Inflation Expectations and the Supply Chain

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Motivation

- How firms form expectations is key to MP, which targets aggregates that depend on firms' expectations and decisions

- Firms look at same easily accessible aggregate statistics, yet information rigidity results in forecast disagreement and inattention (Mankiw and Reis, 2002; Sims, 2003; Coibion and Gorodnichenko, 2015)

- So, what do firms look at when forecasting inflation?
  - Information on the price expectations of businesses who are, after all, the price setters is particularly scarce (Bernanke, 2007)
  - Evidence from surveys of firms substantially different from professional forecasters and households (Candia et al., 2022)

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$\rightarrow$ Firms may learn from their surroundings/network and assign an *aggregate* value to *local* signal (Lucas, 1972)

This paper

- Do firms' supply chains affect their inflation expectation formation?
- Due to information rigidities, firms may end up using price changes observed when purchasing inputs from their suppliers to form views about future aggregate inflation
- Implications for inflation expectations adjustment to past inflation and FIRE framework

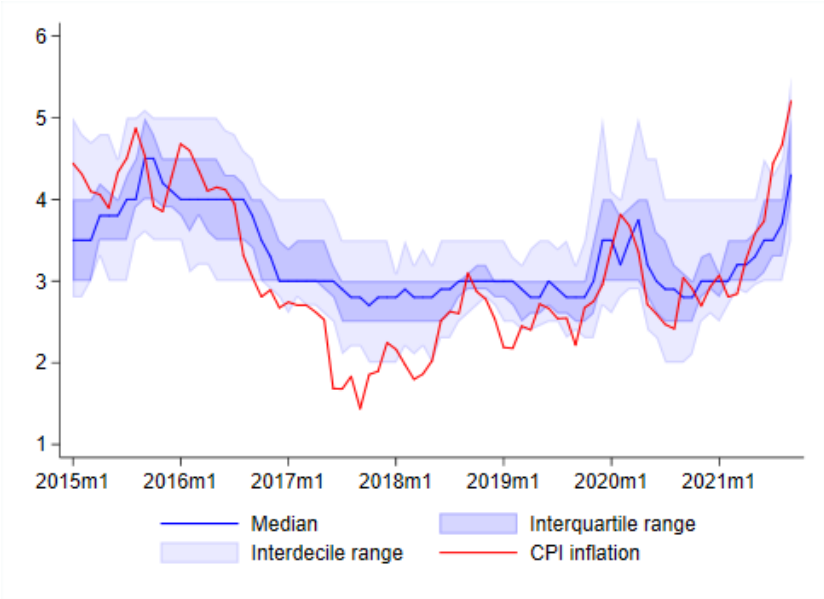
Unique data and appropriate empirical setting

- (Matched) data sources
  1. Expectation survey: manufacturing and retail firms
     - Monthly, since December 2004
     - Key question: *"What do you think inflation will be in the next 12 months (measured by the Consumer Price Index CPI)?"*
  2. VAT registry
     - B2B transaction data since 2014 to identify supply chain
     - p and q for all products purchased and sold
  3. Customs
     - p and q for all products imported and exported
  4. Income tax form
     - Monthly revenue and purchases of materials
  5. Bureau of unemployment insurance
     - Firms' monthly wage bill

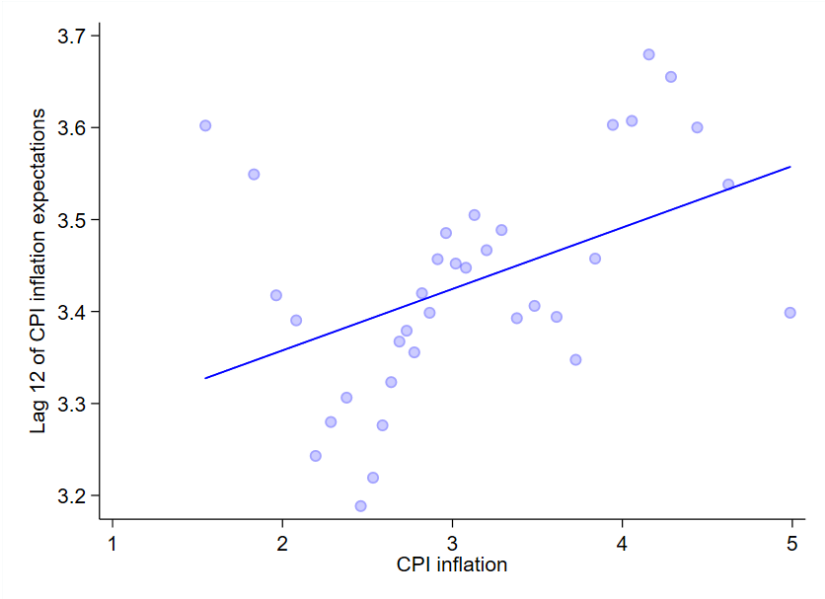
- Chile during Jan 2015–Sep 2021
  - Great setting $\rightarrow$ CPI inflation moved between 1.4% and 5.2%

