Inflation Expectations and the Supply Chain*

Elías Albagli — Central Bank of Chile

Francesco Grigoli — IMF

Emiliano Luttini — World Bank

Abstract

Leveraging a unique dataset on Chilean firms merging expectation surveys and records from the VAT and customs registries, we study how firms form inflation expectations. We show that firms rely on price changes observed along their supply chain to form expectations about inflation, even if movements in input prices are orthogonal to changes in inflation. Our findings point to the existence of information frictions and add to the evidence rejecting the full-information rational expectations hypothesis. The mechanism we highlight in this paper can lead to more persistent inflation dynamics and weaken the expectation channel of policies.

Keywords: Inflation expectations, information frictions, rational inattention, supply chain

JEL Codes: E30, E31

*Elías Albagli, ealbagli@bcentral.cl; Francesco Grigoli fgrigoli@imf.org; Emiliano Luttini, eluttini@bcentral.cl.

The views expressed in this paper are those of the authors and do not necessarily represent those of the Central Bank of Chile, the IMF, its Executive Board, or its management. Officials of the Central Bank of Chile processed the disaggregated data from the Internal Revenue Service. We thank Héctor Álvarez for the excellent research assistance. We are also grateful to Francesco D'Acunto, Olivier Coibion, Gita Gopinath, Pierre-Olivier Gourinchas, Jose Mota, Gurnain Pasricha, Carolin Pflueger, Damiano Sandri, Michael Weber; and to the participants to the annual meeting of CEBRA's International Trade and Macroeconomic program 2023, ASSA 2023, the Conference of the Bank of Italy on Inflation Expectations in Modern Macro, the conference of Banco de la Republica on Monetary Policy, 5th IMF Annual Macro-Financial Research Conference, IMF's 2022 Advances in Monetary Economics Conference, 2022 NBER Conference on Inflation Expectations, the SETA 2022, the Reserve Bank of New Zealand seminar, and IMF seminars for comments and suggestions.

1 Introduction

How firms form beliefs about future inflation is crucial to many aspects of policymaking. *In primis*, it is relevant to monetary policy, as it targets aggregates—prices and employment—that depend on firms' expectations and decisions. It is widely acknowledged that information frictions can hamper firms' ability to collect and process data to forecast inflation. Yet, our understanding of what factors firms rely upon to form their beliefs remains limited, partly because "Information on the price expectations of businesses who are, after all, the price setters (...) is particularly scarce", as noted by Bernanke (2007). At the same time, surveys of households or professional forecasters are only poor substitutes for surveys of firms: the scant empirical evidence on firms documents substantially different facts compared to professional forecasters and households.[1]

In this paper, we show that firms use price changes observed when purchasing inputs from their suppliers to form views about future aggregate inflation. To do that, we leverage a unique dataset merging confidential information from the expectation surveys of Chilean firms with administrative records of prices and quantities from the VAT and customs registries. This study is the first to assemble a panel dataset with a long-time series about firms' inflation expectations and prices at which they source their inputs. Our results are remarkable because we focus on price changes along the supply chain that are orthogonal to movements in aggregate inflation. We estimate that a one standard deviation increase in supply chain inflation orthogonal to CPI inflation leads firms to increase their CPI inflation expectations by about 0.1 percentage points. We also quantify the response of firms' inflation expectations to past inflation and find that it feeds into inflation expectations at a slower pace than the full-information rational expectations (FIRE) framework predicts.

Our results provide empirical support for macroeconomic models incorporating information frictions á la Lucas (1972). In Lucas' "island model", firms do not observe all prices in the economy. Instead, they operate as if they were located on different islands and happen to form expectations about inflation using the information on prices from the islands they trade with. Our findings are consistent with the notion that firms extrapolate an *aggregate* value for future inflation from a *local* signal obtained from their purchasing prices, even if movements in the latter are orthogonal to changes in aggregate inflation. Thus, we argue that our results reject the FIRE hypothesis and lend support to theories incorporating information frictions in the expectation formation mechanism.

[1] Using surveys of different countries, Candia, Coibion and Gorodnichenko (2022) document that the average of the inflation forecasts of firms deviate significantly from that of professional forecasters and households and present a more pervasive disagreement, among other things.

These results are in line with some established empirical facts such as firms' disagreement about future inflation and inattention to macroeconomic news (Coibion, Gorodnichenko and Kumar, 2018; Candia, Coibion and Gorodnichenko, 2022), which we also document for Chile. Specifically, we show that supply chain inflation displays significant dispersion across Chilean firms, which is unsurprising as firms buy different goods and services from different trading partners. This is, however, consequential in light of our results that firms form their beliefs using prices observed in the transactions with their suppliers, as the dispersion in supply chain inflation can translate into inflation forecast disagreement. Also, we show that supply chain inflation is significantly more volatile than CPI inflation. The high volatility of supply chain inflation, together with the costs associated with processing macroeconomic news, can lead to inattention to aggregate inflation as firms focus on shocks more immediately relevant to their businesses.

Finally, we find that the relationship between input price inflation and CPI inflation expectations does not depend on the frequency of input purchases nor the size of their price changes, providing evidence against perceptual learning of firms and support for the rational inattention framework. We also show that firms forecast higher CPI inflation in response to positive changes in input prices. However, they do not change their inflation expectations when input prices decline, suggesting some downward rigidity in the formation of firms' inflation expectations.

Our work illustrates the difficulties of policymakers in designing policies to stabilize inflation. We derive some implications by combining our results with the New Keynesian Phillips curve prediction that inflation expectations pass-through to firms' sales prices. If firms pay attention to their local conditions and are less attentive to the aggregate ones, inflation expectations would react less strongly to the news than under the frictionless information benchmark. That is, inflation expectations become relatively less sensitive to past information. In the New Keynesian framework in which firms' inflation expectations determine their sales prices, the stickiness of expectations would translate into higher inflation persistence. For example, in a high but receding inflation context, expectations can remain stubbornly high because of the slow adjustment of expectations to news on the economy's inflation. This mechanism would make the high level of inflation more persistent relative to the predictions of the FIRE hypothesis.

In addition, our results that inflation expectations depend at least in part on supply chain prices imply a less effective expectation channel of policies. Improvements in central bank communication aimed at reducing firms' inattention have the potential to dampen the effects of the information frictions highlighted in this paper. In this regard, experimental studies examining the effects of the type, amount, and how information is communicated can be informative.[2]

Related literature This paper contributes to the literature documenting information frictions in the inflation expectation formation mechanism. The closest paper to ours is Andrade et al. (2022), which shows that French firms learn from inflation observed in their industry. Our paper, however, differs from theirs in a number of aspects. We shift the focus from industry inflation to supply chain inflation, which better aligns with Lucas (1972)'s framework in which firms observe prices at which they settle transactions with their suppliers. This also squares with the fact that firms typically source their inputs from different sectors, which inflation is likely different from the one of the sector to which firms are assigned by statistical offices. Similarly, firms may operate at the intersection of different industries, a reason why industry inflation may be an imprecise proxy of the price changes that matter for these firms. Also, the survey we rely on provides some advantages. First, it elicits a quantitative (rather than qualitative) answer for inflation expectations, allowing it to pin down an estimate for the impact of a change in supply chain inflation on firms' expectations. Second, inflation expectations are measured over a 1-year horizon (compared to 3 months), a horizon that is closer to the one relevant to monetary policy. And third, the survey is sent to firms each month rather than each quarter. The higher frequency reduces the time span between the moment in which firms observe price changes and the moment in which they submit the answers to the survey, which in turn mitigates the concerns that confounding factors may bias the estimates.

More generally, the paper is related to the literature on learning from observed prices. Most of the evidence in this area, however, is based on household surveys. Cavallo, Cruces and Perez-Truglia (2017) and D'Acunto et al. (2021) find that shopping prices lead to changes in consumers' inflation expectations in the United States and Argentina. Also, Coibion and Gorodnichenko (2015*b*) show that gasoline prices impact inflation expectations of households in the United States. Kuchler and Zafar (2019) document that individuals extrapolate from counties' house-price changes to expectations about the real estate sector in the United States economy. One exception is Kumar et al. (2015), who provide some evidence that in New Zealand firm managers form expectations about aggregate inflation based on the prices observed when they go on personal shopping.

In addition, while most survey-based studies use data on advanced economies, we focus on Chile, an emerging market that experienced larger and more frequent swings in

[2]See, for example, Coibion, Gorodnichenko and Weber (2022) who study how communicating different messages to individuals can affect their inflation expectations (as well as their spending decisions). Relatedly, Salle (2022) stresses the importance of experimental studies on firms to mitigate the distortions due to information rigidity.

inflation. As argued by Cavallo, Cruces and Perez-Truglia (2017), Candia, Coibion and Gorodnichenko (2021), Candia, Coibion and Gorodnichenko (2022), and Fuster and Zafar (2022), advanced economies have a history of low and stable inflation, which makes economic agents inattentive to inflation and other macroeconomic events (Kumar et al., 2015). On the other hand, emerging markets traditionally recorded higher and more volatile inflation and have the potential to enrich our understanding of the inflation expectation formation mechanism.

Finally, our findings also add to the evidence documenting violations of the FIRE hypothesis (Mankiw, Reis and Wolfers, 2003; Coibion and Gorodnichenko, 2012, 2015*a*; Bordalo et al., 2020; Born et al., 2021) and to the literature on rational inattention, which shows that firms devote resources to process volatile information that is more relevant for them (Mackowiak and Wiederholt, 2009; Pasten and Schoenle, 2016). Our paper is the first to provide evidence about the departure from the FIRE benchmark by linking a survey of firms' inflation expectations with information on prices at which they source their inputs. We also contribute to this literature by unveiling that prices representing a substantial share of the firm's input structure determine its inflation expectations.

The rest of the paper is organized as follows. Section 2 describes the data used in the analysis and how we construct measures of supply chain inflation. Section 3 presents some key stylized facts about firms' inflation expectations and discusses their relationship with supply chain inflation. Section 4 presents the empirical results about the impact of supply chain inflation on firms' inflation expectations. Section 5 discusses the heterogeneity of the results and their robustness. Section 6 concludes.

