Carbon Pricing and Firms' Expectations: Evidence from Italy

Giacomo Mangiante*

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Abstract

This paper studies the impact of carbon pricing on firms' expectations and decisions. Combining survey data from Italian firms with high-frequency-identified carbon policy shocks, I show that increases in carbon prices raise firms' inflation expectations across horizons ranging from 6 months to 36–60 months ahead. Similar effects are found for firms' expected and realized price growth, alongside increases in forecast errors and disagreement, pointing to the presence of information frictions in expectations formation. The transmission operates primarily through indirect channels: most of the response of the 12-month ahead expectations is driven by the higher energy prices induced by the policy. The effects also display significant heterogeneity. Firms that emphasize labor costs, competitors' pricing, or demand constraints in their price-setting report more muted pass-through, while those in energy-intensive sectors such as manufacturing and construction show stronger responses than firms in services and commerce. Providing firms with information on current inflation significantly amplifies the pass-through of carbon prices to expectations, highlighting the role of central bank communication. Overall, the influence of carbon pricing on long-term expectations, the dominance of the indirect channel, and the presence of information rigidities suggest that central banks, in pursuing price stability, should closely monitor and potentially respond to the inflationary consequences of climate policies.

Keywords: Climate policies, Carbon pricing, Inflation expectations, Monetary policy, Survey data
JEL classification: E31, E52, E58, Q43, Q54

*Bank of Italy, Rome, Italy. Email: mangiante.giacomo@gmail.com
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1 Introduction

The interaction between climate policies and central banks has recently attracted growing attention from both policymakers and the public. Some monetary authorities, such as the European Central Bank and the Bank of England, have taken an active role, while others, including the Federal Reserve, have emphasized a more limited mandate. As Chair Jerome Powell put it: “The Federal Reserve is not and will not be a climate policymaker” (Powell, 2023). Whether climate policies are inflationary, and to what extent central banks should respond, is ultimately an empirical question but existing evidence remains scarce and inconclusive.

This paper examines how carbon pricing affects firms’ expectations and decisions, focusing on Italy. Exogenous changes in the carbon price are captured using the policy shock series of Känzig (2023), which identifies 126 regulatory events between 2005 and 2019 that altered the supply of emission allowances in the EU ETS. Policy surprises are derived from movements in carbon futures prices around these events, aggregated monthly, and extracted as shocks via a proxy VAR framework.

I merge this series with Italian firm-level survey data from the Bank of Italy’s Survey on Inflation and Growth Expectations (SIGE), conducted quarterly since 1999. The SIGE provides rich information on firms’ expectations over multiple horizons (6 months to 36–60 months ahead), as well as realized and expected own-price growth. I estimate the causal effects of carbon policy shocks using panel local projections (Jordà, 2005).

The results show that firms’ inflation expectations react strongly to carbon policy shocks, both in the short and medium-to-long run. Expected and realized own-price growth as well as forecast errors and disagreement about aggregate inflation also increase consistent with models of information frictions. Forecast errors later turn negative, suggesting firms over-extrapolate from past realizations. Importantly, decomposing the overall effect shows that the increase in expected inflation operates primarily through the indirect energy-price channel. Carbon policy shocks have only a marginal direct effect on firms’ expectations; instead, they raise energy costs, which in turn prompt firms to revise their inflation expectations upward. Information treatments embedded in the SIGE provide further evidence: firms informed about current inflation display more accurate expectations and are also more sensitive to carbon policy shocks. This highlights the role of central bank communication in shaping firms' responses.

Beyond prices, I show that carbon policy shocks deteriorate firms' assessments of both their own business outlook and aggregate economic conditions. Firms anticipate weaker demand, tighter investment conditions, and reduced employment, consistent with contractionary supply-side effects that persist over multiple horizons. Finally, I document substantial heterogeneity in the pass-through of carbon pricing. Sectoral characteristics, cost structures (e.g., the importance of labor costs), and the weight firms place on competitors' pricing strategies all shape the magnitude of the response.

Central banks worldwide are assessing their role in addressing climate change. The presence of information frictions in firms' expectations formation processes warrants caution for monetary authorities; dismissing these shocks as purely supply-driven and choosing not to respond could have important negative effects. Firms' incomplete information in making forecasts could lead to significant second-round effects, as rising short-term inflation expectations may increase the persistence of the shocks. Moreover, the observed increase in medium- to long-term inflation expectations in response to a carbon policy shock indicates that central bankers should closely monitor the inflationary impacts of climate policies to prevent potential de-anchoring from the inflation target.

