Trade Exposure and the Evolution of Inflation Dynamics

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Motivation

- Great Recession suggests "missing" deflation and recent recovery suggests "missing" inflation.
- More generally, relationship between inflation and fluctuations in economic activity appears to have weakened over time.
- Possible explanations:
  - Conduct of monetary policy
  - Globalization

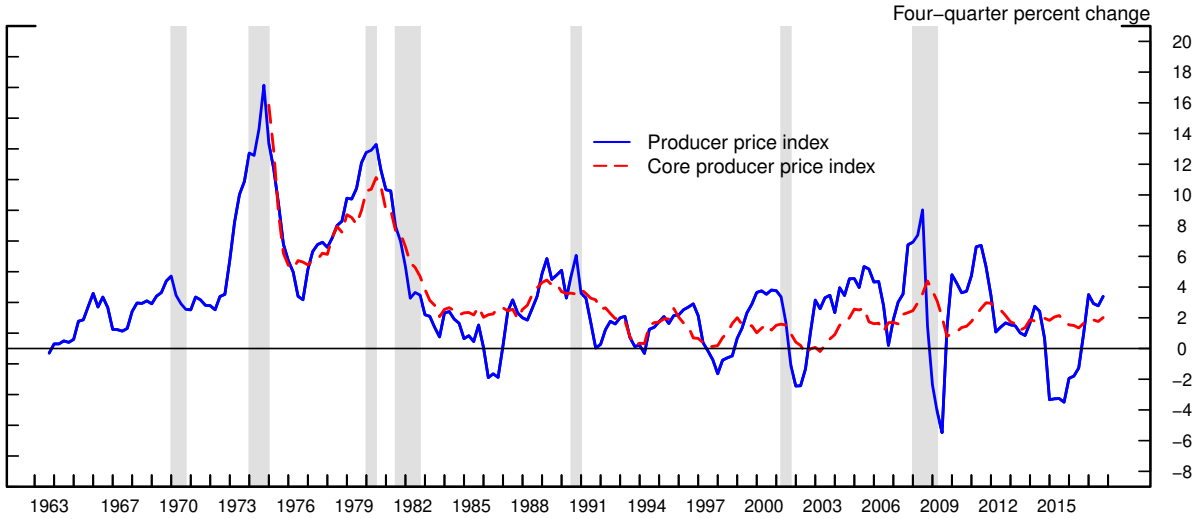
Trade, Globalization, and the Phillips Curve

- Increased competition leads to more price flexibility and steeper Phillips Curve (Rogoff 2003; Sbordone 2007).
- Conditional on price rigidity, increased openness reduces inflation response to output gap in New Keynesian models (Razin & Binyamini 2007).
- Recent evidence:
  - Ball (2006): No evidence to suggest increased openness can account for flatter Phillips Curve.
  - Bordo & Filardo (2007): Global slack matters for inflation at the country level.
  - Forbes (2018): Global factors account for larger fraction of variation in headline CPI (but not core CPI).

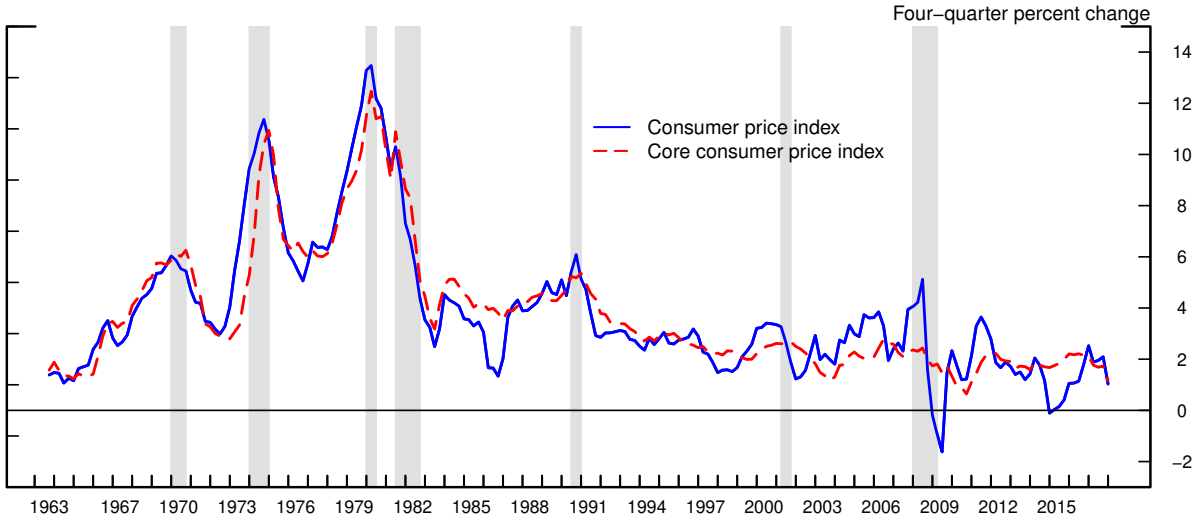
This paper

- Aggregate U.S. data:
  - Re-examine evidence on changing slope of Phillips curve for PPI and CPI.
  - Explore the extent to which a "flatter" Phillips curve can be linked to a rising trade share as in Ball (2006).
- Industry-level data:
  - Explore the relationship between inflation and output using newly available industry-level (6-digit NAICS) data for the U.S.
  - FAVAR analysis to examine responsiveness to aggregate shocks to financial conditions (demand) and commodity prices (supply).
  - What is the role of trade exposure at the industry level?