2 Data

Our empirical setting is Chile during January 2015—September 2021. Consumer prices experienced significant swings during this period. Amid the end of the commodity supercycle and weak aggregate demand, inflation fell from an average of 4.3 percent in 2015 to less than 2 percent in 2017. As economic activity bounced back, inflation converged towards the central bank target of 3 percent in late 2018 and hovered within the target band of 2—4 percent up to the onset of the COVID-19 pandemic. A mix of lockdown policies aimed at containing the spread of the virus and expansionary fiscal measures resulted in supply bottlenecks, which led inflation to spike in the last months of 2020 and early 2021 to over 5 percent. This variation in the inflation rate provides an ideal setting to study the expectation formation mechanism of firms.

For the analysis, we combine confidential datasets from different sources. The first dataset draws from the expectation survey (*Índice Mensual de Confianza Empresarial*) run by the Central Bank of Chile. The survey is sent to about 600 firms each month, of which about two-thirds submit their answers. It targets all large firms and randomly selected smaller ones, which on average account for 35.5 percent of total sales during the sample period. The expectation survey asks 18 questions to firms operating in four broad sectors: manufacturing, retail, construction, and mining. The question we focus on in this paper elicits firms' expectations about CPI inflation expectations by asking: "What do you think inflation will be in the next 12 months (measured by the Consumer Price Index CPI)?". This question targets only firms in the manufacturing and retail sectors, representing 35 percent and 23 percent of each sector's sales, respectively.

The second dataset consists of the administrative records from the VAT registry maintained by the Internal Revenue Service.[3] We extract all the invoices in which firms answering the expectation survey are buyers or suppliers. We retrieve information about what goods and services are sold, in what quantities, and at what prices. It should be noted that one product may have different varieties and that we obtain the information at the variety level (rather than the product level).[4] In what follows, we use the term product when we refer to a variety. We convert sales in Chilean Pesos into real values called *Unidad de Fomento*, a CPI inflation-indexed unit of account calculated and published by the Central Bank of Chile.[5]

The third dataset includes information on firms' imports (cost, insurance, and freight) and exports (free on board) at the transaction level from the National Customs Service. Each transaction record reports an identifier for the imported or exported product, the transacted amount, and the quantities.[6]

2.1 Supply chain inflation

We construct a firm-level index of input price inflation to measure supply chain inflation as follows.[7] Let p_{ijt} and q_{ijt} be the prices and quantities for each product j purchased by firm i during period t, where i is a firm answering the expectation survey. We reduce

[3]Chile was a pioneer in introducing electronic invoicing, leading the way for other countries in Latin America as Brazil and Mexico. The use of electronic invoices started in 2003, but it was made mandatory for all firms in 2014.

[4]In the classification used by the Chilean authorities, there are over 16 million varieties purchased and sold by the firms that answer the expectation survey during the sample period.

[5]See https://si3.bcentral.cl/estadisticas/Principal1/metodologias/EC/IND_DIA/ficha_tecnica_UF_EN.pdf.

[6]The product classification follows the Harmonized System Codes, which is different from the classification used for domestic transactions.

[7]In what follows, we use the terms input price inflation and supply chain inflation interchangeably.

the probability of erroneous records by dropping observations for which (a) the identifier of the buyer and the seller is the same; (b) the price is less than 10 Chilean pesos, $p_{ijt} \leq 10$ (about 1.25 US dollar cents); and (c) the purchased quantity is zero or negative, $q_{ijt} \leq 0$. For each product purchased by each firm, we compute the year-on-year log difference of the median price observed in each month, π^{50}_{ijt}. To aggregate this at the firm level, we compute the average of product inflation weighted by the transaction amount, $\pi_{it} = \sum_j \frac{p_{ijt} q_{ijt}}{p_{it} q_{it}} \pi^{50}_{ijt}$. We finally limit extreme volatility in the indicator by trimming observations outside the $[-30, 100]$ percent change band.[8] To summarize, our indicator of supply chain inflation consists of the percent change in input costs that firms observe when they purchase from their suppliers.

Similarly, we construct a firm-level index of sales price inflation following the same methodology. This corresponds to the percent change in sales prices that firms charge their customers. While input price inflation is by construction based only on 'business-to-business' transactions, sales price inflation uses both 'business-to-business' and 'business-to-consumer' transactions.

Figure 1 shows the cross-firm distribution over time of input and sales price inflation. Input price inflation displays significant cross-firm dispersion. The average cross-sectional standard deviation over the sample period is 23.6 percent, suggesting that firms observe markedly different conditions along the supply chain. This is somewhat expected, as firms buy different products and services from different trading partners. It is also striking how cross-firm heterogeneity differs between input and sales price inflation. The maximum and the minimum of the interdecile range of input price inflation over the sample period are -17 and 62 percent, respectively, while they are -10 and 50 percent for sales price inflation. Excluding the post-COVID-19 period when inflation increased even at the bottom of the firm distribution, the difference becomes even more evident: the interdecile range of input price inflation before 2020 is as large as 75 percentage points compared to 46 percentage points for sales price inflation. This suggests that input prices do not fully pass-through to sales prices.

At any given point in time, the distributions of input and sales price inflation are right-skewed. In the case of input price inflation, about 3/4 of the data points are within the 0–20 percent range; however, significant deviations from the median are more on the upside than on the downside. Despite the much smaller dispersion of sales price inflation, larger upside deviations remain visible.

Input and sales price inflation display significant volatility over time compared to CPI

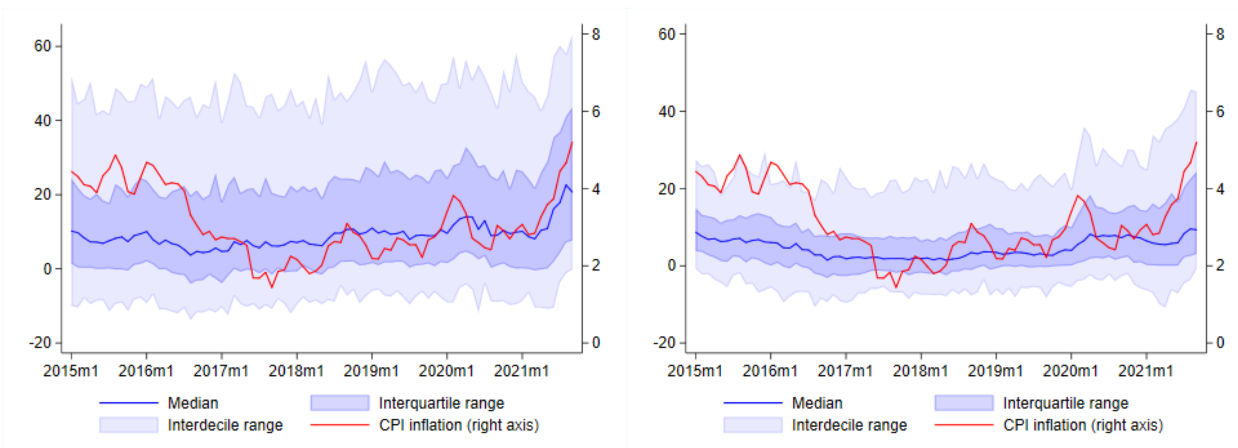
[8] Widening the band does not significantly affect the results, but introduces more volatility in the estimated impulse responses.

inflation. Input price inflation for the median firm hovered between 3.7 and 22.6 percent during 2015–2021, with a standard deviation of 23.8 percent. Sales price inflation fluctuated slightly less, between 1.4 and 9.5 percent, with a standard deviation of 17.5 percent. As a benchmark, CPI inflation moved between 1.4 and 5.2 percent, and the standard deviation was only 0.9 percent.

Despite the reduced number of firms answering the expectation survey, cross-firm heterogeneity, and time volatility, the medians of both indicators track the evolution in CPI inflation. The correlation coefficient for input price inflation is 35 percent, and the one for sales price inflation is 69 percent, both significant at a 5 percent significance level. This suggests that movements in input and sales price inflation tend to happen in the same direction as CPI inflation. Yet movements uncorrelated with CPI inflation are not infrequent, especially for input price inflation.[9]

Figure 1: Supply chain inflation
(Percent)

(a) Input price inflation (b) Sales price inflation



Notes: Panel 1a and panel 1b present the cross-firm distribution of input price inflation and sales price inflation, respectively. The blue lines denote the medians of the corresponding variable and the shaded areas denote the cross-firm interquartile ranges (dark blue) and the cross-firm interdecile ranges (light blue). The red lines denote CPI inflation.

We defined our indicator of input price inflation as a measure of the *domestic* price

[9]Figure A.1 in Appendix A provides some further illustrations of the distribution of supply chain inflation as well as CPI inflation. The histograms in panels A.1a and A.1b show a larger probability mass for positive price changes, suggesting that price increases are more frequent than price declines. As a reference, a 10 percent increase in input (sales) price inflation is about four (three) times more likely than a 10 percent decline. Panel A.1e shows the probability distribution of CPI inflation, which support is narrower than supply chain inflation. In this case, the distribution resembles a bimodal one, with a larger mass for the 2 to 3 percent range.

pressures that firms observe along the supply chain. However, firms may also experience price changes for inputs purchased from *foreign* suppliers and change their domestic sales prices and/or export prices accordingly. While most firms that answer the expectation survey only purchase domestically or import a small share of their purchases, we test the robustness of our results by constructing firm-level measures of import and export price inflation.[10] To do that, for each firm i and product j^*—where * is a superscript for either an imported or an exported product—we obtain the unit price in period t by dividing the amount the firm imported or exported by the quantity during the month, $p^*_{i,j,t} = (p^*_{i,j,t} q^*_{i,j,t})/q^*_{i,j,t}$. Then, we compute the log difference of the median price at the firm-product-month level, $\pi^{*,50}_{i,j,t}$. In the last step, for each firm, we compute the average of the product-specific median prices weighted by the transaction amount and obtain an indicator of export price inflation and one of import price inflation, $\pi^*_{it} = \sum_j \frac{p^*_{ijt} q^*_{ijt}}{p^*_{it} q^*_{it}} \pi^{50,*}_{ijt}$. Also, in this case, we drop observations outside of the $[-30, 100]$ percent change band.

To measure the inflation pressures that the firm observes domestically and abroad, we construct an indicator of input price inflation that considers import price developments. We construct this indicator as the weighted average of domestic input price inflation and import price inflation, where the weights are simply the share of domestic purchases and imports to total purchases. Analogously, we compute the weighted average of domestic sales price inflation and export price inflation, where the weights are the share of domestic sales and exports to total sales.