Firms' disagreement about aggregate inflation

(a) Dispersion in inflation expectations



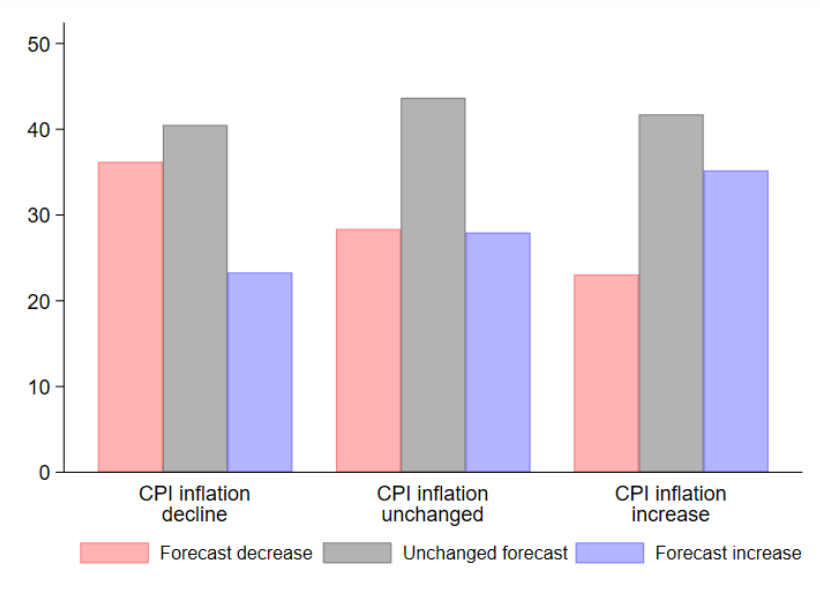
(b) Inflation and expectations



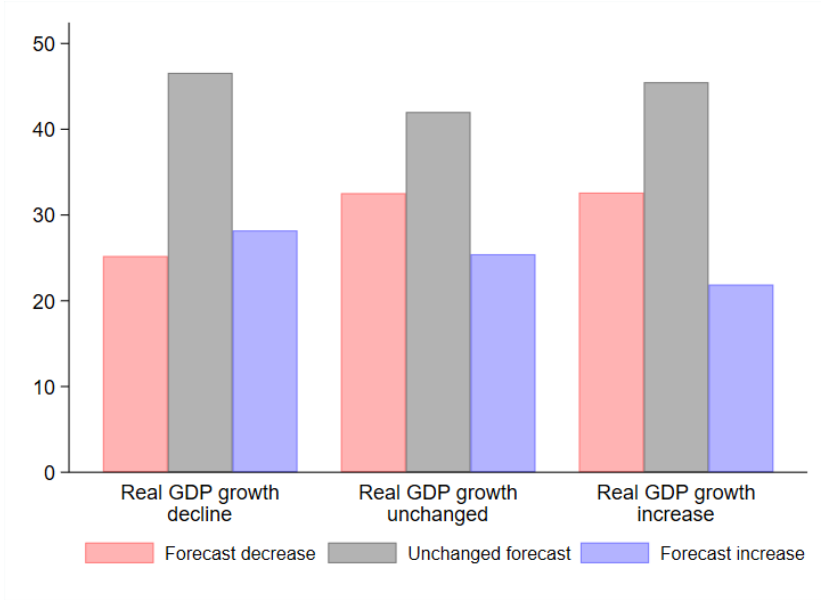
- Firms have different views about inflation...
- ... but tend to correlate with inflation

Inattention to macroeconomic developments

(a) Share of firm-month observations responding to changes in CPI inflation



(b) Share of firm-month observations responding to changes in GDP growth



- Almost $1/2$ of firms do not change forecasts, $1/5$ do so in 'wrong' direction
- Firms appear to attribute changes in inflation to supply shocks

Reconciliating supply chain, disagreement, and inattention

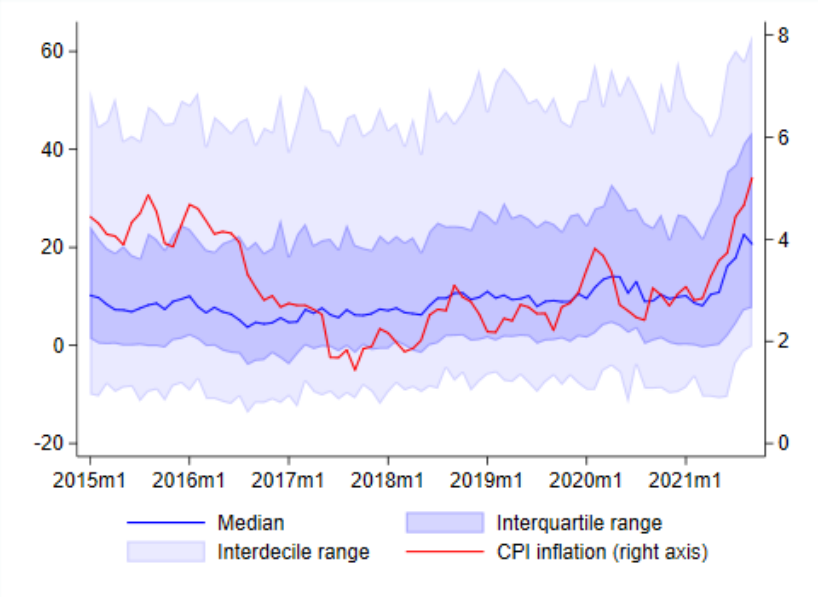
- In Lucas (1972), firms are located on different islands and learn from a subset of islands they trade with
  - Signal extraction problem: firms need to forecast aggregate inflation to take production decisions Signal extraction problem