Producer and Consumer Price Inflation

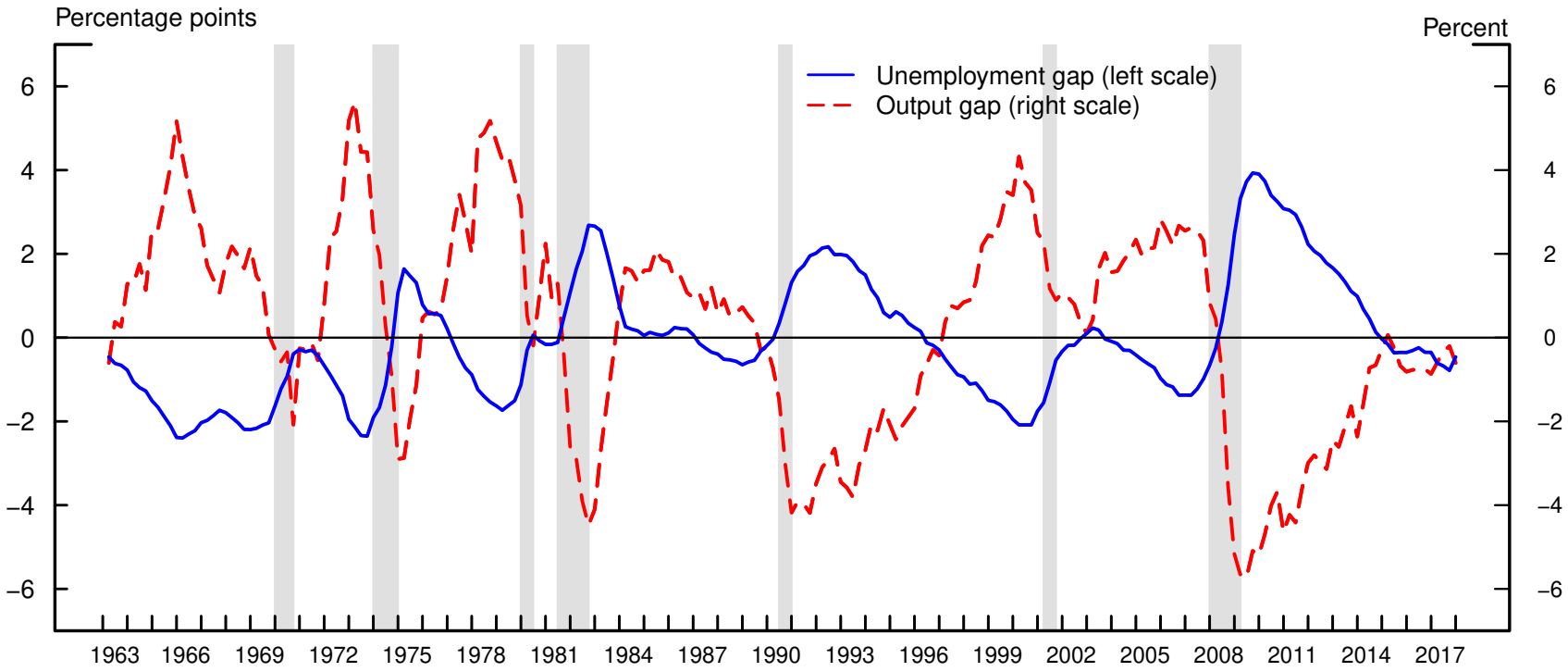


A. Producer price inflation

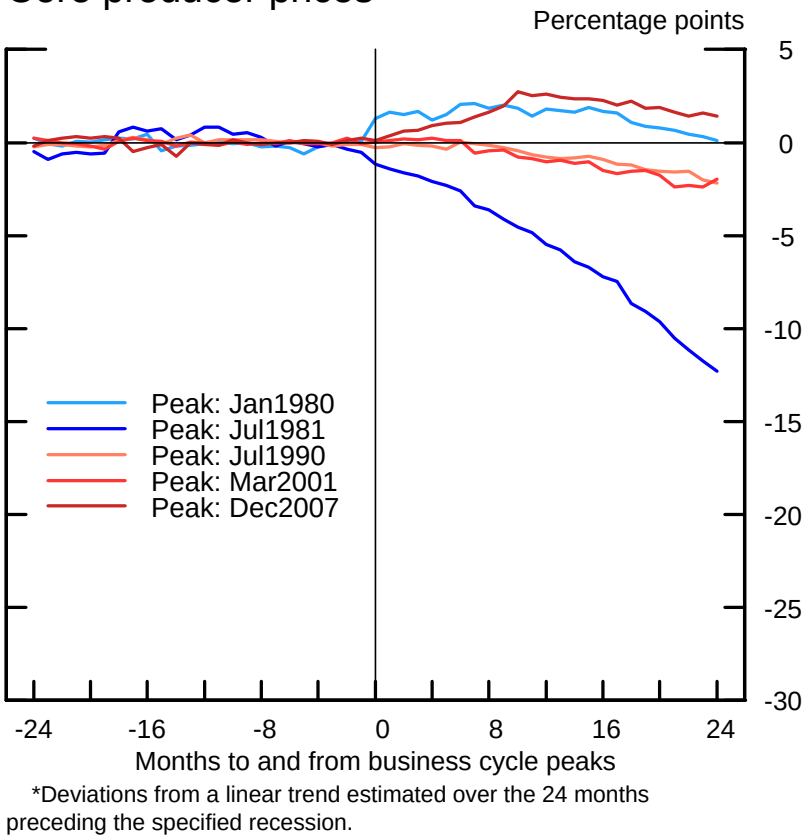


B. Consumer price inflation

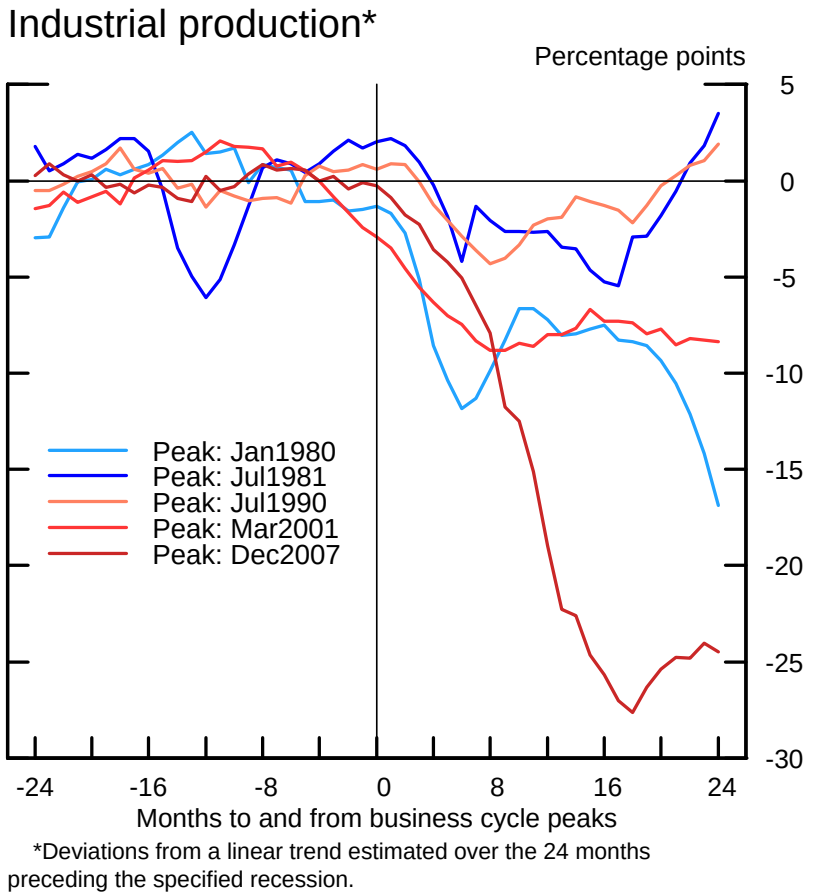
Measures of Economic Slack (FRB/US)



Cyclical Dynamics of Producer Prices and Production



A. Core PPI



B. Industrial production

Estimation

- Phillips Curve:

$$\Delta_{h+1} p_{t+h} = \mu + \lambda \text{gap}_t + \sum_{s=1}^{4} \phi_s \Delta p_{t-s} + \epsilon_{t+h}$$

- Resource gap measures:
  - Output gap: log(output/potential)
  - Unemployment gap: unemployment rate − natural rate
  - Potential output and natural rate of unemployment estimated using FRB/US.
- Inflation measures:
  - PPI and CPI
  - All items vs. excl. Food & Energy (Core)
- Sample period: 1962:Q1–2017:Q4
  - Core PPI available from 1974 onward

Phillips Curve Estimates: Producer Price Inflation

	$h = 1$		$h = 4$	
Explanatory Variables	(1)	(2)	(3)	(4)
A. Producer Prices				
$[y_t - y_t^*]$	0.356^{**}	.	0.414^{***}	.
	(0.144)		(0.153)	
$[U_t - U_t^*]$	.	-0.396^{*}	.	-0.469^{*}
		(0.238)		(0.257)
Sum: inflation lags	0.578^{***}	0.600^{***}	0.470^{***}	0.495^{***}
	(0.113)	(0.113)	(0.093)	(0.100)
Adj. R^2	0.360	0.333	0.392	0.343
B. Core Producer Prices				
$[y_t - y_t^*]$	0.186^{***}	.	0.223^{***}	.
	(0.056)		(0.067)	
$[U_t - U_t^*]$	.	-0.243^{**}	.	-0.273^{**}
		(0.105)		(0.131)
Sum: inflation lags	0.776^{***}	0.797^{***}	0.730^{***}	0.755^{***}
	(0.071)	(0.076)	(0.071)	(0.081)
Adj. R^2	0.743	0.725	0.760	0.727

NOTE: Newey-West standard errors in parentheses; *** $p < 0.01$; *** $p < 0.05$; and * $p < 0.10$.

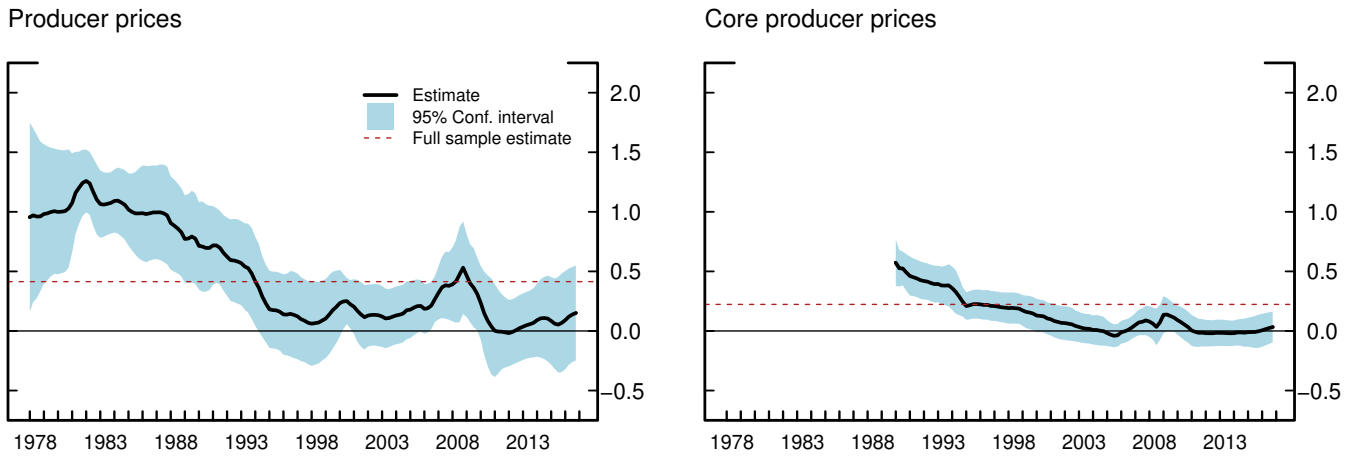
Phillips Curve Estimates: Consumer Price Inflation

	$h = 1$		$h = 4$	
Explanatory Variables	(1)	(2)	(3)	(4)
A. Consumer Prices				
$[y_t - y_t^*]$	0.258^{***}	.	0.318^{***}	.
	(0.075)		(0.084)	
$[U_t - U_t^*]$	.	-0.321^{***}	.	-0.380^{***}
		(0.120)		(0.128)
Sum: inflation lags	0.779^{***}	0.795^{***}	0.690^{***}	0.709^{***}
	(0.066)	(0.070)	(0.068)	(0.077)
Adj. R^2	0.657	0.635	0.676	0.632
B. Core Consumer Prices				
$[y_t - y_t^*]$	0.176^{***}	.	0.265^{***}	.
	(0.044)		(0.060)	
$[U_t - U_t^*]$	.	-0.263^{***}	.	-0.364^{***}
		(0.079)		(0.107)
Sum: inflation lags	0.868^{***}	0.875^{***}	0.787^{***}	0.797^{***}
	(0.056)	(0.060)	(0.065)	(0.074)
Adj. R^2	0.802	0.794	0.778	0.750

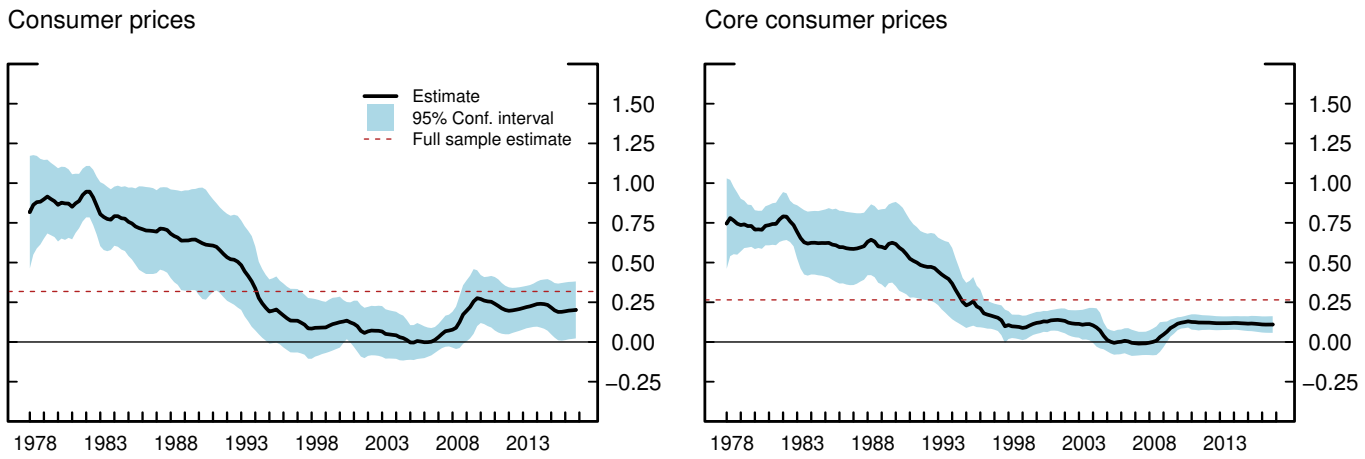
NOTE: Newey-West standard errors in parentheses; *** $p < 0.01$; *** $p < 0.05$; and * $p < 0.10$.