Figure 2 reports two binned scatter plots that illustrate the correlation between the domestic measures of supply chain inflation and the correlation between the measures that account for international trade. Panel 2a shows that input price inflation and sales price inflation are positively, albeit weakly, correlated. A simple visual inspection suggests that the pass-through to changes in sales prices is higher for small increases in input prices. On the other hand, input price declines tend to translate into (small) sales price increases. Panel 2b conveys a similar message, with the domestic and imported input price inflation positively correlated with the domestic and export sales price inflation.

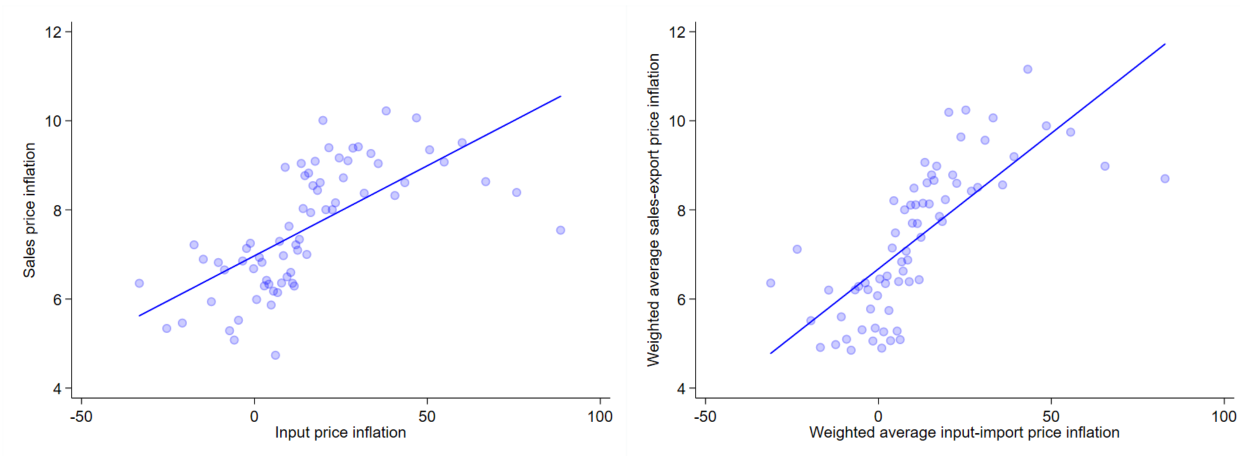
3 Disagreement, inattention, and the supply chain

Firms have substantially different views about next year's CPI inflation. Panel 3a of Figure 3 shows that the cross-sectional dispersion of firms' expectations is generally wide. However, such dispersion varies over time, narrowing when actual CPI inflation con-

[10] As shown in Figure B.1 of Appendix B, 45 percent of the firms in the sample do not import their inputs from abroad, and another large fraction only has a small share of imports in total purchases.

Figure 2: Relationship between input price inflation and sales price inflation (Percent)

(a) Domestic measures (b) Measures including international trade



Notes: In panel 2a each dot represents the average of input price inflation and sales price inflation over equally sized bins. In panel 2b each dot represents the average of the domestic and imported input price inflation and the domestic and export sales price inflation over equally-sized bins. The lines denote the linear fit. Data is residualized with respect to firm fixed effects.

verges towards the central bank's target and widening when it deviates from it. During the sample period, the interdecile range is larger than 2 percentage points in a few instances, and it collapses to about 0.5 percentage points when inflation approaches the target.

The distribution of inflation expectations appears generally symmetric. When it turns asymmetric, the right tail becomes longer than the left one, even when inflation is below the target. However, firms do not appear to systematically predict inflation above the inflation outcome.[11] Panel 3b indicates that firms' predictions correlate with the inflation outcome (the correlation coefficient is 11 percent and is significant at 5 percent significance level).

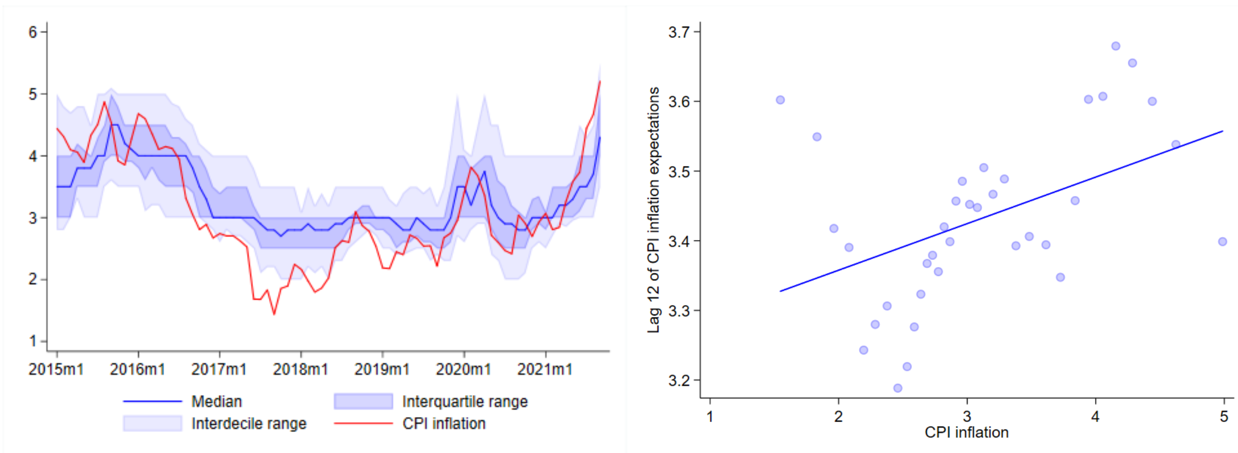
We then examine whether firms are attentive to macroeconomic developments. To do that, we compute the share of firm-month observations that display a change in expectations in response to a change in CPI inflation. To avoid mild variations in inflation affecting our calculations, we classify changes smaller than half of the standard deviation as periods of unchanged CPI inflation. Panel 4a of Figure 4 shows that in more than 40 percent of the cases, firms did not change their predictions of inflation when the previ-

[11] Coibion, Gorodnichenko and Kumar (2018) find that disagreement is large across firms in New Zealand and that they generally predict a higher level of inflation compared to the observed one.

Figure 3: Firms' disagreement about aggregate inflation
(Percent)

(a) Dispersion in firms' inflation expectation

(b) Inflation and firms' expectations



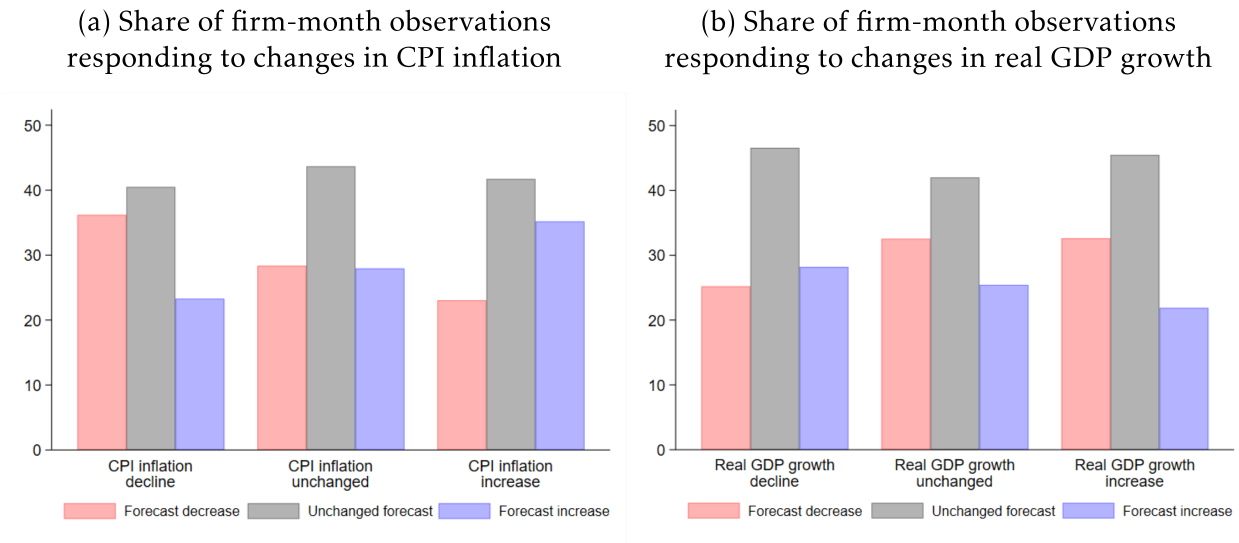
Notes: In panel 3a the blue line denotes the median of firms' expectations about CPI inflation, the shaded areas denote the cross-firm interquartile range (dark blue) and the cross-firm interdecile range (light blue), and the red line denotes CPI inflation. In panel 3b, each dot represents the average of the twelfth lag of firms' inflation expectations and CPI inflation over equally-sized bins, and the line denotes the linear fit. Data is residualized with respect to firm fixed effects.

ous period's CPI inflation changed, which is suggestive of inattention. Given that Chile is an emerging market that experienced swings in inflation during the sample period, the result is remarkable.

As expected, when inflation declines, we observe more instances of falling inflation expectations than when inflation increases or remains the same. Similarly, when inflation increases, we observe more firms increasing their inflation projections than when inflation stays the same or falls. Yet, more than one-fifth of firms predicts a change in inflation in the opposite direction compared to the direction of the change in actual inflation observed in the previous month, suggesting that other factors could potentially influence how firms form their views.

Panel 4b reports the results of the same experiment replacing changes in CPI inflation with changes in real GDP growth. We find consistent results regarding the share of firms that do not change their inflation expectations. We also find that in response to a decline in real GDP growth, the number of firms forecasting an increase in CPI inflation is larger than the number of firms forecasting a decline. In response to an increase in real GDP growth, the number of firms forecasting an increase in CPI inflation is smaller than the number of firms forecasting a decline. Thus, the evidence suggests that firms attribute changes in real GDP growth to supply shocks.[12]

Figure 4: Inattention to macroeconomic developments
(Percent)



Notes: The red and blue bars denote the shares of firm-month observations that report a decline or an increase in inflation expectations a month after a change in CPI inflation (panel 4a) or a change in real GDP growth (panel 4b), where a change is defined as a variation larger than half of the variable's standard deviation; the gray bars denote the share of firm-month observations that report unchanged inflation expectations.