- In this framework:
  - Disagreement can arise if firms rely on dispersed supply chain conditions to form aggregate beliefs
  - Firms may be inattentive to macro developments if these are less relevant than supply chain inflation for their business

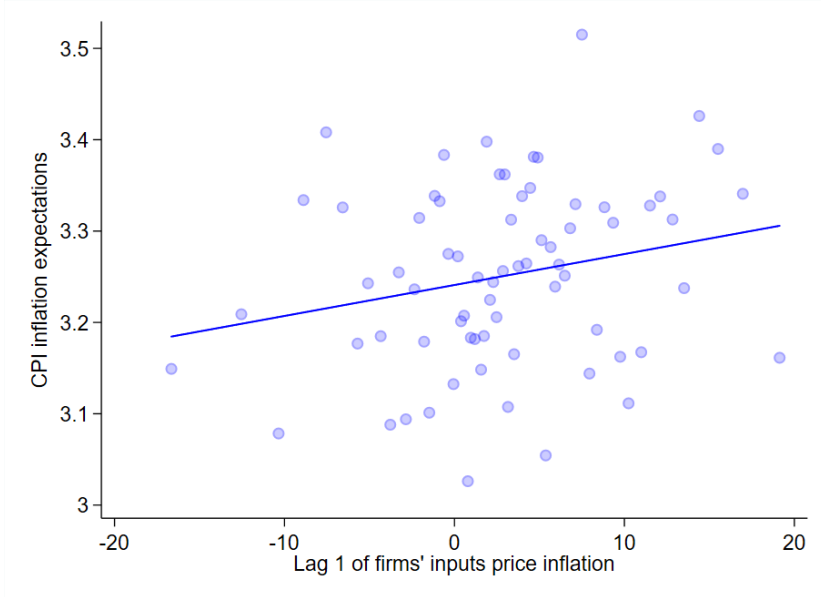
Supply chain inflation and firms' expected inflation

Construction

(a) Input price inflation



(b) Input price inflation and firms' expectations



- Dispersion of input price inflation reflects heterogeneity along supply chain, with longer right tail
- Significant volatility over time compared to actual inflation
- Yet, inflation expectations correlated with supply chain inflation

Responses of firms' aggregate inflation expectations

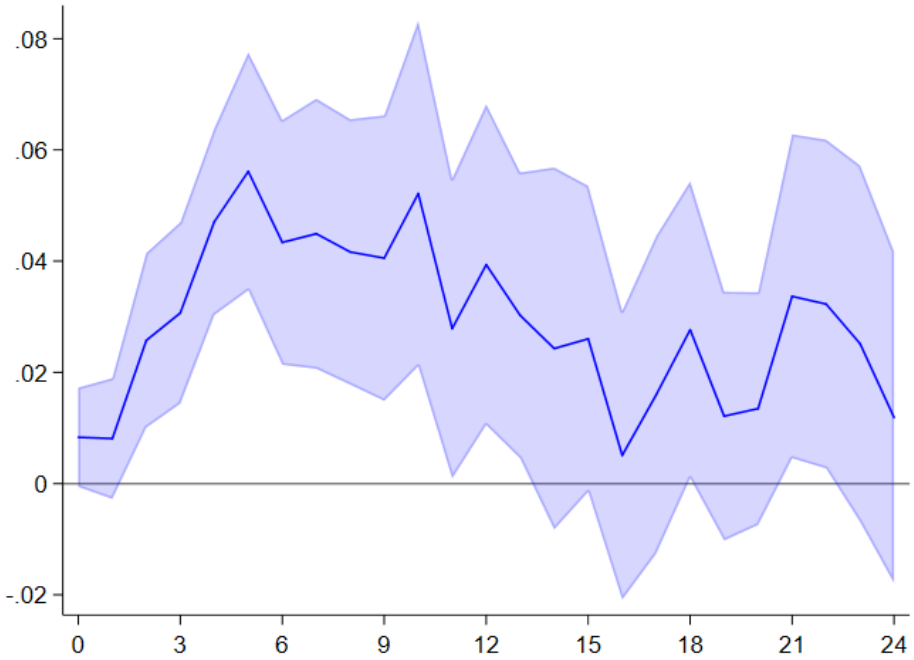
$$E_{i,t+h}\pi_{t+h+12} - E_{i,t-1}\pi_{t-1+12} =$$
$$\alpha_i^h + \sum_{p=1}^{P} \beta_p^h \pi_{t-p} + \sum_{p=1}^{P} \gamma_p^h \pi_{i,t-p} + \sum_{p=1}^{P} \theta_p^h X_{i,t-p} + \varepsilon_{i,t}^h$$