Time-Varying Coefficients on Output Gap

15-year rolling window estimates



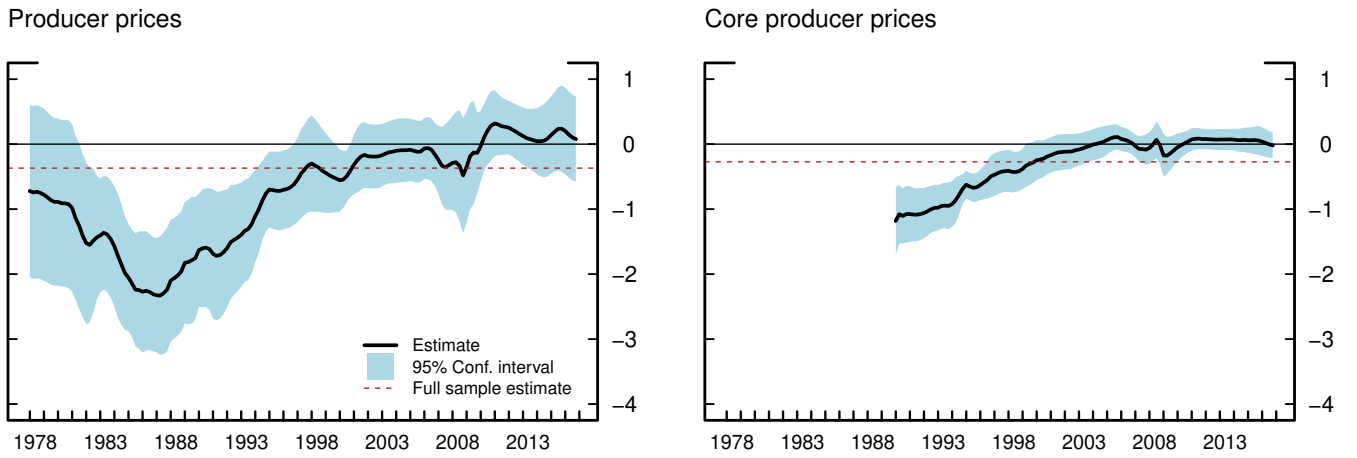
A. Producer price inflation



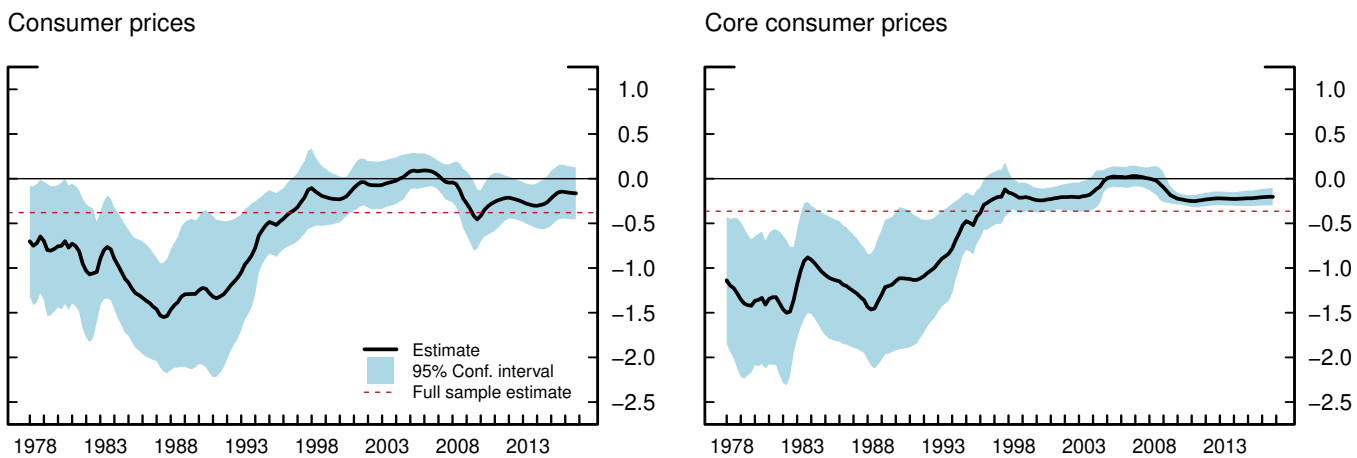
B. Consumer price inflation

Time-Varying Coefficients on Unemployment Gap

15-year rolling window estimates

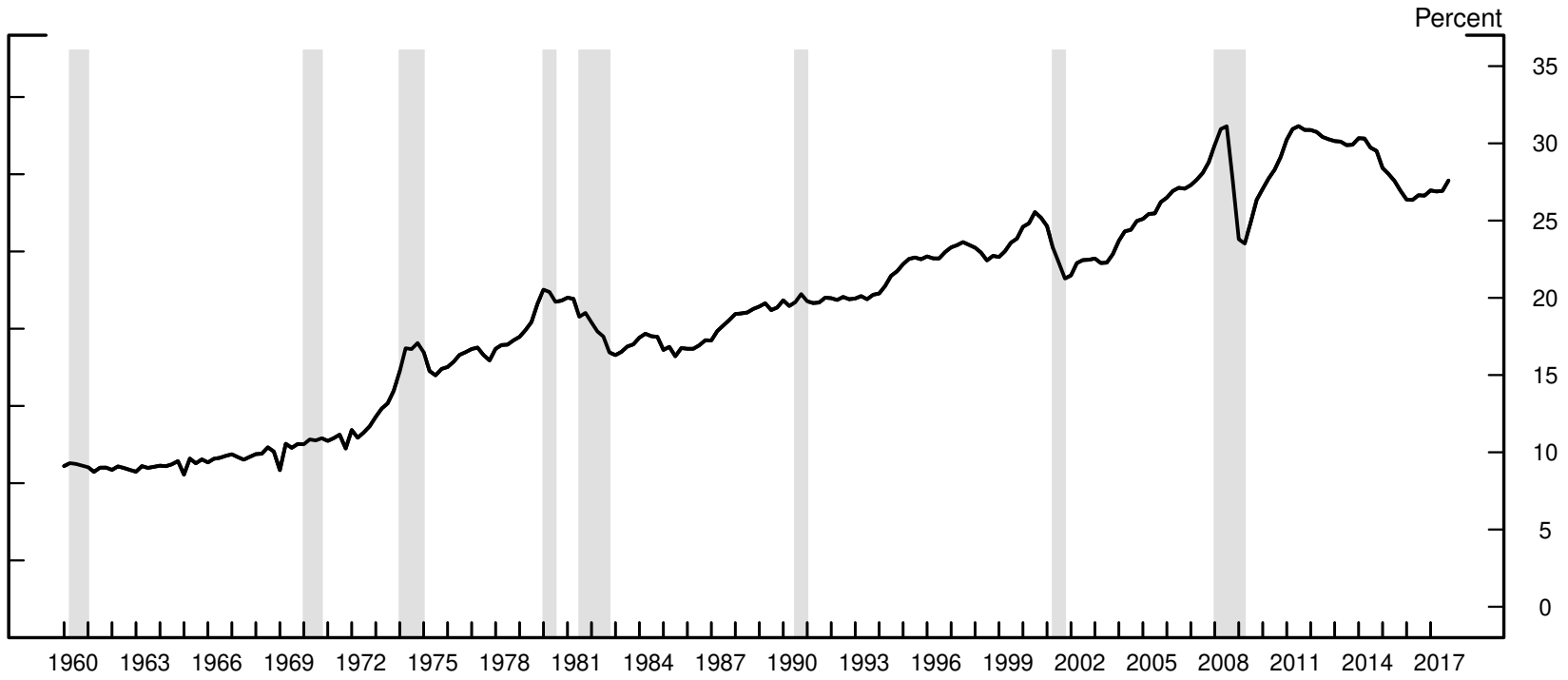


A. Producer price inflation



B. Consumer price inflation

U.S. Trade Share



Core PPI Inflation and the Trade Share

	$h = 1$		$h = 4$	
Explanatory Variables	(1)	(2)	(3)	(4)
$[y_t - y_t^*]$	0.903^{***}	.	1.016^{***}	.
	(0.309)		(0.312)	
$[y_t - y_t^*] \times \text{TrdShr}_{t-1}$	-0.031^{**}	.	-0.038^{***}	.
	(0.014)		(0.014)	
$[U_t - U_t^*]$	.	-2.261^{***}	.	-2.824^{***}
		(0.627)		(0.635)
$[U_t - U_t^*] \times \text{TrdShr}_{t-1}$	.	0.085^{***}	.	0.108^{***}
		(0.026)		(0.027)
TrdShr_{t-1}	-0.034	-0.101^{***}	-0.058^{*}	-0.145^{***}
	(0.050)	(0.033)	(0.030)	(0.041)
Sum: inflation lags	0.751^{***}	0.704^{***}	0.702^{***}	0.626^{***}
	(0.067)	(0.072)	(0.076)	(0.057)
Adj. R^2	0.762	0.762	0.768	0.800

NOTE: Newey-West standard errors in parentheses; *** $p < 0.01$; *** $p < 0.05$; and * $p < 0.10$.