It is well documented that forecast disagreement and inattention are related and can arise in a noisy information setting (Sims, 2003) and in a sticky information one (Mankiw and Reis, 2002). While we do not point to any specific source of information rigidity, we posit those information frictions exist such that firms observe price changes along the supply chain and, based on those changes, form their expectations about aggregate inflation. That is, as in Lucas (1972), firms operate as if they were located on different islands and learn from a subset of islands they have relationships with. Thus, firms extract a signal about future aggregate inflation from realized supply chain inflation.[13] If this is true, forecast disagreement may arise because firms would rely on local conditions, which are not necessarily the same across firms, and may not even have an aggregate effect. Focusing on local conditions, in turn, would lead firms to be inattentive to inflation developments because they would deem aggregate information less relevant than supply chain information for their business, hence deviating from the predictions of the FIRE

[12] This is consistent with the evidence in Candia, Coibion and Gorodnichenko (2020) that shows that households and firms hold a 'stagflationary view of inflation'.

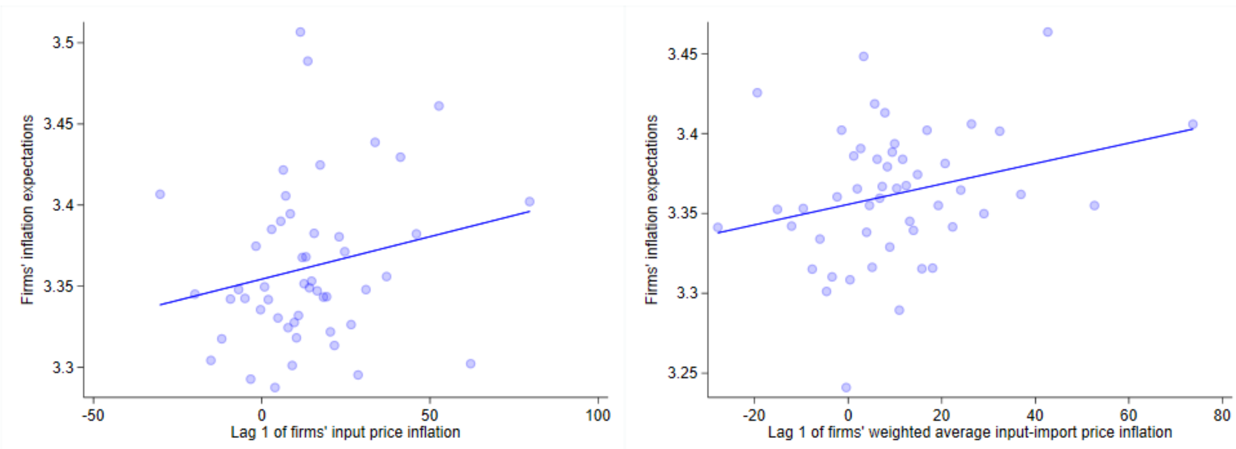
[13] See Appendix C for a formalization of the signal extraction problem.

framework.

Figure 5 reports some *prima facie* evidence of the relationship between supply chain inflation and firms' expectations about CPI inflation. The binned scatter plots in panels 5b and 5a display a positive association between firms' inflation expectations and the previous month's value of domestic input price inflation and domestic and imported input price inflation, respectively.

Figure 5: Supply chain inflation and inflation expectations
(Percent)

(a) Domestic input price inflation (b) Domestic and imported input price inflation



Notes: In panel 5a each dot represents the average of input price inflation and firms' inflation expectations over equally-sized bins. In panel 5b each dot represents the average of domestic and imported input price inflation and firms' inflation expectations over equally-sized bins. The lines denote the linear fit. Data is residualized with respect to firm fixed effects.

4 Firms' inflation expectation formation

In this section, we analyze the role of price changes observed along the supply chain and CPI inflation in determining firms' CPI inflation expectations and discuss the implications for inflation stabilization dynamics.

4.1 The role of supply chain inflation and CPI inflation

We test our conjecture that firms update their inflation expectations based on the prices at which they settle transactions with their suppliers, even if these have no impact on aggregate inflation. This is in contrast with the predictions of the FIRE benchmark, for which firms should discard idiosyncratic shocks that are irrelevant to aggregate inflation dynamics.

Specifically, we follow a similar approach to Andrade et al. (2022) and estimate a reduced-form specification using local projections

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

where the dependent variable is the cumulative change in firm i's beliefs about next year's CPI inflation in month $t+h$, with $h = [0,\dots,24]$, relative to its views about inflation in $t-1$. The independent variables include two lags of the supply chain inflation measure, $\pi_{i,t-p}$, domestic input price inflation, and two lags of CPI inflation, π_{t-p}. The set of controls, $X_{i,t-p}$, includes two lags of the dependent variable to account for persistence in firms' inflation expectations, one lag of aggregate activity (i.e., the latest reading of the quarterly real GDP growth), and two lags of firms' sales in real terms.[14] To account for time-invariant differences in inflation expectations across firms, the specification includes firm fixed effects α_i^h. This implies that the coefficients are identified using the within-firm variation of expectations and input prices over time. Standard errors are clustered at the firm and time level.

Some aspects of our research design are noteworthy. Instead of using a sector inflation index as independent variable as in Andrade et al. (2022), we leverage the richness of the data and compute a firm-specific index of supply chain inflation. A more granular index has the advantage of providing a tighter link with the notion of islands in the Lucas (1972)'s framework and squares with the fact that firms typically source their inputs from different sectors with different inflation indexes. Similarly, firms may operate at the intersection of different industries, a reason why industry inflation may be an imprecise proxy of the price changes that matter for these firms. Another advantage of using a firm-level index of supply chain inflation is that it is arguably more exogenous than an industry-level one, which depends on the firms' pricing decisions that, in turn, are likely affected by their expectations of future inflation. Also, the survey we rely on provides some advantages. First, it elicits a quantitative (rather than qualitative) answer for inflation expectations, allowing to quantify the impact of changes in supply chain in-

[14]Since GDP growth is available at the quarterly frequency, we repeat the observation for three consecutive months, in line with the idea that firms observe the latest available real GDP growth number. Replacing the lag of real GDP growth with the monthly indicator of economic activity published by the Central Bank of Chile does not alter the results (for more information about this indicator see https://www.bcentral.cl/en/web/banco-central/area/statistics/imacec).

flation on firms' expectations. Second, inflation expectations are measured over a 1-year horizon (compared to 3 months), a horizon that is closer to the one relevant to monetary policy. And third, the survey is sent to firms each month rather than each quarter. The higher frequency reduces the time span between the moment in which firms observe price changes and the moment in which they submit the answers to the survey, which in turn mitigates the concerns that confounding factors may bias the estimates.

We do not include time fixed effects as they are collinear with CPI inflation, which is a variable we want to condition on and retrieve a coefficient for.[15] Thus, one should note that our specification does not prevent other nominal shocks from feeding into supply chain inflation and affecting inflation expectations. This, however, would be a concern if we were to argue that our results originate from variation in supply chain inflation orthogonal to any other source of information; this is not the case. We interpret our results as if shocks jointly affecting input prices and inflation expectations lead to changes in the prices at which firms source their inputs. This type of learning mechanism is what models departing from the FIRE benchmark posit about the expectation formation process of firms; finding statistical significance of the supply chain inflation coefficients is evidence in their favor.

The coefficients of interest γ_1^h trace the cumulative response in firms' inflation expectations to price innovations that firms observe along the supply chain. Testing the statistical significance of these coefficients is an 'acid' test of the FIRE benchmark since it reveals the effect of changes in supply chain inflation that are orthogonal to changes in aggregate inflation. While these coefficients should be interpreted as the response of inflation expectations to innovations in supply chain inflation, there is the possibility that some firms answering the survey have monopsony power, thereby influencing prices at which they buy their inputs according to their inflation expectations. In the robustness section, we mitigate this concern by excluding firms that source inputs from suppliers with less than 25 customers.

The other coefficients of interest are β_1^h, which describe the effect of changes in CPI inflation on firms' inflation forecasts. Suppose inflation is a stationary process and firms are fully rational. In that case, once firms incorporate new information on inflation into their expectations, the impact of this information on future expectations should decrease. In Appendix D, we show how changes in firms' CPI inflation expectations relate to past inflation under FIRE, considering different degrees of persistence of the inflation process.

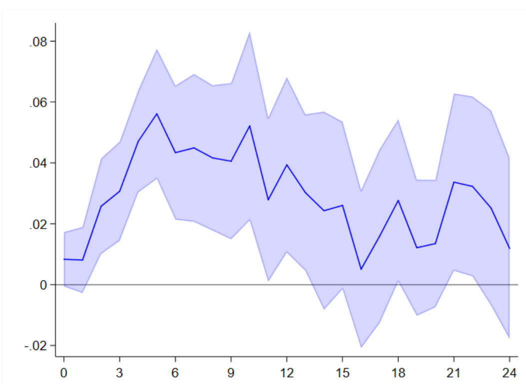
[15] The literature suggests that production networks are characterized by large firms with a lot of connections (Bernanke, 2007; Alfaro-Urena et al., 2018; Cardoza et al., 2020), including in Chile (Grigoli, Luttini and Sandri, 2021). In presence of suppliers that sell to many firms, time fixed effects would absorb the variation we are interested in.

We show that the sequence of β_1^h starts at a positive value and decreases to negatives, with the final value depending on the persistence of the process. Finding an alternative pattern could indicate that firms assign a higher weight to past inflation than FIRE predicts.

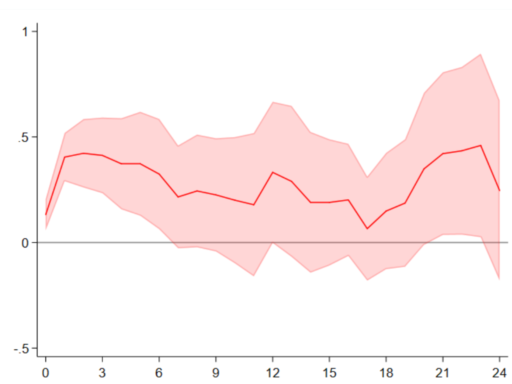
Figure 6 presents the results of the estimations. Panel 6a shows that a one standard deviation increase in input price inflation leads to a 0.1 percentage point increase in inflation expectations five months after the innovation. The effect dies out after 14 months, likely reflecting the time needed for firms to realize that these input price changes do not feed into aggregate inflation. These results are particularly striking in that they show that firms are responsive to conditions observed along the supply chain even when these do not affect inflation. Panel 6b reports that a one standard deviation increase in CPI inflation (equal to 0.9 percentage points) is associated with higher firms' expectations for next year's inflation by almost 0.4 percentage points a month after the innovation. The figure shows that the estimated sequence of β_1^h remains positive and statistically significant up to two quarters after the innovation. This result stands in contrast with the predictions of the FIRE benchmark in Appendix D, which indicates that the effect should be increasingly negative over time.[16]

Figure 6: Response of firms' inflation expectations to input price and aggregate inflation (Percentage points)

(a) Input price inflation



(b) CPI inflation



Notes: The figure shows the response of firms' inflation expectations to a one-standard deviation increase in the variable reported in each panel's title. The horizontal axes represent the number of months after the innovation, the lines denote the point estimates, and the shaded areas correspond to 90 percent confidence intervals computed with standard errors clustered at the firm and time level.