- **Sample**
  - After cleaning, 340 firms for over 7,800 observations
- **Orthogonality**
  - Controlling for aggregate inflation isolates changes in supply chain prices that do not have implications for inflation
  - FIRE test: $\gamma_p^h = 0$
- **Strengths of our approach**
  - Input prices exogenously determined wrt firms' inflation expectations
  - Direct measure of prices observed by firms ($\neq$ sector inflation)
  - Expectations elicited at 1-year horizon, closer to MP horizon
  - Survey's higher frequency reduces chances of confounding factors

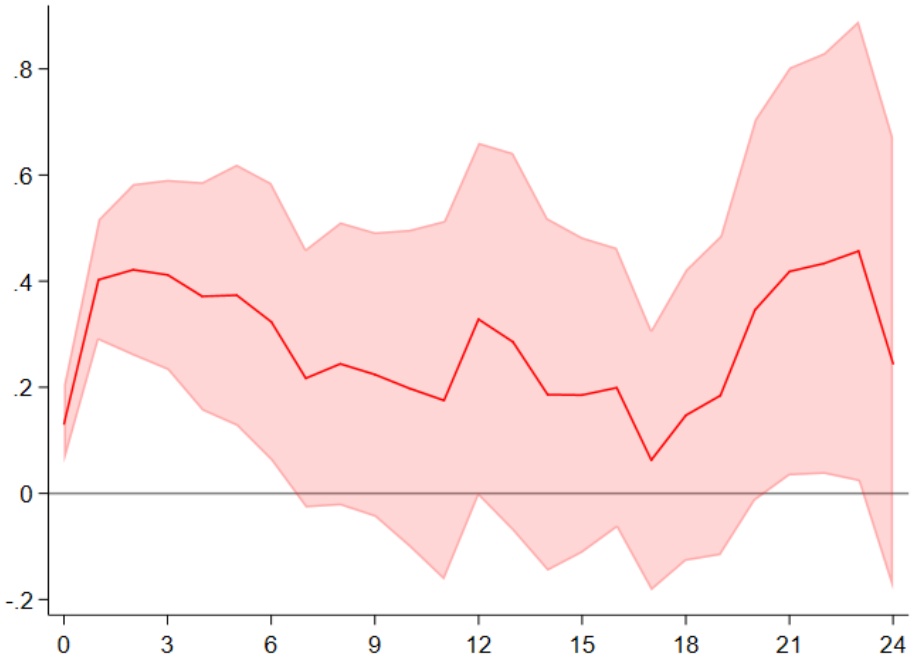
Baseline results

Robustness

(a) 1SD increase in input price inflation



(b) 1SD increase in CPI inflation

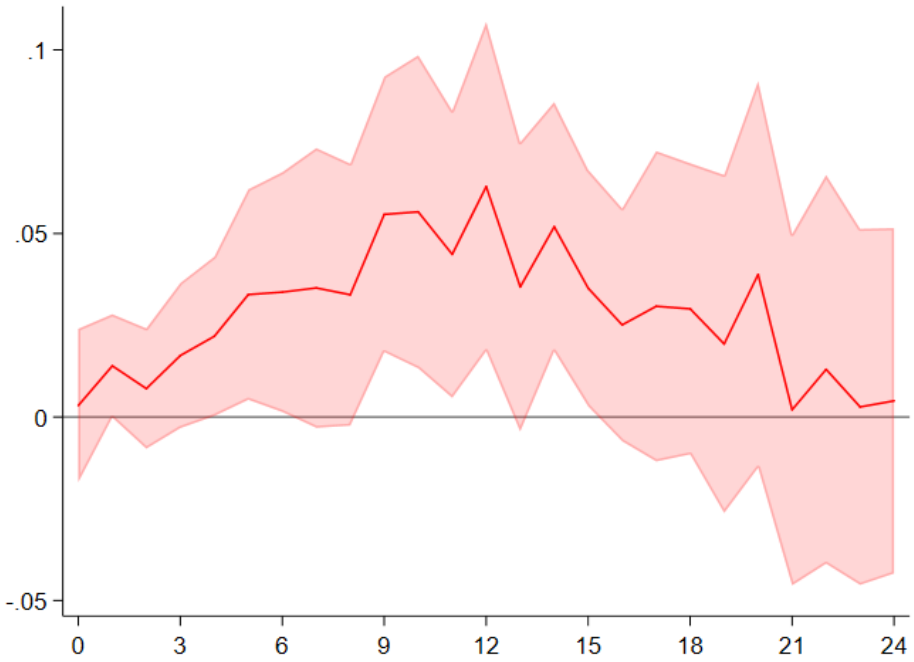


- Effect (at peak) of 1SD ↑ in Input price inflation → 0.1pp
- Effect (at peak) of 1SD ↑ in CPI inflation → 0.4pp
- Robust to selecting firms with suppliers that have at least 25 buyers