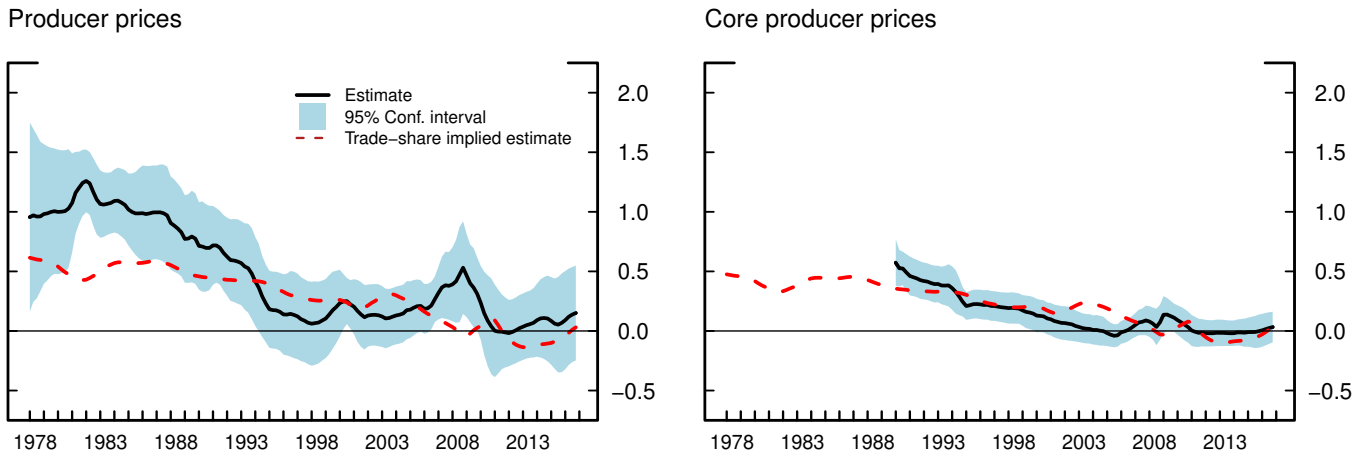
Core CPI Inflation and the Trade Share

	$h = 1$		$h = 4$	
Explanatory Variables	(1)	(2)	(3)	(4)
$[y_t - y_t^*]$	0.519^{***}	.	0.898^{***}	.
	(0.141)		(0.203)	
$[y_t - y_t^*] \times \text{TrdShr}_{t-1}$	-0.017^{***}	.	-0.031^{***}	.
	(0.005)		(0.008)	
$[U_t - U_t^*]$	.	-0.871^{***}	.	-1.194^{***}
		(0.311)		(0.415)
$[U_t - U_t^*] \times \text{TrdShr}_{t-1}$	.	0.028^{**}	.	0.040^{**}
		(0.011)		(0.015)
TrdShr_{t-1}	-0.002	0.009	-0.007	-0.001
	(0.017)	(0.022)	(0.021)	(0.028)
Sum: inflation lags	0.889^{***}	0.906^{***}	0.824^{***}	0.830^{***}
	(0.060)	(0.069)	(0.072)	(0.088)
Adj. R^2	0.810	0.802	0.815	0.772

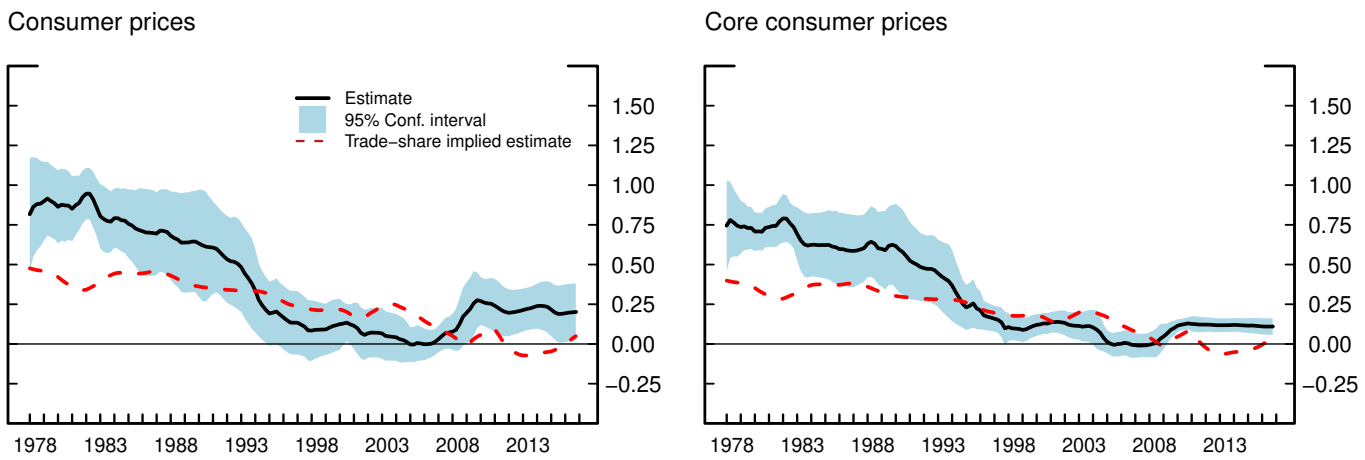
NOTE: Newey-West standard errors in parentheses; *** $p < 0.01$; *** $p < 0.05$; and * $p < 0.10$.

Time-Varying Coefficients vs. Trade-Share Effect

15-year rolling window estimates of the output gap coefficient



A. Producer price inflation

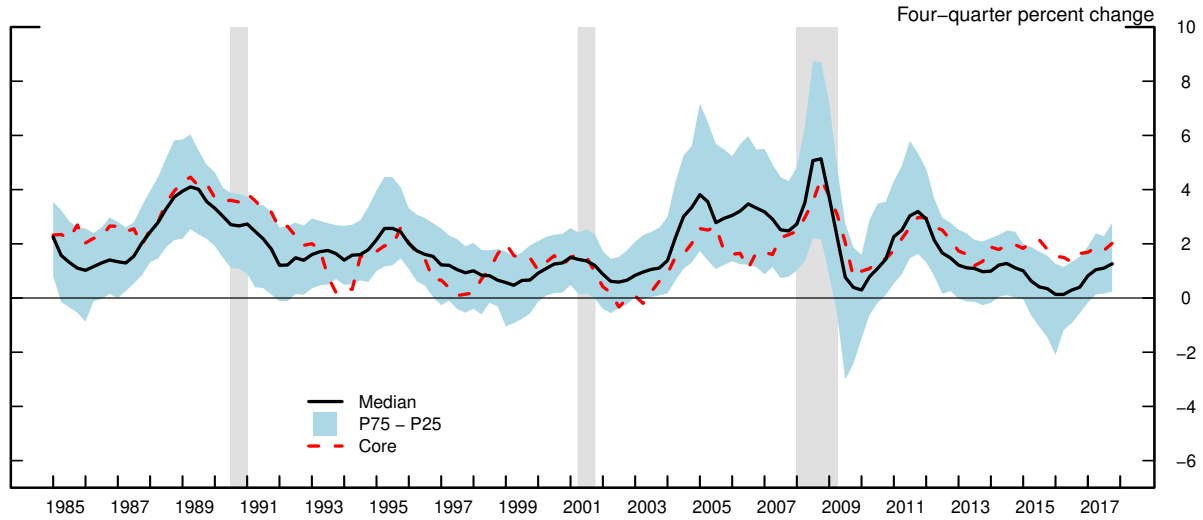


B. Consumer price inflation

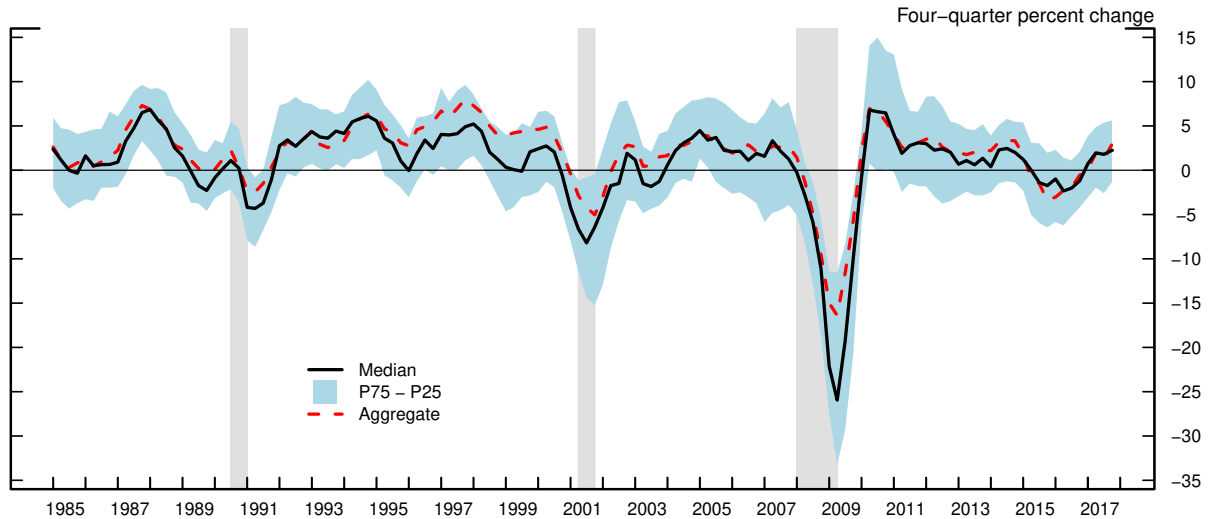
Industry-Level Analysis

- Prices and industrial output at the 6-digit NAICS level.
  - Data used to construct both aggregate IP and PPI data.
  - Broad industry coverage starting in 1984.
  - Balanced panel with employment and wages starting in 1990:Q1.
    - Weighted regressions and "aggregate response" using employment shares as weights.
- Augment this with 4-digit NAICS data on exports, imports, and output to compute trade shares.