Related literature. This paper contributes to two main strands of the literature. First, it adds to the growing body of work on the economic effects of carbon pricing. While carbon pricing is widely recognized as an effective tool for reducing emissions (Ralf et al., 2014; Andersson, 2019), its broader macroeconomic implications remain contested. At the aggregate level, most studies find only limited effects on employment and GDP growth in European countries (Metcalf and Stock, 2020a,b) and for British Columbia's carbon tax (Metcalf, 2019;

Bernard and Kichian, 2021). Similarly, Konradt and di Mauro (2023) documents negligible inflationary pressure from carbon taxes in Europe and Canada. Other evidence, however, points to meaningful price effects: using a dynamic panel of OECD countries, Moessner (2022) finds that a $10 increase in ETS prices raises energy CPI inflation by 0.8 percentage points and headline inflation by 0.08. In California, Benmir and Roman (2022) show that cap-and-trade shocks significantly increase energy prices and dampen real activity.

Beyond aggregate effects, an important line of research emphasizes the heterogeneous impact of carbon pricing across agents, sectors, and regions. These distributional consequences are crucial for designing effective and politically sustainable climate policies. For instance, Känzig (2023) document heterogeneous household effects along the income distribution, while Mangiante (2024) find that poorer Euro Area countries are more sensitive to carbon policy shocks. Berthold et al. (2023) highlight the role of emission intensity in shaping the cross-country transmission of shocks, and Konradt and Mangiante (2025) show that carbon pricing can fuel political polarization by raising vote shares for extremist and populist parties.

The study most closely related to this paper is Hensel et al. (2024), who use French firm survey data to show that carbon policy shocks affect inflation expectations and realized prices. Using the same shocks developed by Känzig (2023), I provide new evidence for Italy and extend their analysis in several key dimensions. First, whereas the French survey only covers short-term expectations (3 months), the SIGE provides horizons up to 36–60 months, allowing me to show that even medium- and long-term expectations respond to carbon policy shocks. This is highly relevant for central banks, whose mandates focus on medium-term inflation. Second, I decompose the impact into direct effects and indirect effects via energy prices, showing that firms' expectations largely respond through the energy price channel and that long-term expectations are primarily driven by revisions in short-term expectations. Third, unlike the mostly qualitative French survey, the SIGE collects quantitative expectations, enabling more precise estimation. Fourth, this richer format allows me to study disagreement across firms, providing evidence consistent with models of sticky information and rational inattention. Fifth, the survey's long-standing information treatment (since 2012) offers a unique opportunity to examine how central bank communication shapes firms' responsiveness to shocks. Finally, I extend the analysis to firms' expectations of their own business conditions and the broader economy, documenting heterogeneity across sectors and highlighting the role of labor costs and competitors' pricing strategies in shaping responses.

Second, this paper contributes to the literature on expectation formation. Much of this literature has focused on households, where gasoline prices have been identified as a key driver of inflation expectations due to their salience and volatility (Coibion and Gorodnichenko, 2015; Cavallo et al., 2017; D'Acunto et al., 2021). Research on firms is comparatively sparse, owing to limited data availability, but recent contributions are beginning to close this gap. Hensel et al. (2024) show that French firms' expectations react strongly to carbon policy shocks, echoing the importance of energy costs for households. This paper extends that line of research by providing new evidence on the role of information frictions in firms' expectation formation.

A large literature documents that economic agents are not fully informed when forming forecasts, with observed dispersion and forecast errors often consistent with models of rational inattention (Sims, 2003; Reis, 2006; Bartosz and Wiederholt, 2009; Afrouzi, 2016). For example, Gorodnichenko et al. (2018) show that New Zealand firms' beliefs fit such models, while Coibion and Gorodnichenko (2012) document systematic responses of expectations, errors, and disagreement to aggregate shocks. Angeletos et al. (2020) demonstrate that professional forecasters' errors for inflation and unemployment initially rise but then fall after shocks, consistent with dispersed information and over-extrapolation. In line with this, Hensel et al. (2024) show that French firms' forecast errors initially rise and then decline in response to carbon shocks. My results corroborate and extend these findings: in Italy, disagreement among firms also rises following carbon policy shocks, and this effect is stronger among firms receiving official inflation information, suggesting that central bank communication plays a powerful role in shaping both the level and the dispersion of expectations.

Road map. The remaining paper is organized as follows. Section 2 describes the data used in this paper. Section 3 reports the results of the main analysis on firm-level data. In Section 4, I perform a battery of robustness checks to strengthen the validity of the baseline results. Section 5 discusses some policy implications for central banks. Finally, Section 6 concludes.