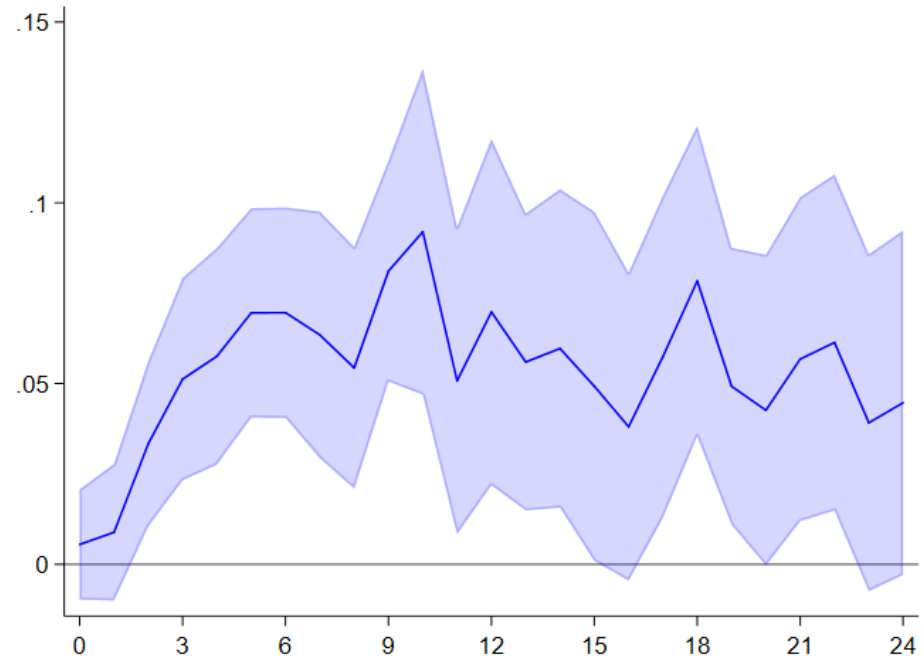
Sector vs idiosyncratic supply chain inflation

- Assess the importance of idiosyncratic changes in supply chain inflation by controlling for industry inflation

(a) 1SD increase in industry inflation



(b) 1SD increase in input price inflation



- Results consistent with firms not directly observing prices of the sector, rather they observe the prices at which they source inputs from their suppliers
- Also, firms may operate at the intersection of different industries

Imposing orthogonality at all horizons

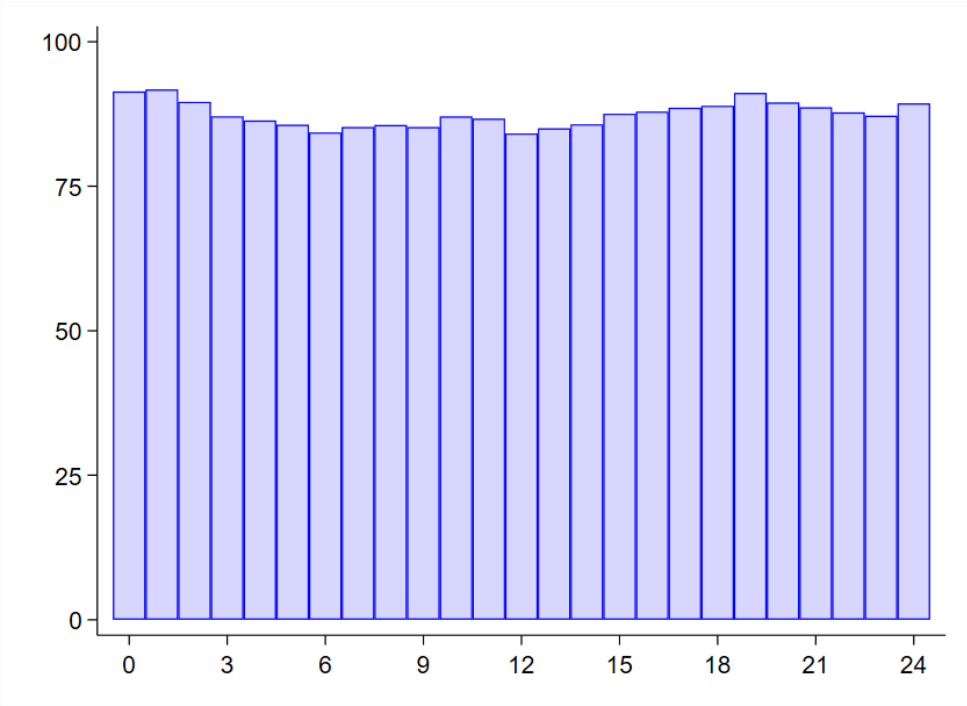
- FIRE$\rightarrow$ firms use input prices to forecast future inflation, even after controlling for aggregate inflation
- Our specification only ensures *contemporaneous* orthogonality of supply chain inflation to aggregate inflation
- Test robustness to 'future' orthogonality
  1. Firm-by-firm regressions to assess non-predictability (i.e., $\gamma_p^{i,h}$ not significant)

$$\pi_{t+h} = \iota^i + \sum_{p=1}^{P} \beta_p^{i,h} \pi_{t-p} + \sum_{p=1}^{P} \gamma_p^{i,h} \pi_{i,t-p} + \nu_{i,t+h}$$