Industry-Level Inflation and Output Growth

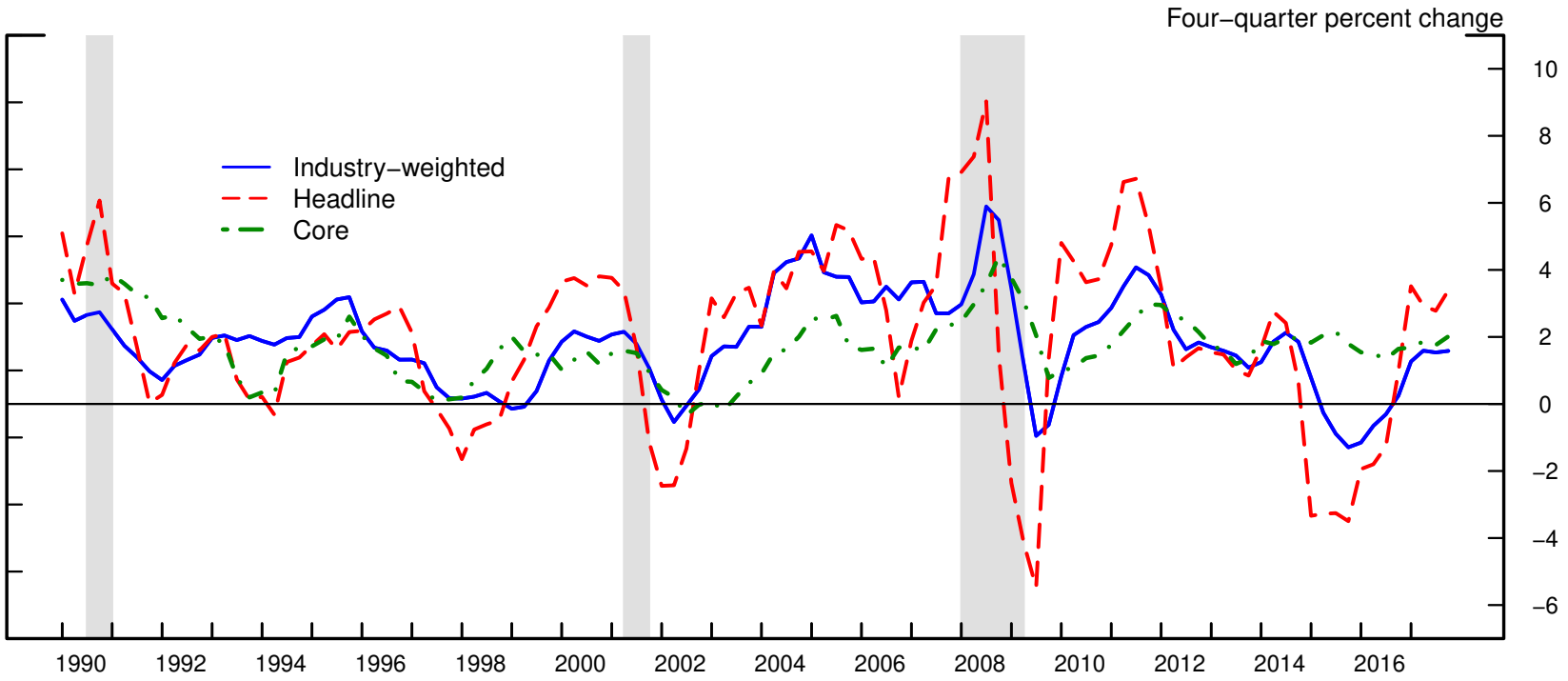


A. Producer prices



B. Industrial production

Industry-Level PPI Inflation vs. Broader Aggregates



Estimation

- Panel-data version of the Phillips Curve:

$$\Delta_{h+1} p_{i,t+h} = \lambda \text{gap}_{it} + \sum_{s=1}^{4} \phi_s \Delta p_{i,t-s} + \mu_i + \eta_t + \epsilon_{i,t+h}$$

- Economic activity: gap_{it}
  - $\Delta_4 q_{it}$ = year-over-year growth in output
  - $q_{it} - \tilde{q}_{it}$ = output gap, where $\tilde{q}_{it}$ is stochastic trend estimated using Hamilton (2017) filter
- η_t measures common component captured by time dummies.
- **Sample split**: High trade-intensity vs. low trade-intensity industries based on employment-weighted median cutoff.

Industry-Level Estimates

	Sample: 1984:Q1–2017:Q4		Sample: 1998:Q1–2017:Q4	
Explanatory Variables	(1)	(2)	(3)	(4)
$[q_{it} - \tilde{q}_{it}]$	0.014^{**}	.	0.020^{***}	.
	(0.006)		(0.007)	
$\Delta_4 q_{it}$	.	0.027^{***}	.	0.030^{***}
		(0.008)		(0.008)
Sum: inflation lags	-0.057^{*}	-0.054^{*}	-0.082^{**}	-0.079^{**}
	(0.031)	(0.030)	(0.037)	(0.037)
Adj. R^2	0.220	0.222	0.246	0.246
No. of industries	319	319	319	319
Avg. T_i (quarters)	95.6	95.8	60.4	60.5
Obs.	30,512	30,566	19,266	19,287

NOTE: Two-way clustered standard errors in parentheses; *** $p < 0.01$; *** $p < 0.05$; and * $p < 0.10$.

Industry Level Estimates: High vs. Low Trade Share

Balanced panel (1991:Q1–2017:Q4); weighted vs. unweighted estimates

	Industry Category		
Explanatory Variables	All	Low Trade Shr.	High Trade Shr.
A. Weighted Estimates			
$[q_{it} - \tilde{q}_{it}]$	0.015	0.029^{***}	0.006
	(0.010)	(0.011)	(0.011)
Sum: inflation lags	−0.060	-0.159^{***}	0.044
	(0.041)	(0.043)	(0.043)
Adj. R^2	0.243	0.228	0.306
B. Unweighted Estimates			
$[q_{it} - \tilde{q}_{it}]$	0.025^{***}	0.035^{***}	0.014^{**}
	(0.007)	(0.013)	(0.006)
Sum: inflation lags	−0.060	-0.091^{**}	0.004
	(0.036)	(0.042)	(0.045)
Adj. R^2	0.198	0.198	0.227

NOTE: Two-way clustered standard errors in parentheses; *** $p < 0.01$; *** $p < 0.05$; and * $p < 0.10$.

Comments

- Industry-level response coefficients of similar magnitude as aggregate over same time period.
- Industry-level estimates show no evidence of attenuation in output response over time.
- Price response to output is twice as large in low trade-intensity industries relative to high trade-intensity industries.
- Identification:
  - Industry responses reflect a mixture of industry-level demand and supply shocks.
  - Use FAVAR to examine identified shocks to aggregate demand vs. supply.

FAVAR Analysis

- System

$$\begin{bmatrix} X_{1t} \\ X_{2t} \end{bmatrix} = \begin{bmatrix} \Lambda_{1,1} & \Lambda_{1,2} \\ \Lambda_{2,1} & \Lambda_{2,2} \end{bmatrix} \begin{bmatrix} F_{1t} \\ F_{2t} \end{bmatrix} + \begin{bmatrix} \nu_{1t} \\ \nu_{2t} \end{bmatrix},$$

  where

$$\Lambda = \begin{bmatrix} \Lambda_{1,1} & \Lambda_{1,2} \\ \Lambda_{2,1} & \Lambda_{2,2} \end{bmatrix}$$

  is an $(n \times k)$ matrix of factor loadings.

