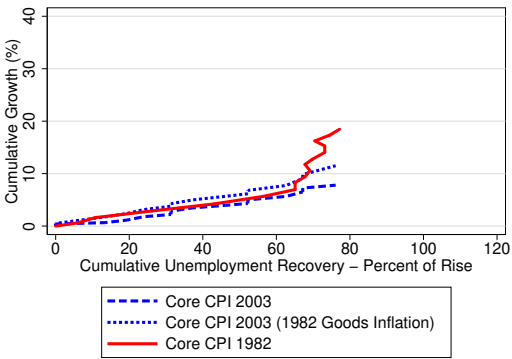


(b) Inflation versus Unemployment Recovery

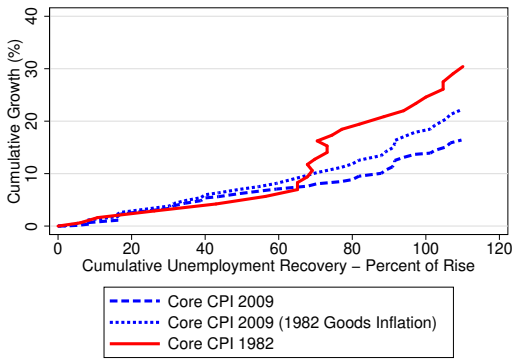


Counterfactual Inflation for the 2003-2007 and 2009-2020 expansions using core goods inflation in 1982

(a) 2003-2007 Expansion



(b) 2009-2020 Expansion



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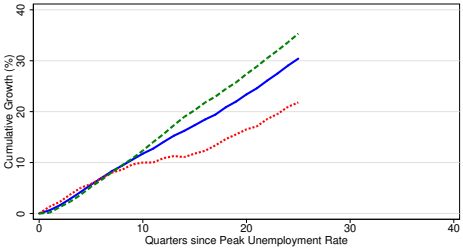
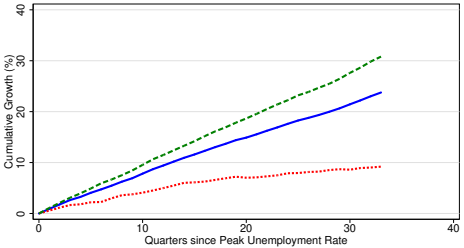
Inflation vs. Time in the Last Four Expansions

Back

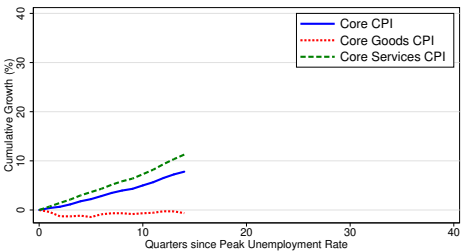
1982-1990



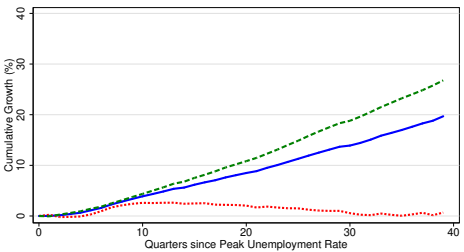
1991-2000



2003-2007



2009-2020



Cumulative growth in wages and in unit labor costs relative to unemployment recovery gap

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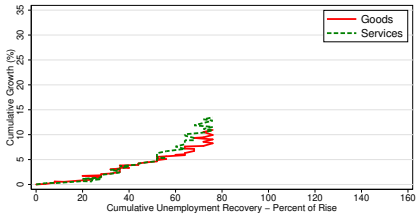
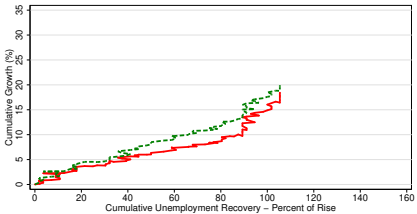
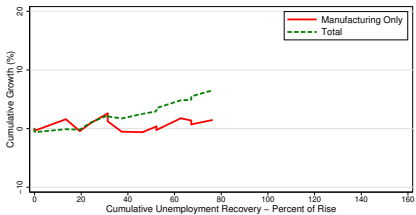
(a) Wage Growth: 2003-2007 Expansion