[16]To test if import prices have the potential to alter these conclusions, we estimate the same specification replacing domestic input price inflation with domestic and imported input price inflation. The results in Figure 10 of Appendix B closely resemble the ones of the domestic counterparts. We conclude that our results hold even for firms that rely on international trade to source their inputs.

4.2 Industry-level inflation

We assess the importance of supply chain inflation versus industry inflation by augmenting the specification in equation (1) with an industry-specific inflation index alongside our measure of supply chain inflation

$$E_{i,t+h}\pi_{t+h+12} - E_{i,t-1}\pi_{t-1+12} = \alpha_i^h + \sum_{p=1}^{P} \gamma_p^h \pi_{i,t-p} + \sum_{p=1}^{P} \beta_p^h \pi_{t-p} + \sum_{p=1}^{P} \psi_p^h \pi_{s,t-p} + \sum_{p=1}^{P} \theta_p^h X_{i,t-p} + \varepsilon_{i,t}^h \tag{2}$$

where $\pi_{s,t-p}$ is inflation in industry s, which is the sector to which firm i is assigned.[17]

Figure 7 presents the results of the estimation of equation (2). Panel 7a shows that an innovation in industry inflation leads firms to forecast higher CPI inflation, but the effect is significant only at some horizons. Panel 7b reports the response of inflation expectations to an innovation in input price inflation controlling for industry inflation (as well as CPI inflation). Despite the inclusion of industry inflation in the specification, the effect remains significant and is twice as large as the effect of industry inflation.

These results are consistent with the earlier findings that firms observe the prices at which they source inputs from their suppliers to form their beliefs about future inflation. Specifically, these findings suggest that our conclusions hold even when we orthogonalize supply chain inflation not only with respect to CPI inflation but also with respect to changes in industry prices.

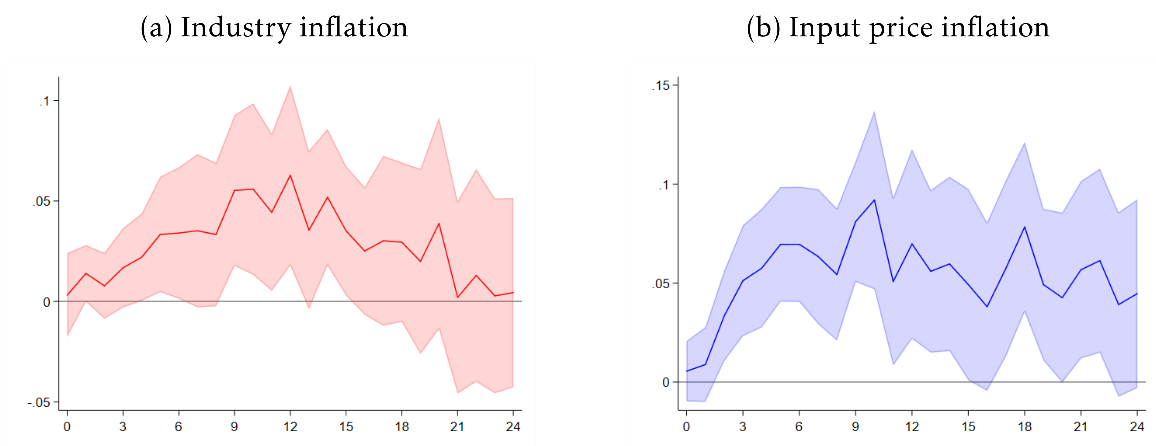
4.3 Future orthogonality of supply chain inflation to CPI inflation

The FIRE hypothesis posits that shocks without aggregate consequences should leave firms' expectations about aggregates unaffected. In contrast, we find that changes in prices along the supply chain that have no impact on inflation lead to changes in firms' inflation expectations. Our results, however, originate from a specification that assumes *contemporaneous* orthogonality between supply chain and CPI inflation. Thus, there is the possibility that changes in firms' supply chain inflation have predicting power with respect to *future* CPI inflation because, for example, firms may anticipate that a surge in supply chain prices will lead to higher CPI inflation in the future.

To ensure orthogonality with respect to future CPI inflation, we run a battery of firm-by-firm regressions to assess the non-predictability of future CPI inflation to current in-

[17] We rely on industry-level inflation indexes from the Central Bank of Chile. Industries are defined according to the *Clasificador Chileno de Actividades Económicas*, which is an adaptation of CIIU Revision 4. This consists of 170 industries, most of which are part of the broader manufacturing sector. The results are virtually unchanged when we use a less detailed classification with 42 industries.

Figure 7: Industry inflation and supply chain inflation
(Percentage points)



Notes: The figure shows the response of firms' inflation expectations to a one-standard-deviation increase in the variable reported in each panel's title. The horizontal axes represent the months after the innovation, the lines denote the point estimates, and the shaded areas correspond to 90 percent confidence intervals computed with standard errors clustered at the firm and time level.

put price inflation after accounting for current CPI inflation[18]

$$\pi_{t+h} = \iota^i + \sum_{p=1}^{P} \gamma_p^{i,h} \pi_{i,t-p} + \sum_{p=1}^{P} \beta_p^{i,h} \pi_{t-p} + \nu_{i,t}^h \tag{3}$$

where non-predictability of future CPI inflation would deliver a statistically insignificant $\gamma^{i,h}$ coefficient, with $h = [0, \ldots, 24]$. Then, for each horizon we compute the share of firms for which supply chain inflation cannot predict CPI inflation. Finally, we re-estimate our baseline specification in equation (1) excluding firms whose supply chain inflation predicts future CPI inflation.[19]

Figure 8 reports the results. At any given horizon, only a small share of firms presents a statistically significant estimate of $\gamma^{i,h}$. Panel 8a indicates that at least 80 percent of firms' supply chain inflation does not have any predictive power to future CPI inflation once we control for current CPI inflation. Panel 8b reports the results of the specification in equation (1) only including firms for which our measure of supply chain inflation is orthogonal to future CPI inflation. The estimated response is similar to the ones obtained in our baseline results in Figure 6.

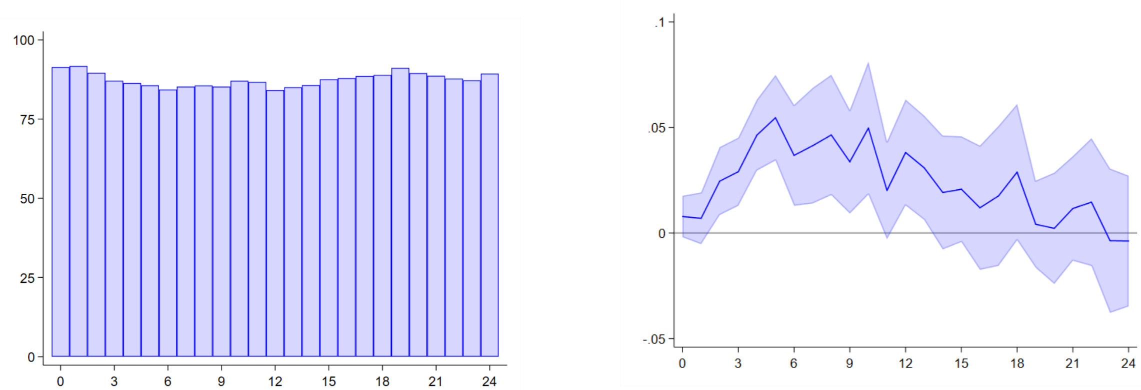
[18]We exclude firms with time series of fewer than thirty observations.

[19]We assess the statistical significance of the $\gamma^{i,h}$ coefficient using a 95 percent significance level, but results are similar when setting the significance threshold to 90 percent, which would result in more firms being dropped from the sample.

Figure 8: Orthogonality with respect to future CPI inflation
(Percentage points, unless otherwise specified)

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

(b) Response to input price inflation



Notes: Panel 8a shows the share of firms for which input price inflation is unrelated to future CPI inflation, where the bars denote the share of firms for which γ^h in equation (3) is statistically insignificant at the 95 percent confidence level. Panel 8b shows the response of firms' inflation expectations to a one-standard-deviation increase in supply chain inflation excluding firms for which supply chain inflation is not orthogonal to CPI inflation; the line denotes the point estimates and the shaded area corresponds to 90 percent confidence interval computed with standard errors clustered at the firm and time level.

5 Heterogeneity and robustness

We now turn to examining the heterogeneity of the firms' expectation formation mechanism in terms of frequency, sign, and size of input price changes. Then, we present the results of a set of robustness tests.

5.1 Frequency, sign, and size of price changes

In an experimental study, Georganas, Healy and Li (2014) show that individuals weigh more frequent signals when forming inflation expectations, consistent with the insights from the literature on perceptual learning (Watanabe, Nanez and Sasaki, 2001). At the household level, D'Acunto et al. (2021) find that price changes of more frequently purchased goods lead to changes in CPI inflation expectations. Also, they show that larger price movements have a larger impact on expectations, implying that infrequent shoppers who tend to observe more considerable changes across shopping trips respond more to grocery price changes.

However, Candia, Coibion and Gorodnichenko (2022) show that the properties of firms' and households' inflation expectations differ, and so could their determinants. For instance, firms could pay attention to prices of inputs that affect their costs and profits, without overweighting inputs that they purchase more frequently. We test if this is the case by constructing a frequency-based indicator of input price inflation, which overweights price changes of products purchased more frequently. That is, instead of weighting input price inflation by the value of the transactions, we construct weights using the number of transactions n, $\pi_{it}^{freq} = \sum_j \frac{n_{ijt}}{n_{it}} \pi_{ijt}^{50}$.