- The latent factors follow a VAR:

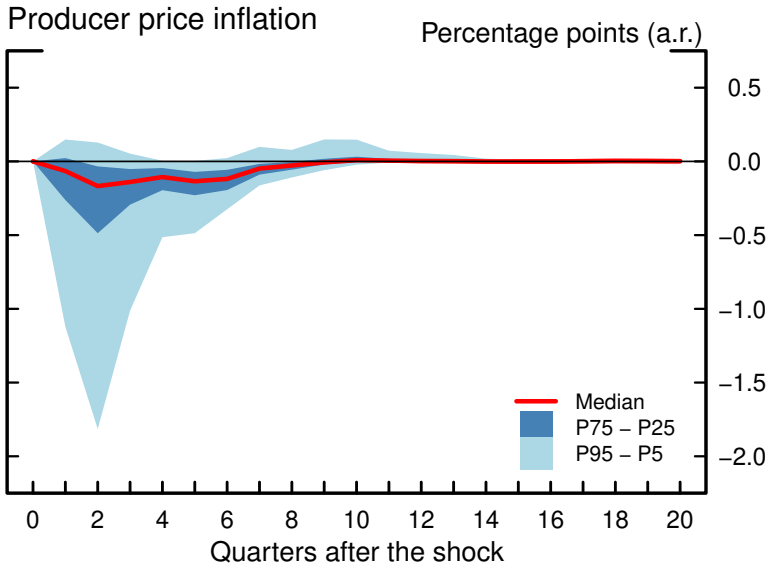
$$\begin{bmatrix} F_{1t} \\ F_{2t} \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{1,t-1} \\ F_{2,t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{bmatrix}$$

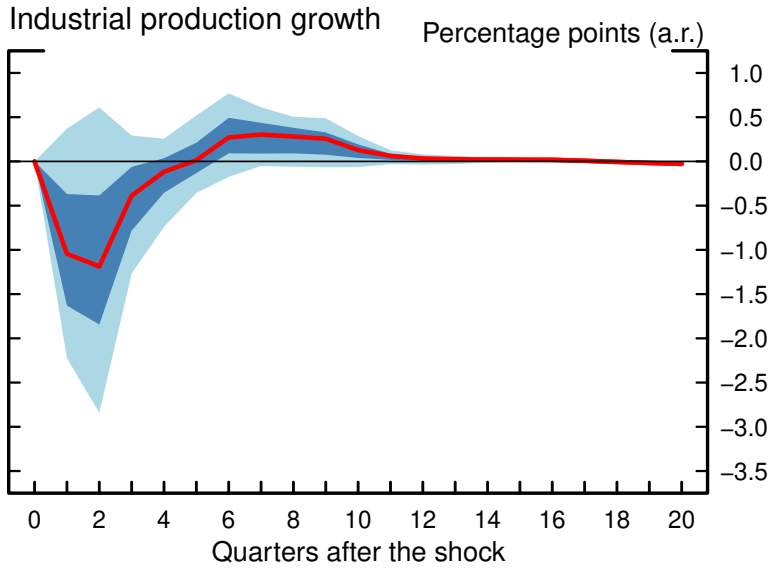
Data and Identification

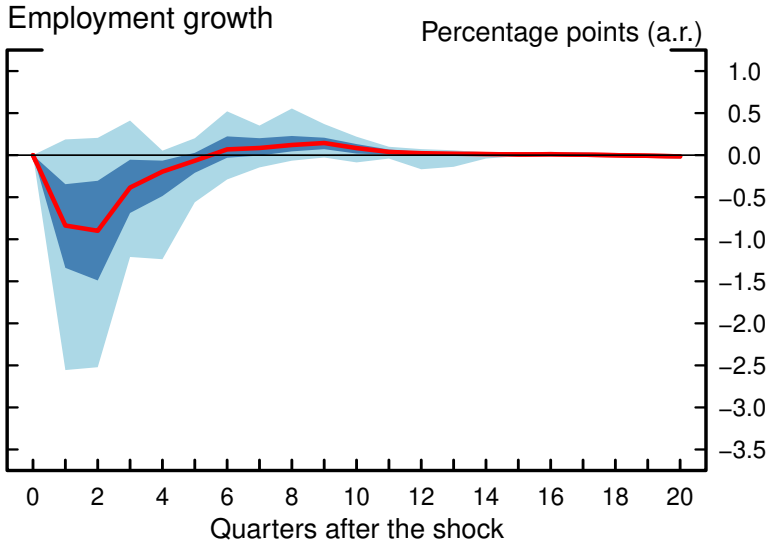
- $X_{1,t}$ = industry-level data on price inflation, wage inflation, output, and employment growth for 185 industries over 1994:Q1–2017:Q4 period
- $X_{2,t}$ = aggregate time-series indicators of financial conditions:
  - GZ spread, EBP, Baa-Aaa spread, 10/2y Treasury spread, VIX
- Identification:
  - $F_{1,t}$ factors in $X_{1,t}$
  - $F_{2,t}$ factors in $\tilde{X}_{2,t}$ where $\tilde{X}_{2,t}$ is residual from regression of $X_{2,t}$ on $F_{1,t}$
  - Examine impulse response to shocks to first component of $F_{2,t}$
  - Note to do this impose $\Lambda_{1,2} = 0$