2 Data

2.1 Survey data

Data on firms' expectations are sourced from the Survey on Inflation and Growth Expectations (SIGE), conducted quarterly by the Bank of Italy since 1999. The survey is designed to be nationally representative by stratifying the sample according to three characteristics: sector of activity, size class (based on the number of employees)[1], and geographical area (based on the firm's administrative headquarters). Each quarter, approximately 1,200 Italian firms are currently surveyed about both aggregate and business-specific variables.

The survey has been extensively used in the literature.[2] The dataset's rich time and panel dimensions make it particularly suited to evaluate the propagation of carbon policy shocks to firms' expectations. Over the sample period from 1999 to 2019, the SIGE includes around 70,000 firm-level observations (time x firm), with each firm participating in the survey for an average of 18 quarters.

I mainly focus on the following questions related to the firms' expectations about future inflation, their own expected price growth, and realized price growth:

- *What do you think the consumer price inflation will be in Italy: In six months? In one*

[1] The survey is conducted only on firms with at least 50 employees.

[2] See, among others, Coibion et al. (2020), Bottone et al. (2021), Ropele et al. (2022), Bottone et al. (2022), Ropele et al. (2024a), Ropele and Tagliabracci (2024), and Ropele and Tagliabracci (2024).

Table 1: Descriptive statistics

	Mean	**Std. Dev.**	**P5**	**P95**	**Obs.**
Main variables (firm-quarter)					
Expected inflation, 6-month ahead	2.11	2.44	0	8	54,503
Expected inflation, 12-month ahead	2.14	1.91	0.05	6	74,393
Expected inflation, 24-month ahead	1.99	1.87	0.02	5.8	57,294
Expected inflation, average 36-60 months ahead	1.92	1.86	0	5.5	44,864
Realized price gr., past 12 months	1.51	4.97	-5	10	75,261
Expected price gr., 12-month ahead	1.62	3.59	-2	8	80,049

Notes: The table reports descriptive statistics from the SIGE survey on Italian firms for the period 1999 to 2019. The data are at quarterly frequency.

year? In two years? On average between three and five years?

- *In the last 12 months, what has been the average change in your firm's prices?*
- *For the next 12 months, what do you expect will be the average change in your firm's prices?*

Firms respond to the SIGE questions by reporting the approximate percentage variation. The questions about different forecast horizons for inflation expectations have been included at various points in time. The question regarding 1-year expected inflation has been available since the survey's inception in 1999. The question related to 6-month ahead expectations was added in 2010q4. The 24-month ahead expectations question was introduced in 2009q1, and the question about the average expected inflation between 36 and 60 months ahead was included starting in 2014q1.[3]

Table 1 presents some descriptive statistics for the main variables of interest at the quarterly frequency. As observed, there is significant heterogeneity among firms in their aggregate and own price growth expectations during the period considered. For instance, the average expected inflation across different forecast horizons is close to the European Central Bank target of 2%, but the standard deviation is substantially above 2%. The tails

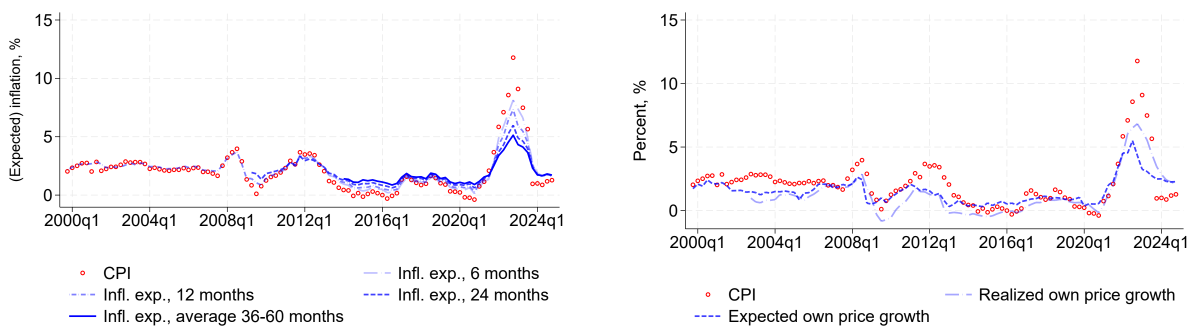
[3]To limit the role played by outliers, the variables are trimmed at the 1st and 99th percentiles for each quarter. However, using raw data delivers basically identical results.

of the distribution are also quite dispersed, with the 12-month ahead expected inflation ranging from 0% to 6% at the 5th and 95th percentiles, respectively.