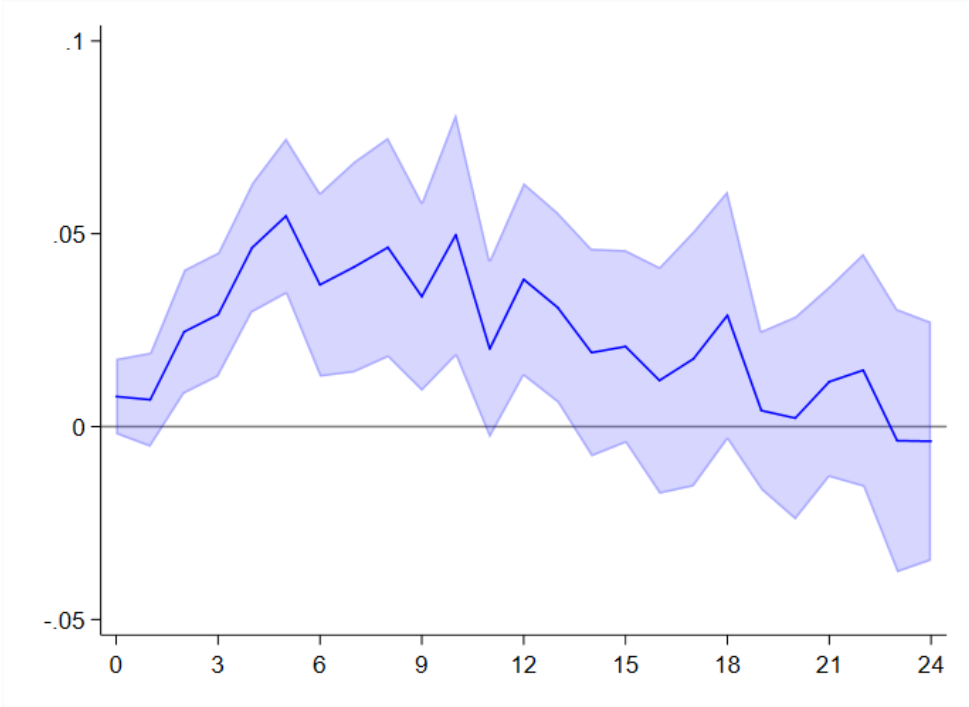
  2. Compute share of firms at any h for which supply chain prices cannot predict aggregate inflation
  3. Re-estimate baseline with firms/horizons for which we ensure non-predictability

Imposing orthogonality at all horizons

(a) Share of firms with input price inflation unrelated to future CPI inflation



(b) 1SD increase in input price inflation



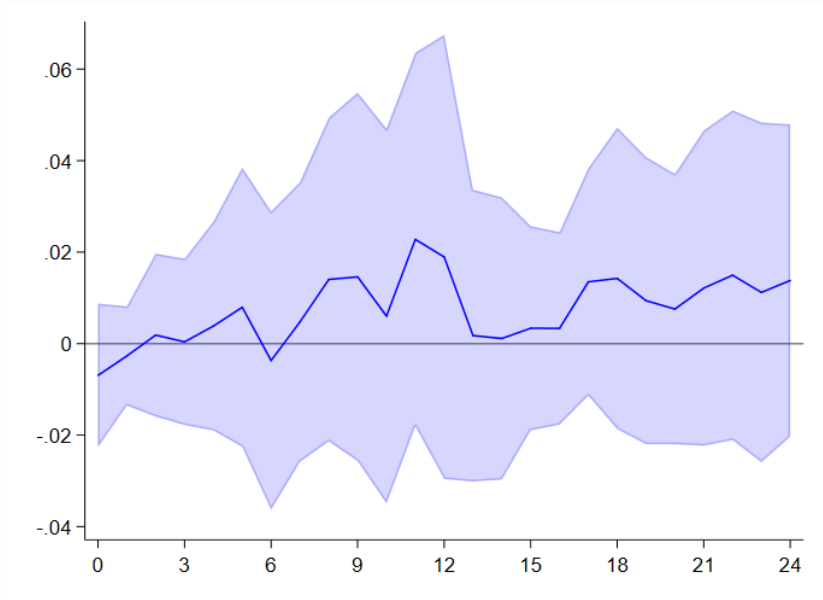
A placebo test

- For each firm i, consider all other firms $J \neq i$ and regress one-by-one all J's supply chain inflation on firm i's supply chain inflation

$$\pi_{j,t} = a^j + b^j \pi_{i,t} + e_{j,t} \quad \forall j \in J$$

- Then add supply chain inflation of firm j that produced the smallest coefficient $|b^{j*}|$ to baseline specification to test that $|b^{j*}| = 0$

(a) Placebo test for input price inflation



Frequency

- Georganas et al. (2014) on perceptual learning → individuals weigh more frequent signals when forming inflation expectations (Watanabe et al. 2001)
- Evidence from grocery shoppers (D'Acunto et al., 2021):
  - Price changes of more frequently purchased goods lead to larger changes in CPI inflation expectations
  - Infrequent shoppers who tend to observe larger changes between shopping trips respond more to price changes

- We test if this matters for firm by constructing a frequency-based indicator of input price inflation