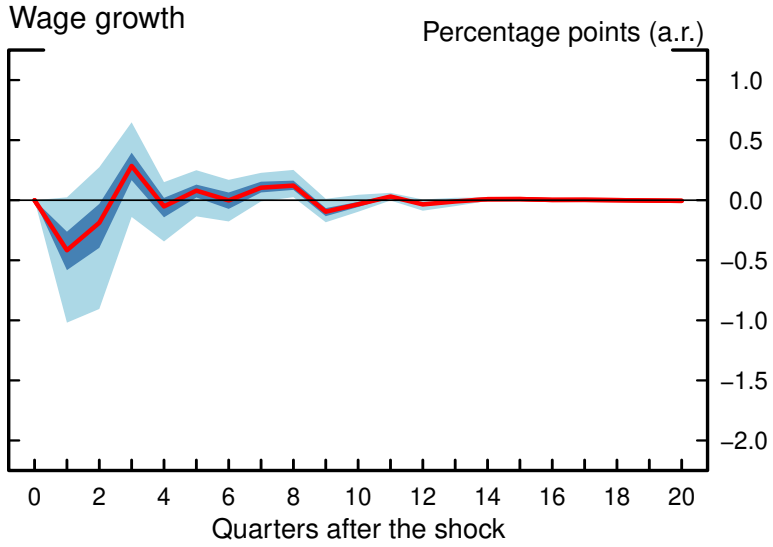
Responses to a Financial Shock

All industries



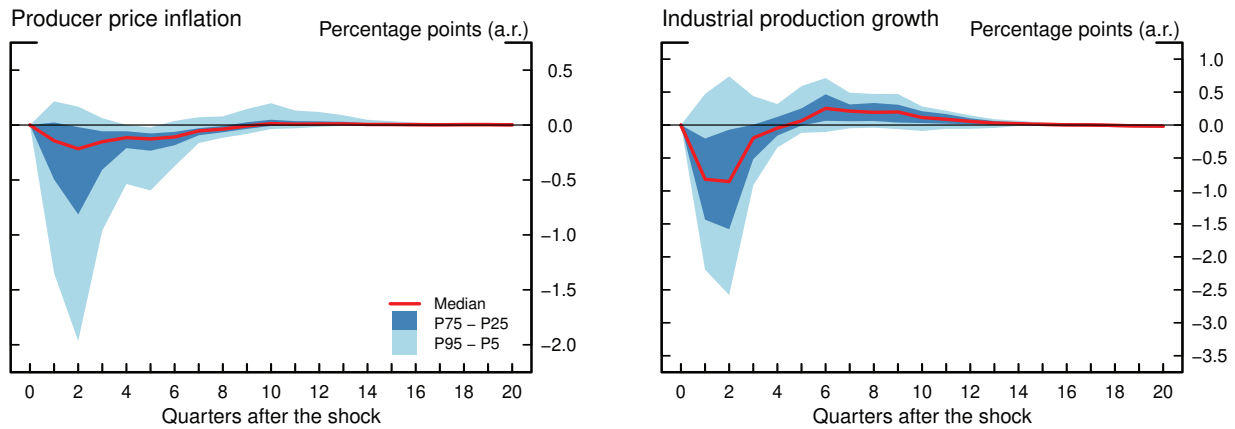




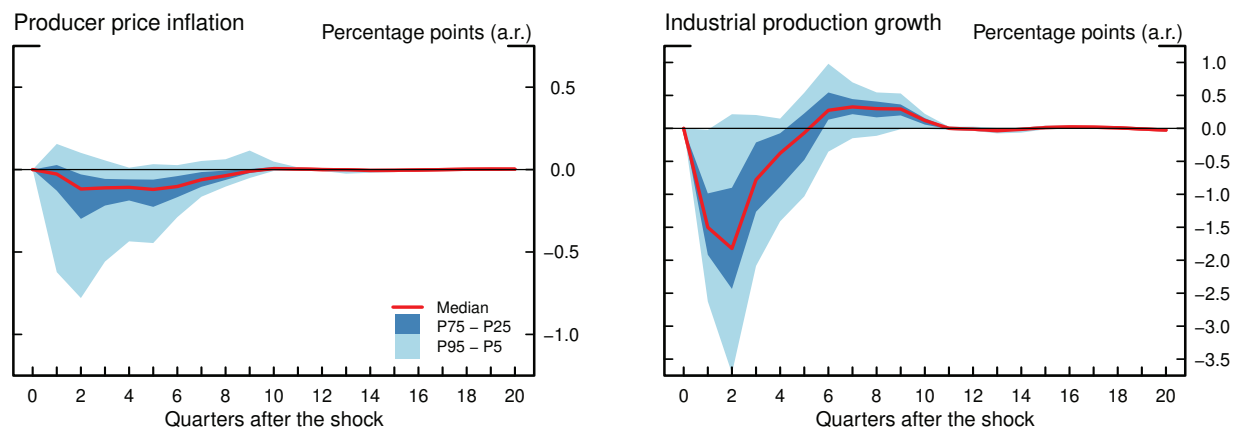


Responses to a Financial Shock

High vs. low trade-share industries



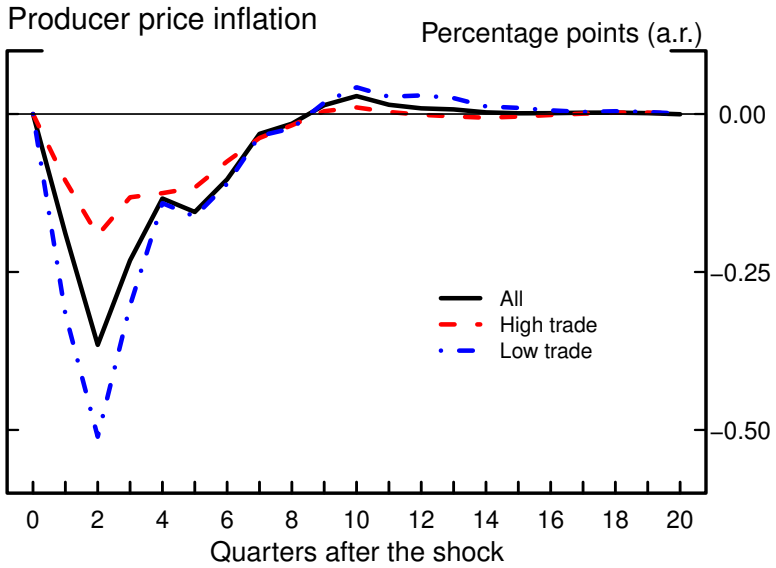
A. Low trade-share industries

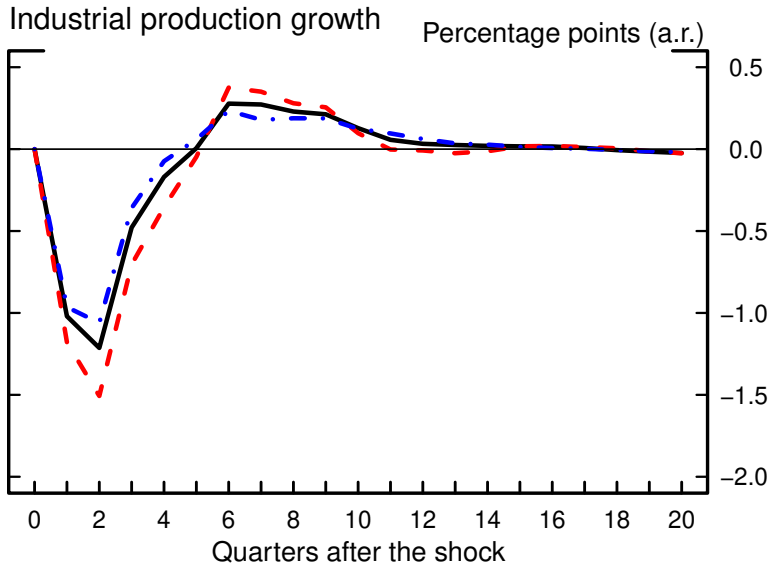


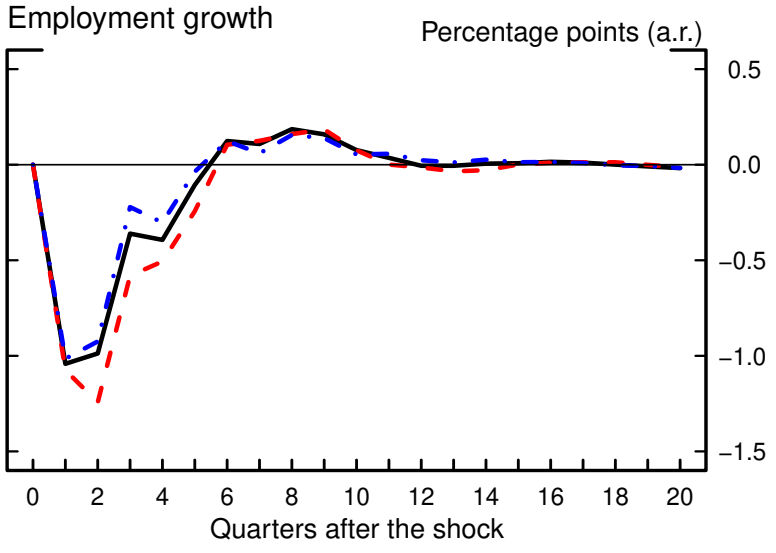
B. High trade-share industries

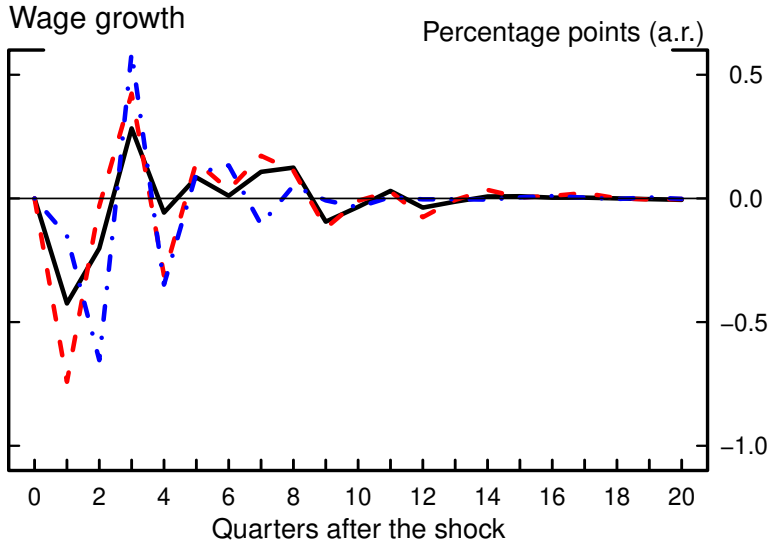
Responses to a Financial Shock

High vs. low trade-share industries; weighted average responses



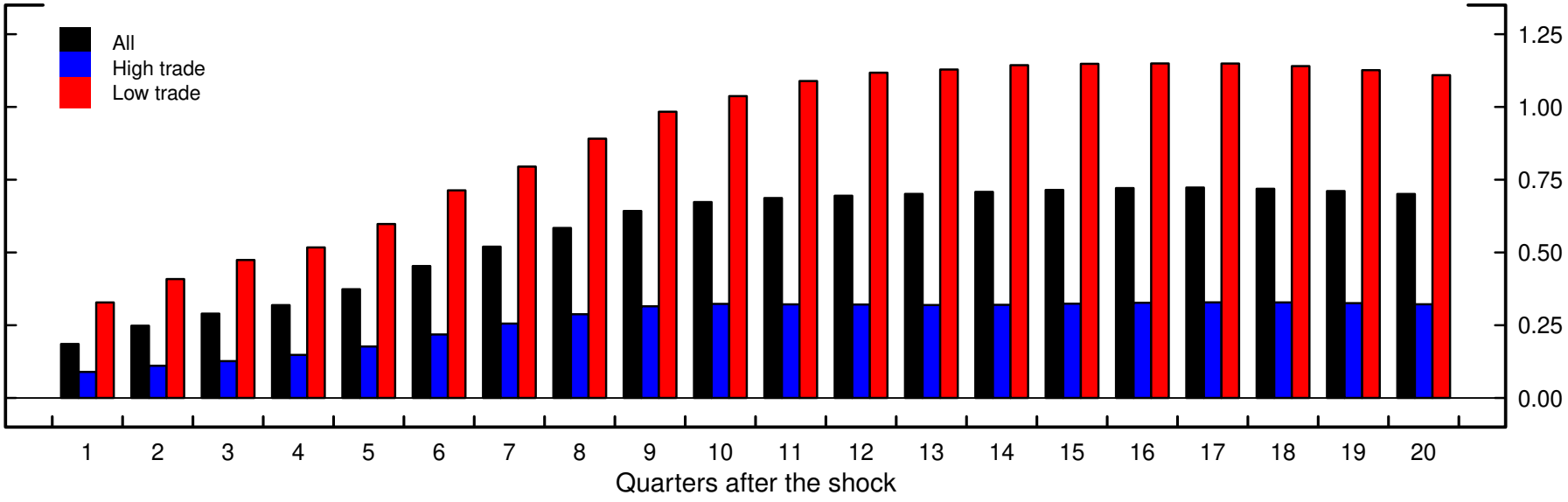






Implied Price Elasticity to Output

High vs. low trade-share industries

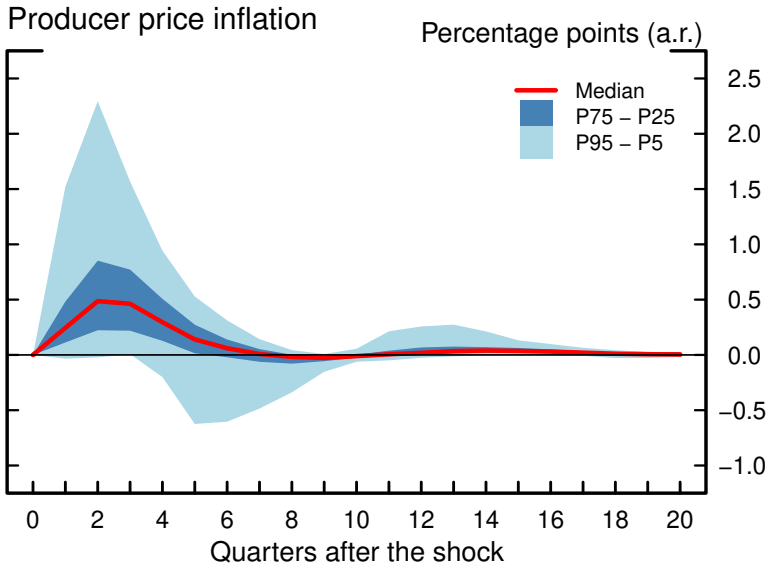


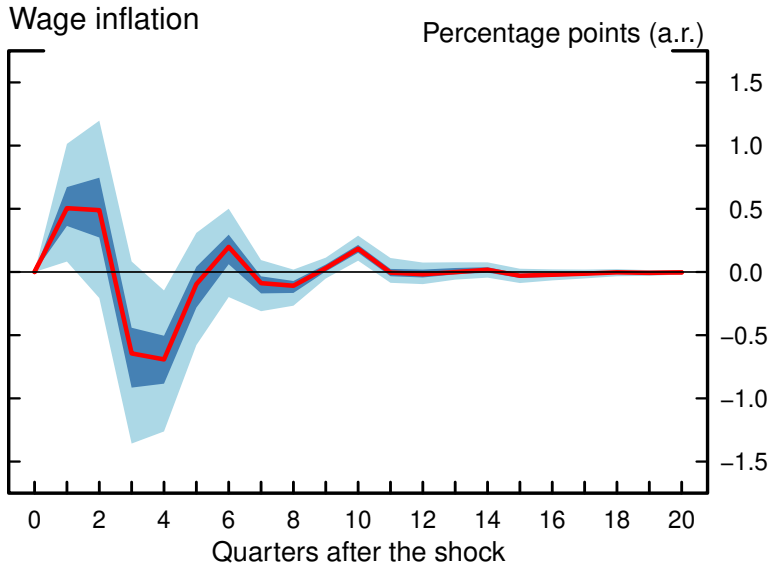
Commodity Price Shocks

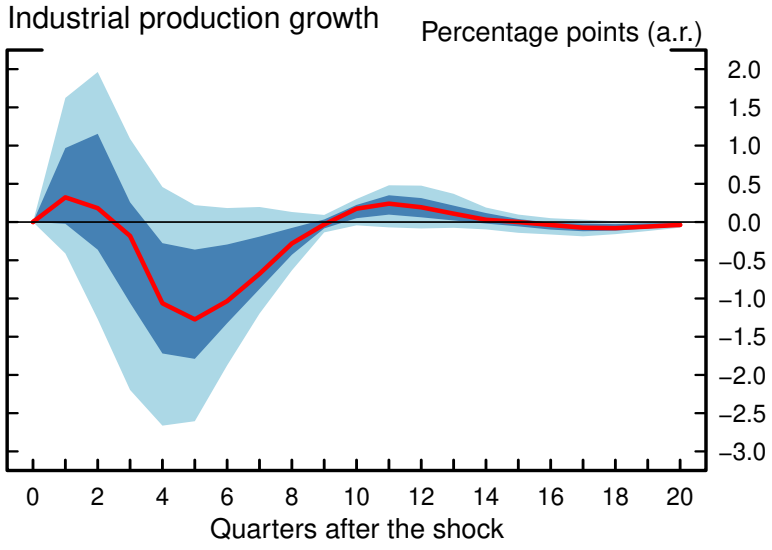
- Financial shocks act like demand shocks—positive comovement between inflation and output.