Columns (1) to (3) of Table 1 report the results of the regressions in which we replace the value-weighted input price inflation with the frequency-based version of it and test its effect 4 to 6 months after the innovation, which is when we observe the peak of the effect in our baseline results. In columns (4) to (6), we include the value-weighted input price inflation and the frequency-based measure. The results do not show any significant effect from the frequency-based measure. In contrast, the coefficient on the value-weighted measure of input price inflation remains significant and virtually identical in magnitude to the one of the baseline regression, providing evidence against perceptual learning in the case of firms.[20]

Table 1: Frequency of input price changes

	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

Notes: This table reports the results for 4 to 6 months after the shock, which is around the peak of the effect of input price inflation on inflation expectations in the baseline results. Shocks are normalized to one standard deviation. All regressions include all baseline regressors and firm fixed effects. Clustered standard errors at the firm and time level are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

We now examine heterogeneity in terms of the sign and size of input price inflation. First, we test if firms react asymmetrically to input price inflation and input price deflation. We replace input price inflation with its interaction with a dummy that takes

[20] Alternatively, using the distribution of the average (of the log) number of transactions of each firm over the sample period, we classify firms into three groups which correspond to the distribution terciles and, therefore, to how frequently they make purchases of inputs. We then include an interaction term between input price inflation and dummies for these groups. Again, we do not find evidence of an effect from the frequency at which firms observe input price changes.

value one when input prices increase and with a dummy that takes value one when input prices decline. Then, we test the prediction of the rational inattention literature that firms should not react differently to input price changes of different magnitudes. On the other hand, if the salience of input prices is relevant, we should find a more substantial effect for large changes of input price inflation (D'Acunto et al., 2021).

Columns (1) to (3) of Table 2 show that firms forecast higher CPI inflation in response to positive changes in input prices; however, they do not change their inflation expectations when input prices decline. The result implies some downward rigidity in firms' inflation expectations. To test differential effects for large changes in input prices, we include the squared term of input price inflation in the specification. Columns (4) to (6) show that the squared term is not statistically significant for horizons four and six, while horizon five is only significant at the ten percent significance level and is negative, supporting the rational inattention framework.

Table 2: Sign and size of input price changes

	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)
Firms	312	314	312	312	314	312
Observations	7,383	7,323	7,133	7,383	7,323	7,133
R-squared	0.355	0.367	0.331	0.354	0.367	0.330

Notes: This table reports the results for 4 to 6 months after the shock, which is around the peak of the effect of input price inflation on inflation expectations in the baseline results. Shocks are normalized to one standard deviation. All regressions include all baseline regressors and firm fixed effects. Clustered standard errors at the firm and time level are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

5.2 Robustness

To ensure the robustness of our findings, we run a set of tests. We perform a placebo test to show that our results are not an artifact of the empirical approach. The test consists of constructing a placebo series for supply chain inflation and examining its relevance for firms' inflation expectations compared to the actual supply chain inflation series.

Specifically, for each firm i we consider all other firms $j \in J \neq i$ and regress one-by-one all J's supply chain inflation on firm i's supply chain inflation

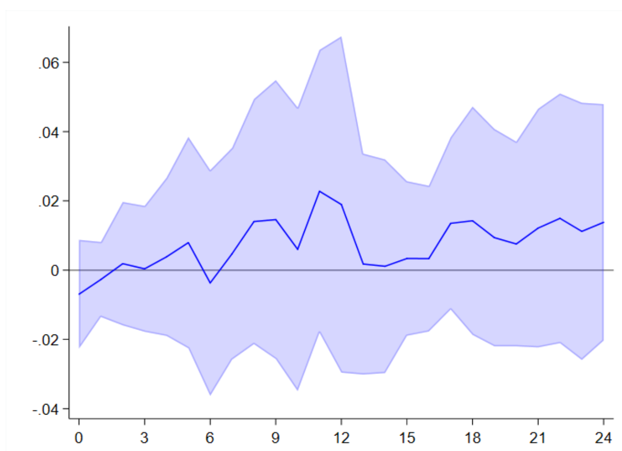
$$\pi_{j,t} = a^j + b^j \pi_{i,t} + e_{j,t} \quad \forall j \in J \tag{4}$$

We then take the supply chain inflation series of firm j that produces the smallest coefficient in absolute terms, $|b^{j*}|$ (i.e., the firm with the least predictive power), and call it placebo supply chain inflation series, $\pi^{placebo}_{j,t-1}$. Finally, we re-estimate the baseline specification with the inclusion of the placebo series

$$E_{i,t+h}\pi_{i,t+h+12} - E_{i,t-1}\pi_{i,t-1+12} = \alpha_i^h + \sum_{p=1}^{P} \gamma_p^h \pi_{i,t-1} + \sum_{p=1}^{P} \beta_p^h \pi_{t-p} + \sum_{p=1}^{P} \theta_p^h \pi^{placebo}_{j,t-1} \sum_{p=1}^{P} \theta_p^h X_{i,t-p} + \varepsilon_{i,t}^h \tag{5}$$

Suppose our results are not an artifact of the empirical procedure. In that case, we should find non-significant coefficients on the placebo series, indicating absence of predictive power with respect to the firms' inflation expectations. Figure 9 shows that the point estimates are not distinguishable from zero at any horizon.

Figure 9: Placebo test
(Percentage points)



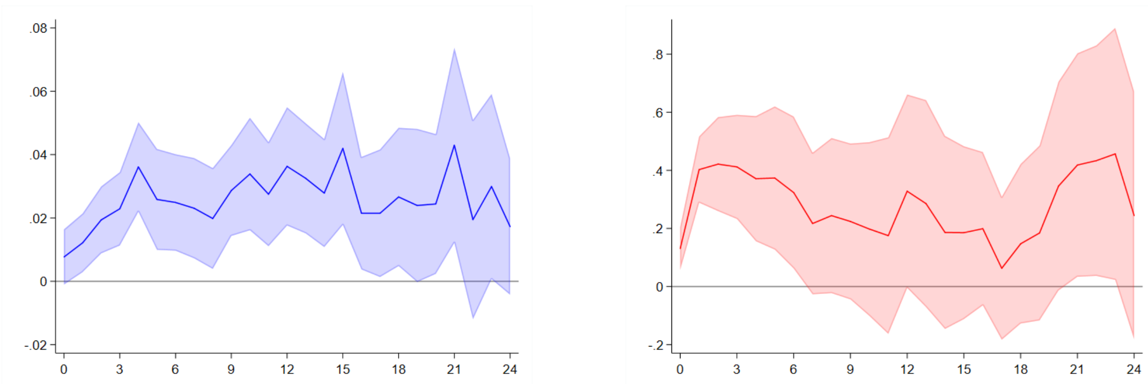
Notes: The figure shows the response of firms' inflation expectations to one-standard-deviation increase in placebo input price inflation. The horizontal axis represents the number of months after the innovation, the line denotes the point estimates, and the shaded area corresponds to 90 percent confidence interval computed with standard errors clustered at the firm and time level.

Another concern is that price fluctuations of imported inputs may drive our results.

Thus, we construct an alternative measure of input price inflation that consists of the weighted average of domestic and imported input price inflation. We then estimate the specification in equation 1 using this alternative measure. Figure 10 shows the responses of inflation expectations to supply chain inflation and aggregate inflation, which corroborate our baseline findings.

Figure 10: Response of firms' inflation expectations
(Percentage points)

(a) Domestic and imported input price inflation (b) CPI inflation



Notes: The figure shows the response of firms' inflation expectations to a one-standard-deviation increase in the variable reported in each panel's title. The horizontal axes represent the months after the innovation, the lines denote the point estimates, and the shaded areas correspond to 90 percent confidence intervals computed with standard errors clustered at the firm and time level.

One argument that jeopardizes the exogeneity of input price inflation concerning firms' inflation expectations is that firms may have monopsony power to impose purchase prices on their suppliers based on their expectations for future inflation. We mitigate this concern by running our baseline specification in equation (1) after excluding firms that buy their inputs from suppliers that have only a few buyers. Specifically, for each firm in the sample, we compute the median number of buyers of its suppliers in any given month. Then, we drop all firm-month observations for which the median number of buyers of the suppliers is below the 25th percentile of the sample distribution (which corresponds to 230 buyers). The assumption is that firms with suppliers that have relatively more buyers are less likely to be able to set their purchase prices. As shown in panel 11a, the results are similar to the baseline.

Another potential issue is that variables are highly autocorrelated and that we cannot interpret movements in input price inflation as innovations. Thus, we change the lag structure in equation (1) to include up to four lags of all independent and dependent variables. The results in panel 11b confirm that adding lags to our baseline specification does not affect the estimates. On the other hand, it could be argued that we are over-controlling by adding too many lags. Hence, we run the opposite experiment of removing the second lag of the independent and dependent variables from the baseline specification. Again, the results shown in panel 11c are consistent with the baseline.

Our indicator of input price inflation may capture some of the price pressures that come from abroad, given that they are correlated. To isolate the impact of domestic price pressures observed along the supply chain, we control for import price inflation. The results in panel 11d corroborate our baseline findings, showing that input price inflation remains significant even after controlling for import price inflation.