Figure 1: Time series of the Italian CPI inflation, firms' inflation expectations, own price growth expectations and realized price growth

Panel A: Inflation expectations

Panel B: Own price growth



Notes: The figure plots the time series of actual CPI growth for Italy alongside the measures of firms' inflation expectations across horizons (left panel) as well as own price growth expectations and realized price growth (right panel). The firm-level data comes from the SIGE survey.

Panel A of Figure 1 compares the time series of the aggregate Italian Consumer Price Index (CPI) growth with the average firm-level inflation expectations across different horizons. The series of expected inflation are strongly correlated with each other and with the actual CPI, confirming the survey's high representativeness for the aggregate economy. Panel B reports the time series for the 12-month ahead own price growth expectations and the realized price growth over the past 12 months. The two series closely follow each other, indicating that firms tend to report their true expectations.

The survey data is matched with the universe of balance sheet information from Cerved Group S.p.A., a leading Italian information provider and one of the largest credit rating agencies in Europe. The dataset is constructed from official records of the Italian Registry of Companies and financial statements filed with the Italian Chambers of Commerce. Since firms are legally required to submit this information, balance sheet data are updated annually and cover the full population of companies. From these statements, I calculate the share of intermediate inputs over total costs.

2.2 Carbon policy shocks

The carbon policy shocks are computed following the procedure developed by Känzig (2023). I briefly summarize the approach here and refer to the original paper for a thorough description. Känzig (2023) identifies 126 events from 2005 to 2019 related to the overall cap in the European Union Emissions Trading System (EU ETS), such as the free allocation and auctioning of allowances, as well as the use of international credits. Carbon policy surprises are then derived from changes in the future price of EU emission allowances around these regulatory events. The underlying assumption is that by considering a small enough time window around each event, the price change can be considered unexpected and exogenous.

The surprises are defined as the EUR change in carbon future prices relative to the prevailing wholesale electricity price on the day before the event. The daily surprises are aggregated into a monthly series by summing the daily surprises within a given month. In months without any regulatory events, the series takes a zero value.

To clean the surprises from potential measurement errors, they are used as an external instrument in a VAR model (proxy-VAR) covering the period from January 1999 to December 2019. Eight variables are included in the VAR model: the energy component of the HICP, total GHG emissions, the headline HICP, industrial production, the unemployment rate, the policy rate, a stock market index, as well as the real effective exchange rate. The carbon policy shocks are extracted from the residuals of the monthly VAR (Stock and Watson, 2018) and are normalized to increase the energy component of the HICP by one percent on impact. The shock series is aggregated into a quarterly series by summing the monthly values.[4]

In Section A of the Appendix, I examine the aggregate effects of these shocks on the Italian economy. I report the responses of the year-on-year inflation rates for the Energy Consumer Price Index (CPI), the Producer Price Index (PPI), and the overall CPI. The

[4]The series of surprises is reported in Figure 14 of the Appendix.

results show that an exogenous increase in the price of carbon has statistically and economically significant inflationary effects at the aggregate level in Italy, although these effects are relatively short-lived.

3 Firms' expectations and carbon policy shocks

To estimate the average firm-level response to a carbon policy shock of the variables provided by the SIGE, I follow the approach used by Andrade et al. (2022) and Hensel et al. (2024):

$$E^i_{t+h} y^i_{t+h} = \alpha^i_h + \beta_h CPS_t + \sum_{p=1}^{P} \theta^p_h X^i_{t-p} + \varepsilon^i_{t,h}, \tag{1}$$

for $h = 1, ..., 12$. $E^i_{t+h} y^i_{t+h}$ is the dependent variable, e.g., own price growth expectations or realized price growth, at time $t+h$ of firm i. The coefficient of interest is β_h which captures the effect of a carbon policy shock on the dependent variable. α^i_h are firm fixed effect, X^i_{t-p} is the set of controls, and P is the number of lagged values. In the baseline specification, I control for three lags of the dependent variable but I show in Section 4 that including additional macroeconomic and firm-specific controls does not affect the main results. Standard errors are computed using two-way clustering at the firm and time levels. This approach controls for potential correlations within firms over time, accounting for correlations across firms within the same time period, which may arise from common macroeconomic shocks.[5] It is important to highlight again that the sample considered stops in 2019q4 so the Covid period and the recent high-inflation episode are excluded from the analysis.

3.1 Replication of French evidence in the Italian survey

I begin by assessing whether the empirical evidence documented by Hensel et al. (2024) for French firms also holds for Italian firms. Their main finding is that carbon policy shocks raise

[5] Similar results are obtained using Driscoll and Kraay (1998) standard errors.

short-term inflation expectations, increase both expected and realized own-price growth, and generate forecast errors that first widen and then turn negative, consistent with information frictions.