	Frequency-based input price inflation			Frequency-based and value-weighted input price inflation		
	(1) $h=4$	(2) $h=5$	(3) $h=6$	(4) $h=4$	(5) $h=5$	(6) $h=6$
Lag of freq.-based input price infl.	0.004	-0.007	-0.006	-0.007	-0.022	-0.017
	(0.008)	(0.009)	(0.010)	(0.008)	(0.019)	(0.011)
Lag of input price inflation				0.045***	0.056***	0.044***
				(0.009)	(0.013)	(0.013)
Firms	312	314	312	312	314	312
Observations	7,383	7,323	7,133	7,383	7,323	7,133
R-squared	0.350	0.363	0.327	0.355	0.367	0.331

Size and sign

- Examine if firms react asymmetrically to input price inflation and input price deflation
- RI vs salience
  - RI $\rightarrow$ firms should not react differently to input price changes of different magnitude
  - Salience $\rightarrow$ stronger effect for large changes of input price inflation

	Sign			Size		
	(1) $h=4$	(2) $h=5$	(3) $h=6$	(4) $h=4$	(5) $h=5$	(6) $h=6$
Lag of positive input price inflation	0.038***	0.041***	0.034**			
	(0.011)	(0.013)	(0.016)			
Lag of negative input price inflation	-0.007	-0.009	-0.008			
	(0.012)	(0.016)	(0.014)			
Lag of input price inflation				0.053***	0.079***	0.061***
				(0.018)	(0.022)	(0.022)
Lag of input price inflation squared				-0.015	-0.036*	-0.026
				(0.017)	(0.019)	(0.021)
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- Some downward rigidity in firms' inflation expectations
- Support to the rational inattention framework

Conclusions and implications

- Main results
  - Firms have significantly different views about future inflation and they pay little attention to macro developments
  - Firms rely on observed price changes along the supply chain to predict inflation, even if these changes are unrelated to inflation
  - Evidence of downward inflation expectation rigidity, but not of perceptual learning based on frequency and size of price adjustments

- Implications
  - Inflation forecast disagreement can translate into price dispersion
  - Reduced effectiveness of expectation channel
  - Our findings are consistent with rational inattention, which weakens the weight inflation has in the formation expectations mechanism (relative to rational expectations) and can give rise to more persistent inflation
  - Improvements in communication can help limit the effects of information frictions

Firms as islands—setting

Back

- N islands with a firm in each that charges p_i, and aggregate prices $p_t = 1/N \sum_i^N p_{i,t}$
- Firms increase output if own price is higher than aggregate price

$$y_{i,t} = \gamma(p_{i,t} - p_t)$$

- Assumption: imperfect information
  - Firms know their price $p_{i,t}$
  - Firms do not know aggregate price $p_t \rightarrow$ need to guess $E(p_t|I_{i,t-1})$
- Supply curve becomes

$$y_{i,t} = \gamma(p_{i,t} - E(p_t|I_{i,t-1}))$$

- How do firms form $E(p_t|I_{i,t-1})$?
  - RE: $p_t = E(p_t|I_{i,t-1}) + \epsilon$ with $\epsilon_t \sim N(0, \sigma)$
  - Island's prices differ randomly from aggregate: $p_{i,t} = p_t + z_t$ with $z \sim (0, \tau)$
- Firms' production decision:
  - If firm had perfect information, $y_{i,t} = z_t$
  - With imperfect information, $y_{i,t} = z_t + \epsilon_t$

Firms as islands—signal extraction problem

Back

- Firms need to assess how much of the composite shock is due to z_t and to ϵ_t, and change output only in response to z_t
  - Proportion of composite shock coming from z: $\theta = \tau^2/(\sigma^2 + \tau^2)$
  - Infer it from the past
- Since $p_{i,t} = p_t + z_t$, they need to guess aggregate prices to decide production

$$\begin{aligned} E(p_t|I_{i,t-1}, p_{i,t}) &= p_{i,t} - E(z_t|I_{i,t-1}, p_{i,t}) \\ &= p_{i,t} - \theta(p_{i,t} - E(p_t|I_{i,t-1})) \\ &= (1-\theta)p_{i,t} + \theta E(p_t|I_{i,t-1})) \end{aligned}$$

- In changes

$$E(\pi_t|I_{i,t-1}, p_{i,t-1}) = (1-\theta)\pi_{i,t} + \theta E(\pi_t|I_{i,t-1})$$

Supply chain inflation

Back

- Construction steps
  1. Collect prices and quantities for each product j purchased by firm i during period t, p_{ijt} and q_{ijt}
  2. Some cleaning
     - Drop if identifier of the buyer and the seller is the same
     - Drop if $p_{ijt} \leq 10$
     - Drop if $q_{ijt} \leq 0$.
  3. For each product purchased by each firm, compute the y-o-y log difference of the median price observed in each month, π^{50}_{ijt}
  4. To aggregate at the firm level, compute the average of product inflation weighted by the transaction amount, $\pi_{it} = \sum_j \frac{p_{ijt}q_{ijt}}{p_{it}q_{it}} \pi^{50}_{ijt}$
  5. Trim observations outside of the $[-30, 100]$ percent change band