Finally, while our standard errors are robust to autocorrelation, it can be the case that they present cross-sectional correlation. Thus, we correct the standard errors following the procedure proposed by Driscoll and Kraay (1998), which accounts for cross-sectional dependence. As shown in panel 11e, results are in line with the baseline. Also, to ensure that we are not over-clustering, we recompute the standard errors clustering them only at the firm level. Even in this case, results are robust, as shown in panel 11f.[21]

6 Conclusions

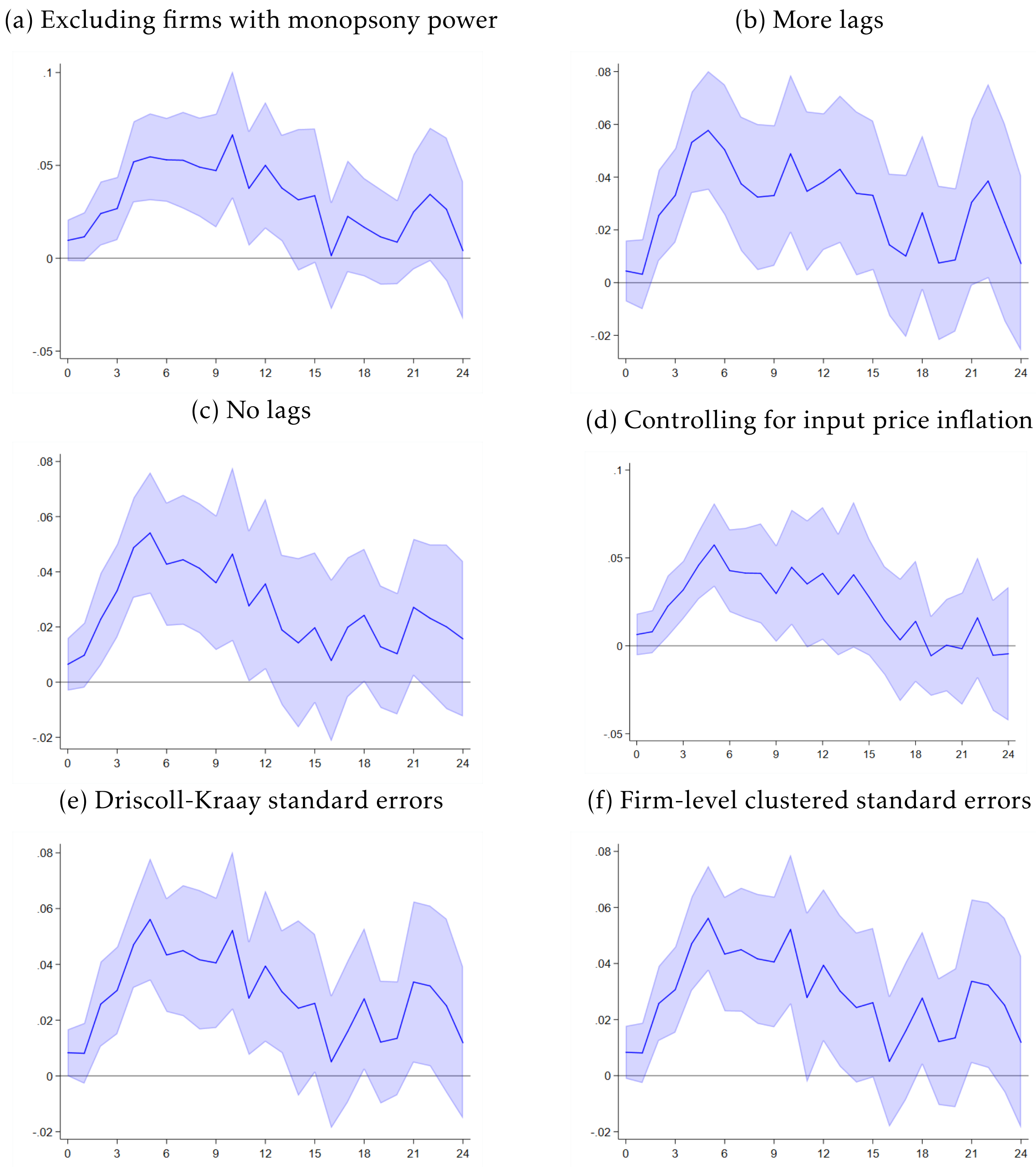
It is widely recognized that information frictions can hamper firms' ability to collect and process data to forecast inflation. Yet, our understanding of what factors firms rely upon to form their beliefs remains limited. In this paper, we provide novel evidence suggesting that firms rely on price changes observed along the supply chain to forecast CPI inflation. Remarkably, this is the case even when input prices changes are orthogonal to CPI inflation. We also show that adjusting inflation expectations to past inflation is slower than under the FIRE benchmark.

Our findings are consistent with the predictions of models with different types of information rigidities, such as a high dispersion in inflation expectations and inattention to macroeconomic developments. That is, since firms do not necessarily observe the same conditions along their supply chains, using input price inflation to forecast inflation can result in more dispersed expectations. At the same time, given that supply chain inflation is volatile, firms may mostly pay attention to analyzing the idiosyncratic shocks that are more immediately relevant to their businesses.

The information frictions at the root of the results that we document in this paper

[21] We only report the results of the robustness tests using a measure of supply chain inflation based on changes in domestic prices. However, results using a measure that averages domestic price changes and price changes of imported inputs convey the same messages and are available upon request.

Figure 11: Robustness tests
(Response of firms' inflation expectations to innovations in input price inflation, percentage points)



Notes: The figure shows the response of firms' inflation expectations to a one-standard deviation increase in input price inflation. The horizontal axes represent the number of months after the innovation, the lines denote the point estimates, and the shaded areas correspond to 90 percent confidence intervals computed with standard errors clustered at the firm and time level (except for panel (f), for which standard errors are clustered at the firm level only).

weaken the effectiveness of the expectation channel of policies and hence should be taken into account for the design of optimal monetary policy. Improvements in central bank communication aimed at reducing firms' inattention are crucial to dampening the undesirable effects of information frictions and preserving the effectiveness of the transmission of policies.

References

Alfaro-Urena, Alonso, Mariany Fuentes Fuentes, Isabela Manelici, and José P Vásquez. 2018. "Costa Rican production network: stylized facts." Documento de Investigación N. 002.

Andrade, Philippe, Olivier Coibion, Erwan Gautier, and Yuriy Gorodnichenko. 2022. "No firm is an island? How industry conditions shape firms' expectations." *Journal of Monetary Economics*, 125: 40–56.

Bernanke, Ben. 2007. "Inflation expectations and inflation forecasting." Speech delivered at the Monetary Economics Workshop of the NBER Summer Institute, Cambridge, MA.

Bordalo, Pedro, Nicola Gennaioli, Yueran Ma, and Andrei Shleifer. 2020. "Overreaction in macroeconomic expectations." *American Economic Review*, 110(9): 2748–82.

Born, Benjamin, Zeno Enders, Manuel Menkhoff, Gernot J Müller, and Knut Niemann. 2021. "How economic expectations react to news: Evidence from German firms." Mimeo. University of Tuebingen.

Candia, Bernardo, Olivier Coibion, and Yuriy Gorodnichenko. 2020. "Communication and the beliefs of economic agents." NBER Working Paper No. 27800.

Candia, Bernardo, Olivier Coibion, and Yuriy Gorodnichenko. 2021. "The inflation expectations of US firms: Evidence from a new survey." NBER No. 28836.

Candia, Bernardo, Olivier Coibion, and Yuriy Gorodnichenko. 2022. "The macroeconomic expectations of firms." NBER Working Paper No. 30042.

Cardoza, Marvin, Francesco Grigoli, Nicola Pierri, and Cian Ruane. 2020. "Worker mobility and domestic production networks." IMF Working Papers 205.

Cavallo, Alberto, Guillermo Cruces, and Ricardo Perez-Truglia. 2017. "Inflation expectations, learning, and supermarket prices: Evidence from survey experiments." *American Economic Journal: Macroeconomics*, 9(3): 1–35.

Coibion, Olivier, and Yuriy Gorodnichenko. 2012. "What can survey forecasts tell us about information rigidities?" *Journal of Political Economy*, 120(1): 116–159.

Coibion, Olivier, and Yuriy Gorodnichenko. 2015*a*. "Information rigidity and the expectations formation process: A simple framework and new facts." *American Economic Review*, 105(8): 2644–78.

Coibion, Olivier, and Yuriy Gorodnichenko. 2015*b*. "Is the Phillips curve alive and well after all? Inflation expectations and the missing disinflation." *American Economic Journal: Macroeconomics*, 7(1): 197–232.

Coibion, Olivier, Yuriy Gorodnichenko, and Michael Weber. 2022. "Monetary policy communications and their effects on household inflation expectations." *Journal of Political Economy*, 130(6): 000–000.

Coibion, Olivier, Yuriy Gorodnichenko, and Saten Kumar. 2018. "How do firms form their expectations? New survey evidence." *American Economic Review*, 108(9): 2671–2713.

Driscoll, John C, and Aart C Kraay. 1998. "Consistent covariance matrix estimation with spatially dependent panel data." *Review of Economics and Statistics*, 80(4): 549–560.

D'Acunto, Francesco, Ulrike Malmendier, Juan Ospina, and Michael Weber. 2021. "Exposure to grocery prices and inflation expectations." *Journal of Political Economy*, 129(5): 1615–1639.

Fuster, Andreas, and Basit Zafar. 2022. "Survey experiments on economic expectations." NBER Working Paper No. 29750.

Georganas, Sotiris, Paul J Healy, and Nan Li. 2014. "Frequency bias in consumers' perceptions of inflation: An experimental study." *European Economic Review*, 67: 144–158.

Grigoli, Francesco, Emiliano Luttini, and Damiano Sandri. 2021. "Idiosyncratic shocks and aggregate fluctuations in an emerging market." *IMF Working Papers*, 2021(289).

Kuchler, Theresa, and Basit Zafar. 2019. "Personal experiences and expectations about aggregate outcomes." *The Journal of Finance*, 74(5): 2491–2542.

Kumar, Saten, Hassan Afrouzi, Olivier Coibion, and Yuriy Gorodnichenko. 2015. "Inflation targeting does not anchor inflation expectations: Evidence from firms in New Zealand." NBER Working Paper No. 21814.

Lucas, Jr Robert. 1972. "Expectations and the Neutrality of Money." *Journal of Economic Theory*, 4(2): 103–124.

Mackowiak, Bartosz, and Mirko Wiederholt. 2009. "Optimal sticky prices under rational inattention." *American Economic Review*, 99(3): 769–803.

Mankiw, N Gregory, and Ricardo Reis. 2002. "Sticky information versus sticky prices: A proposal to replace the New Keynesian Phillips Curve." *Quarterly Journal of Economics*, 117(4): 1295–1328.

Mankiw, N. Gregory, Ricardo Reis, and Justin Wolfers. 2003. "Disagreement about Inflation Expectations." *NBER Macroeconomics Annual*, 18: 209–248.

Pasten, Ernesto, and Raphael Schoenle. 2016. "Rational inattention, multi-product firms and the neutrality of money." *Journal of Monetary Economics*, 80: 1–16.

Salle, Isabelle. 2022. "Comment on "No firm is an island? How industry conditions shape firms' expectation" by Philippe Andrade, Olivier Coibion, Erwan Gautier and Yuriy Gorodnichenko." *Journal of Monetary Economics*, 125: 57–61.