- Define $X_{2,t}$ as vector of 10 commodity return series that include all sub-indexes used to construct the overall commodity price index.
- Re-estimate FAVAR with the same identification procedure.

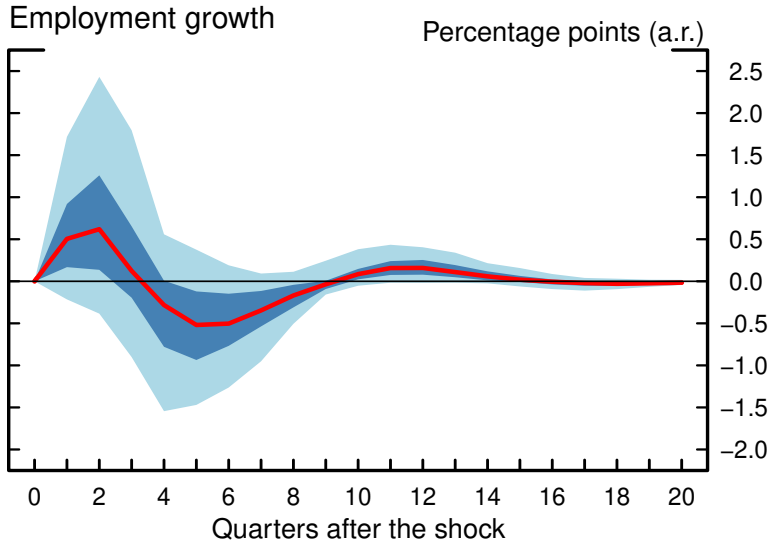
Responses to a Commodity Price Shock

All industries



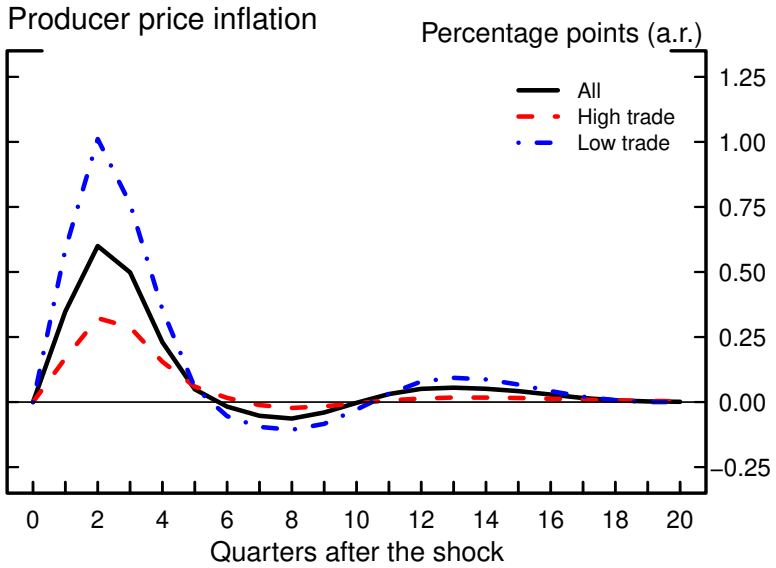


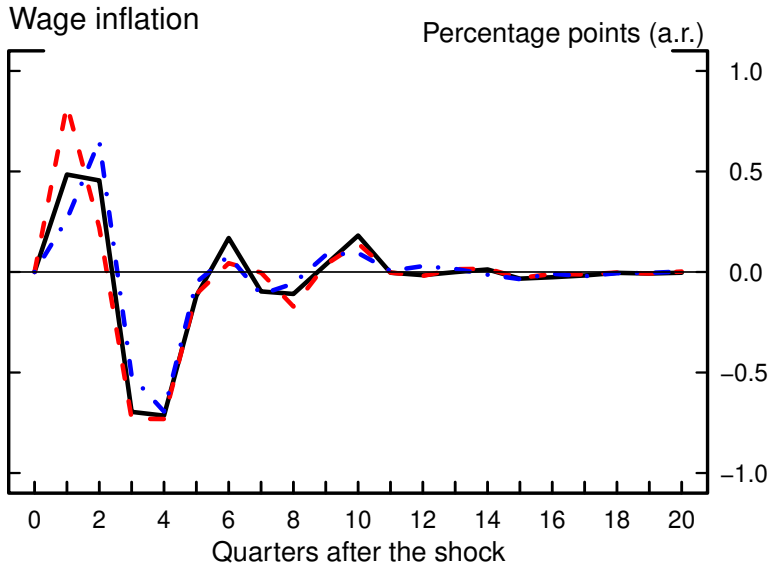


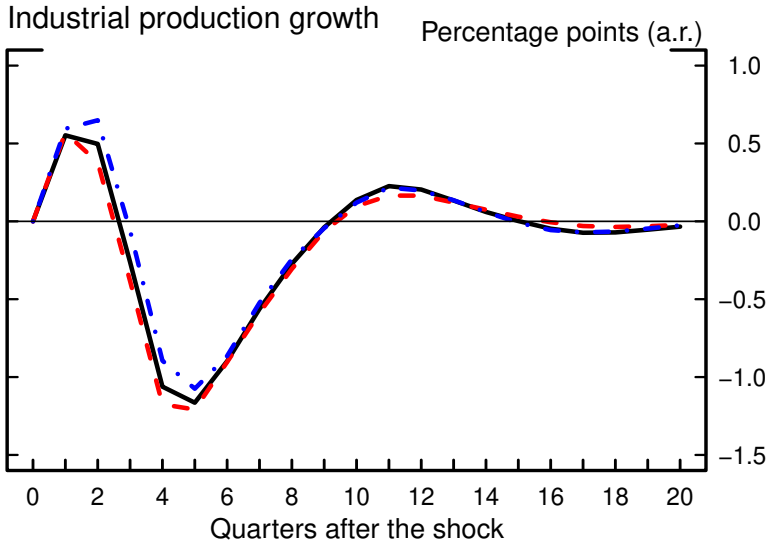


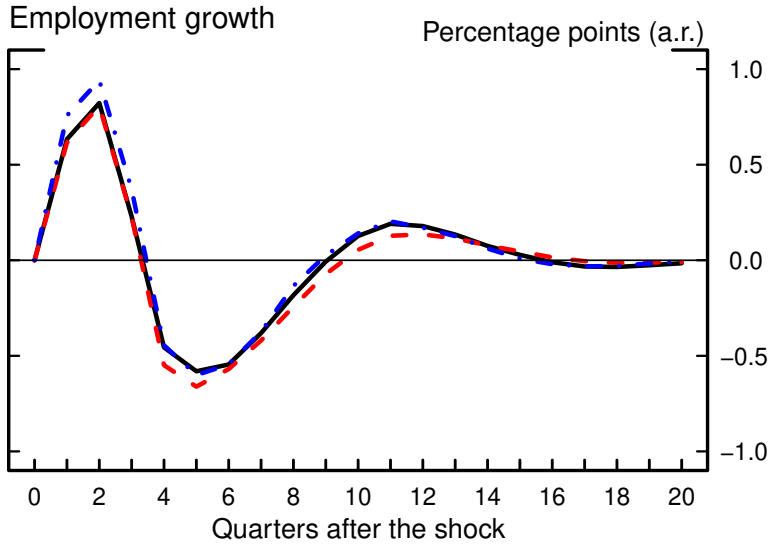
Responses to a Commodity Price Shock

High vs. low trade-share industries; weighted average responses









Concluding Remarks

- Aggregate Phillips Curve estimates show a strong attenuation of the price response to fluctuations in economic activity over time.
- A significant component of this attenuation occurs in conjunction with a rising U.S. trade share.
- Industry-level data provide robust evidence that the price response to fluctuations in output is substantially mitigated in industries with higher trade shares.