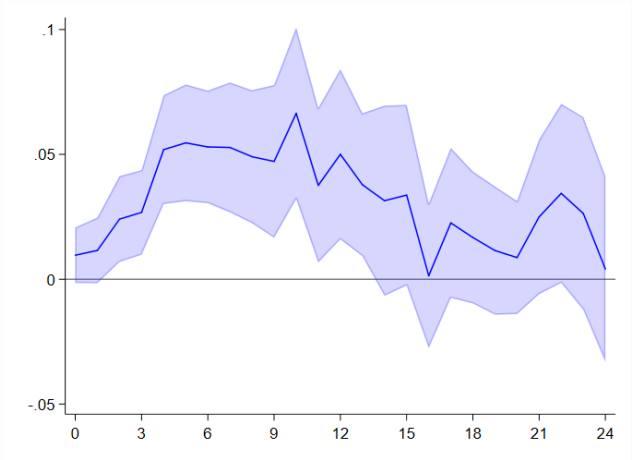
- Firms involved in international trade may experience price changes for inputs sourced *abroad*
  - Most firms answering the survey have zero or small imports
  - Compute weighted average of input and import price inflation

- Do the same for sales and export price inflation

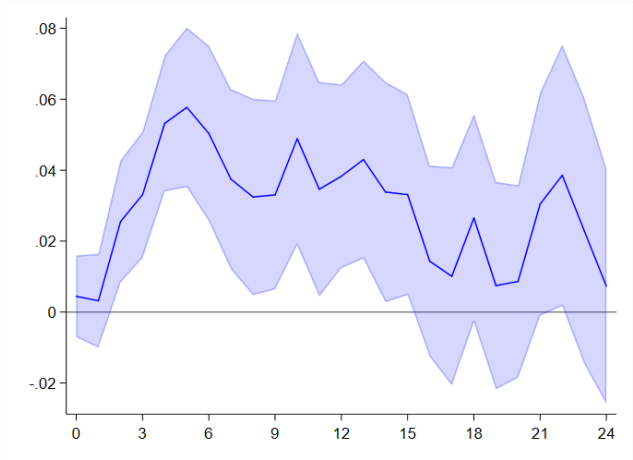
Robustness results

Back

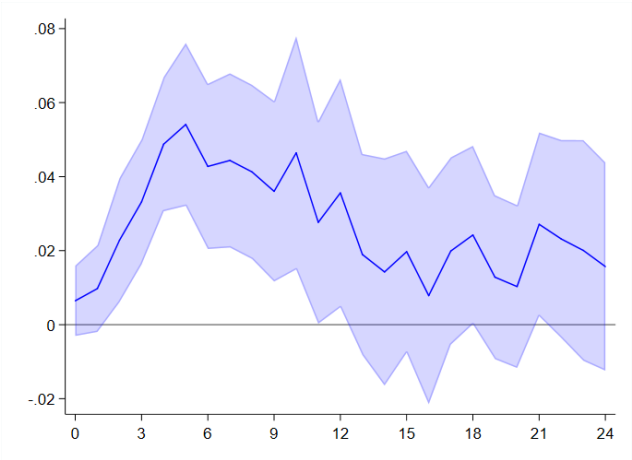
(a) At least 25 suppliers per firm



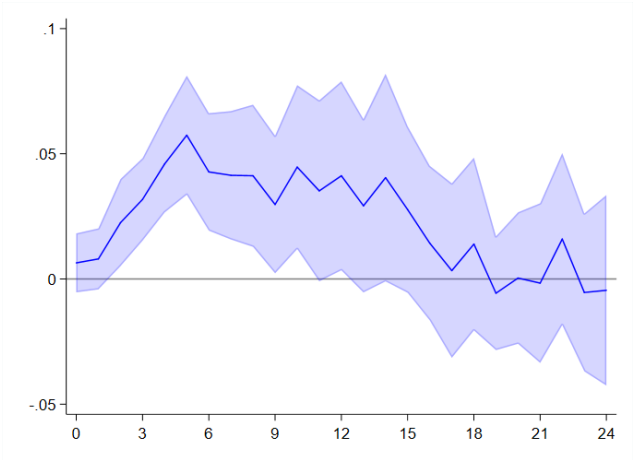
(b) More lags



(c) No lags



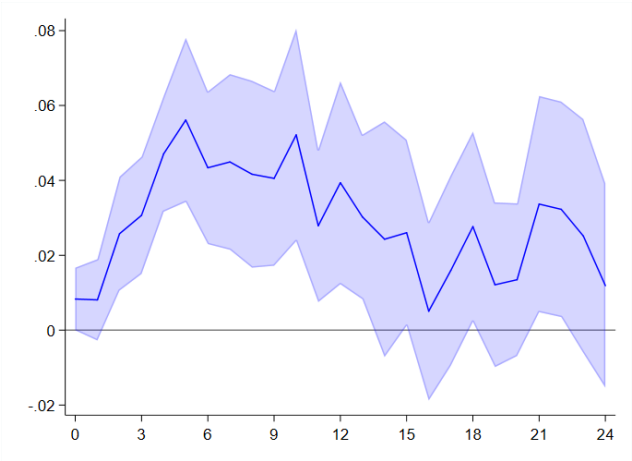
(d) Controlling for input price inflation



Robustness results

Back

(a) Driscoll-Kraay standard errors



(b) Double-clustered standard errors