Sims, Christopher A. 2003. "Implications of rational inattention." *Journal of Monetary Economics*, 50(3): 665–690.

Watanabe, Takeo, Jose E Nanez, and Yuka Sasaki. 2001. "Perceptual learning without perception." *Nature*, 413(6858): 844–848.

Appendix

A Descriptive statistics

Table A.1 reports the descriptive statistics for all variables used in the analysis. Figure A.1 shows the distribution for our measures of supply chain inflation, inflation expectations, and CPI inflation.

Table A.1: Descriptive statistics

	Obs	Mean	St. dev.	Min	Max
Firm-level variables					
Inflation expectations	19,163	3.4	0.9	-5.8	15.0
Input price inflation	48,349	14.1	23.8	-30.0	100.0
Sales price inflation	37,540	7.8	17.5	-30.0	100.0
Import price inflation	25,187	6.8	20.1	-30.0	100.0
Export price inflation	10,638	6.5	19.7	-30.0	100.0
Weighted avg. input-import price inflation	50,244	10.7	20.9	-30.0	100.0
Weighted avg. sales-export price inflation	37,780	7.5	17.3	-30.0	100.0
Sales growth	44,825	5.6	26.5	-50.0	100.0
Country-level variables					
CPI inflation	81	3.1	0.9	1.4	5.2
GDP growth	81	1.8	5.8	-15.4	16.6

B The role of imports

Figure B.1 reports the distribution of the ratio of imports to total purchases, computed as the sum of imports and domestic purchases. Almost half of the firms in the sample source their inputs exclusively from domestic suppliers. However, a few firms heavily rely on imports.

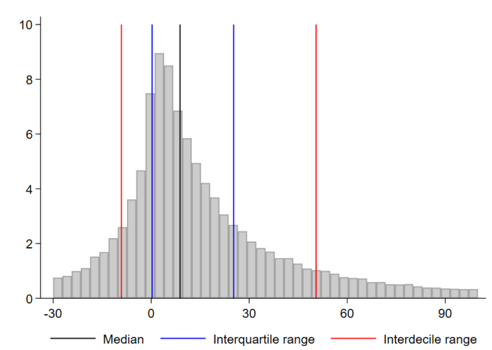
C Signal extraction problem

Assume that there are N islands with a firm in each of them that charges p_i, so that aggregate prices would then be $p_t = 1/N \sum_i^N p_{i,t}$. Firms are willing to increase output if their own price is higher than aggregate prices

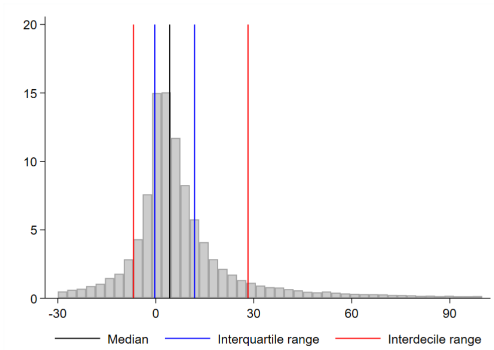
$$y_{i,t} = \gamma(p_{i,t} - p_t)$$

Figure A.1: Distribution of key variables
(Percent)

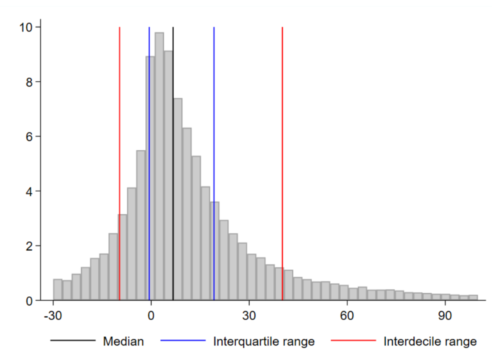
(a) Input price inflation



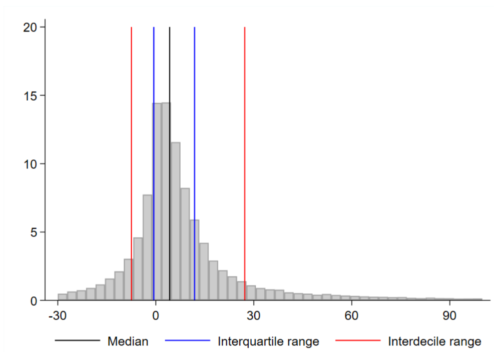
(b) Sales price inflation



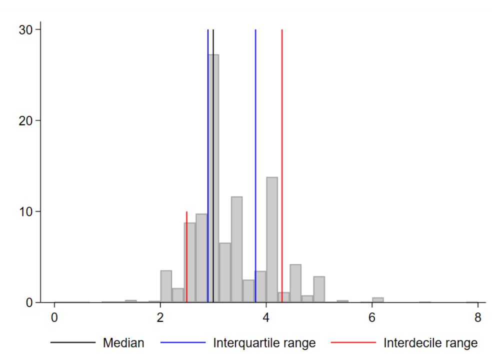
(c) Domestic and imported input price inflation



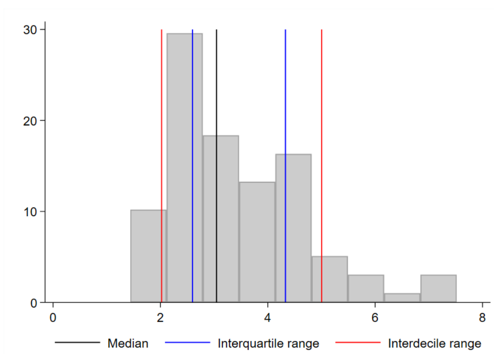
(d) Domestic and export sales price inflation



(e) Inflation expectations

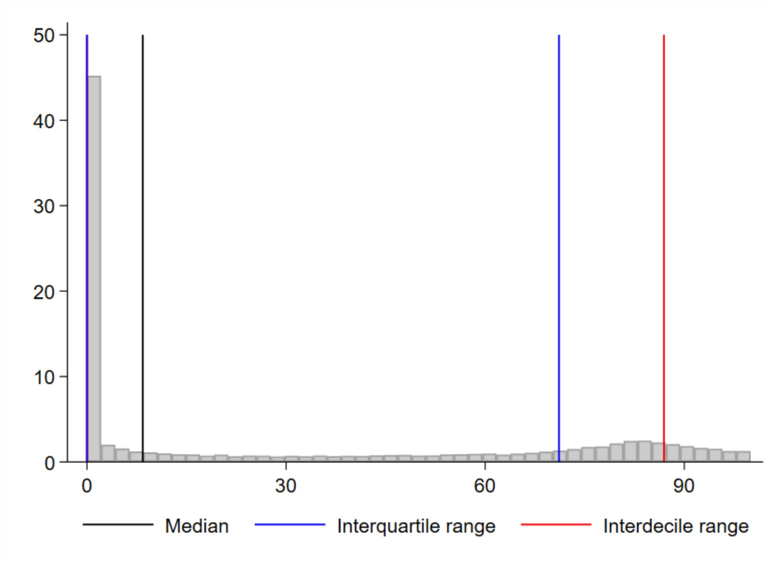


(f) CPI inflation



Notes: The histograms in panels A.1a to A.1e use data at the firm-month level. The histogram for CPI inflation in panel A.1f uses data at the month level.

Figure B.1: Distribution of import share in total purchases
(Percent)



Notes: The share of imports is computed as the ratio of imports to the sum of imports and domestic purchases.

Under imperfect information firms know their price $p_{i,t}$, but they do not know the aggregate price p_t, so they need to make a guess $E(p_t|I_{i,t-1})$. In these conditions, the supply curve becomes

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

How do firms form their beliefs about aggregate inflation? Under rational expectations $p_t = E(p_t|I_{i,t-1}) + \epsilon$ with $\epsilon_t \sim N(0,\sigma)$ and the islands' prices would differ randomly from aggregate $p_{i,t} = p_t + z_t$ with $z \sim (0,\tau)$. Thus, if firms had perfect information, their production decision would simply be $y_{i,t} = z_t$; with imperfect information, this would change to $y_{i,t} = z_t + \epsilon_t$. Firms then 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. As a proportion of composite shock is coming from z, $\theta = \tau^2/(\sigma^2 + \tau^2)$, they can infer it from the past.

Since $p_{i,t} = p_t + z_t$, they need to guess aggregate prices to decide production

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

which in first differences delivers the following expression

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

Thus, firms use the prices they observe in the trade with other islands to form their views about future aggregate inflation.

D The dynamics of the response of inflation expectations to past inflation

To benchmark the sequence of the estimated coefficients β_1^h of equation (1) reported in panel 6b of Figure 6, we derive the response of inflation expectations to changes in actual inflation under rational expectations when inflation expectations follow an AR(1) process

$$\pi_t = \rho\pi_{t-1} + \varepsilon_t^\pi$$

where ε_t^π is a zero-mean shock independently distributed over time.

To simplify without loss of generality, we focus on an individual firm. If the firm's inflation expectations are rational, and considering that during the period they answer the survey inflation is unknown, they will evolve according to

$$E_{t+h}\pi_{t+h} = \rho\pi_{t-1+h}$$

In Section 4, after accounting for covariates, we estimate the β_1^h coefficients in the set of regressions

$$E_{i,t+h}\pi_{t+h+12} - E_{i,t-1}\pi_{t-1+12} = \beta_1^h\pi_{t-1} + \varepsilon_t^h$$

Under an AR(1) process, the left-hand side of the regression equation can be written as follows for the individual firm

$$E_{t-1+h}\pi_{t+h} - E_{t-1}\pi_t = \rho\left(\pi_{t-2+h} - \pi_{t-2}\right)$$

The sequence of β_1^h coefficients consistent with FIRE is the ordinary least squares estimator $\frac{\text{Cov}\left(E_{i,t+h}\pi_{t+h+12} - E_{i,t-1}\pi_{t-1+12};\pi_{t-1}\right)}{\text{Var}(\pi_{t-1})}$. This can be rewritten as

$$\beta_1^h = \frac{\mathrm{Cov}\left(\rho\left(\pi_{t-2+h} - \pi_{t-2}\right); \pi_{t-1}\right)}{\mathrm{Var}\left(\pi_{t-1}\right)} = \rho^{h+1} - \rho$$

Thus, at $h = 0$, firms incorporate the news in inflation according to the coefficient $1-\rho$, and from there, the new information acquired should monotonically decrease its weight over time.