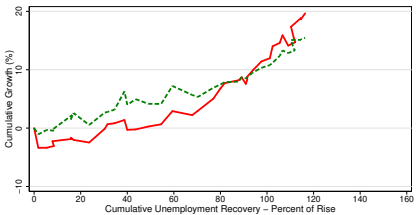
(b) Wage Growth: 2009-2020 Expansion



(c) Unit Labor Cost: 2003-2007 Expansion



(d) Unit Labor Cost: 2009-2020 Expansion



Inflation vs. Epop in the Last Four Expansions

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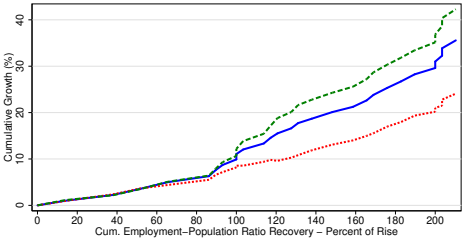
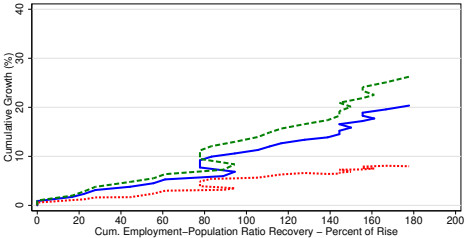
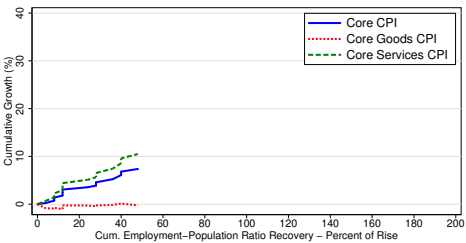
1982-1990



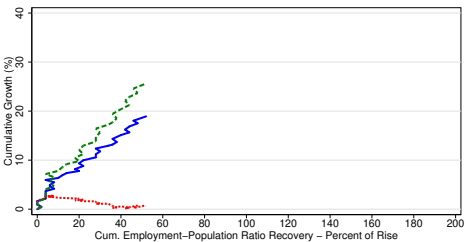
1991-2000



2003-2007

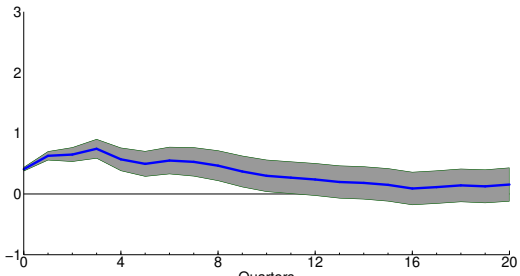


2009-2020

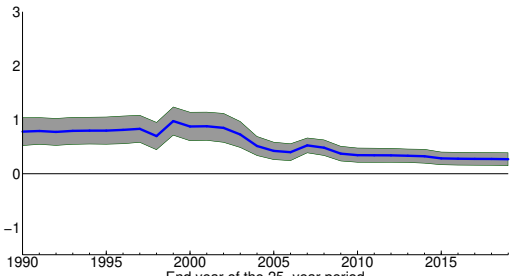


Pass-through from PPI to CPI

Impulse Response of CPI to PPI



Pass-through from PPI to CPI



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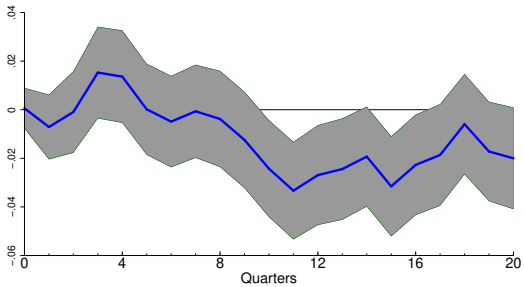
Impulse Responses

Estimate impulse response functions for each quarter $h = 0, ..., 20$

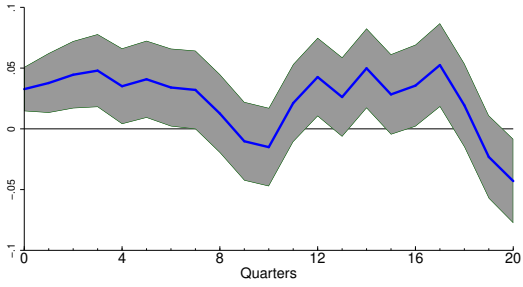
$$\Delta \ln(p_{i,t+h}) = \alpha + \beta_h \Delta \ln(w_{it}) + \sum_{j=1}^{8} \delta_j \Delta \ln(p_{i,t-j}) + \sum_{j=1}^{8} \zeta_j \Delta \ln(w_{i,t-j}) + \eta X_{it} + \delta_i + \rho_t + \epsilon_i t,$$

p_{it} is the producer price index in industry i and period t
Δw_{it} is the change in the industry's wage index
X_{it} is a set of time-varying controls

Manufacturing



Services



Sectors

- Two sectors: goods (G) and services (S). Production carried out by a competitive firm using the output of a continuum of industries $k \in [0,1]$:

$$Y_s = \left(\int_0^1 y_s(k)^{(\sigma-1)/\sigma} dk \right)^{\sigma/(\sigma-1)}$$

  $y_s(k)$: output produced by industry k in sector $s \in \{G, S\}$
  σ: the elasticity of substitution between industries

- The demand curve for goods of industry k

$$y_s(k) = \left(\frac{p_s(k)}{P_s} \right)^{-\sigma} Y_s$$

  where $P_s = (\int_0^1 p_s(k)^{1-\sigma} dk)^{1/(1-\sigma)}$.

Industries

- Industries populated by a finite number of firms, $N_s(k)$, indexed by i. The industry-specific aggregator of varieties is

$$y_s(k) = \left(\sum_{i=1}^{N_s(k)} y_s(k,i)^{(\eta-1)/\eta} \right)^{\eta/(\eta-1)}$$

  η: the elasticity of substitution across varieties
  $y_s(k,i)$: the quantity of firm i's variety in industry k

- The demand for variety (k,i) is then given by

$$y_s(k,i) = p_s(k,i)^{-\eta} p_s(k)^{\eta-\sigma} P_s^{-\sigma} Y_s$$

  where $p_s(k) = (\sum_{i=1}^{N_s(k)} p_s(k,i)^{1-\eta})^{1/(1-\eta)}$.

- Assume $\eta > \sigma > 1$

Firms

Each firm has a constant returns to scale production function that combines labor l and capital k

$$y_s(k, i) = Al^{\alpha}k^{1-\alpha}$$

A is total factor productivity, l is labor, and k is capital.

Standard cost minimization formulates the marginal cost of the firm to produce $y(k, i)$ amount of output as a function of wage, w, and the rental rate of capital, r, as

$$mc(y) = \frac{1}{A}w^{\alpha}r^{1-\alpha}$$

Factor prices are determined competitively and taken as given by the firm.

Market Structure: Firms

Each firm then faces an effective elasticity of demand of

$$\mathcal{E}_s(k,i) = \eta(1 - \varphi_s(k,i)) + \sigma\varphi_s(k,i),$$

$\varphi_s(k,i) = (p_s(k,i)y_s(k,i))/(\sum_{i'} p_s(k,i')y_s(k,i'))$: firm i's market share in industry k.

- Since there is only a finite number of firms, each firm takes into account the effect of its price setting on the price index $p_s(k)$.
- Firms with a higher market share face less competition within their industry, and are focused more on competition across industries, which lowers their effective demand elasticity.

Price Setting

Each firm solves

$$\max_{p} \left[p_s(k,i) - c(k,i)\right] \left(\frac{p_s(k,i)}{p_s(k)}\right)^{-\eta} \left(\frac{p_s(k)}{P_s}\right)^{-\sigma} Y_s.$$

The solution of this problem, taking into account that firms take into consideration the impact of their own price setting on the industry's price index, is

$$p_s(k,i) = \frac{\mathcal{E}_s(k,i)}{\mathcal{E}_s(k,i) - 1} c(k,i),$$

where $\mathcal{M}_s(k,i) \equiv \mathcal{E}_s(k,i)/(\mathcal{E}_s(k,i) - 1)$ is the firm's markup. Firms with a larger market share set higher markups since they face less elastic demand.

Intuition

This equation highlights the key mechanisms that affect pass-through of wage shocks

$$d\log p_s(k,i) = \frac{\Gamma_s(k,i)}{1+\Gamma_s(k,i)} d\log p_s(k) - \frac{1}{1+\Gamma_s(k,i)} d\log A + \frac{\alpha}{1+\Gamma_s(k,i)} d\log w_i.$$

1. direct effect coming from the change in w_i
2. an indirect effect that operates via the change in the industry's price index, $p_s(k)$
3. relative strength of the two channels is modulated by the markup elasticity $\Gamma_s(k,i)$
4. markup elasticity increases with market share, putting more weight on the price index
5. price index $p_s(k)$ moves less if fewer firms are affected by the shock

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