The Italian evidence points to the same patterns. As shown in the top panels of Figure 2, carbon policy shocks trigger a significant increase in firms' inflation expectations at both 6- and 12-month horizons. Expectations rise by about 0.06 percentage points on impact, peaking around 0.2 percentage points after 2–3 quarters, before dissipating within a year. These responses closely mirror those of aggregate inflation (Figure 13 of the Appendix) and are comparable to the French results of Hensel et al. (2024).

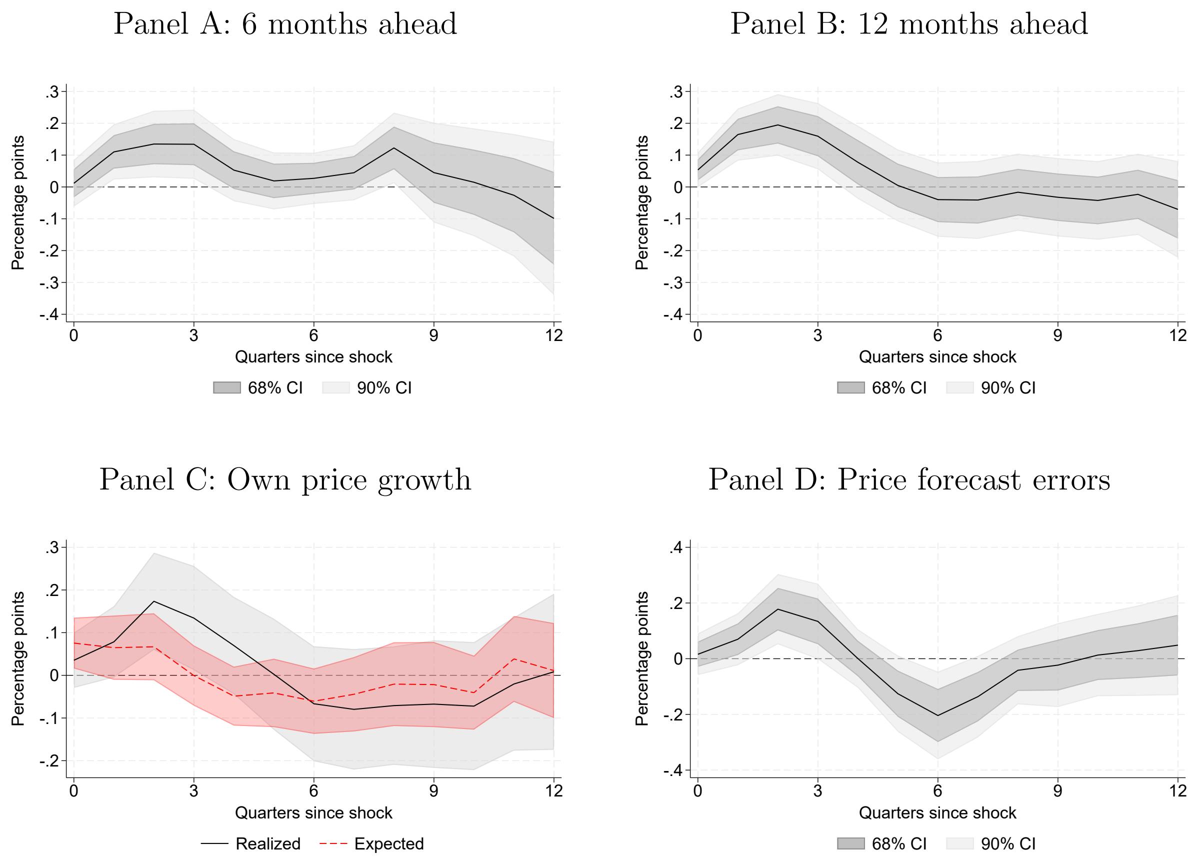
Turning to firms' own prices (Panel C of Figure 2), expected price growth rises by about 0.08 percentage points on impact, while realized prices adjust with a delay, peaking near 0.2 percentage points after one quarter before fading within 4–5 quarters. The dynamics are broadly consistent with those of inflation expectations and aggregate inflation.

Firms do not report their energy cost shares directly, but aggregate statistics suggest they typically range from 2% to 10%, with substantial sectoral heterogeneity[6]. This implies an almost complete pass-through to both expected and realized prices as the shock is standardized to a 1 percent increase in energy prices. Therefore, the full increase in energy prices appears to be transmitted to selling prices rather than being absorbed in margins.

Finally, I evaluate whether firms' expectations under- or over-react relative to realizations. Using price forecast errors—defined as the difference between realized and expected price growth over the past 12 months—Panel D of Figure 2 shows that firms initially underestimate the effect of carbon price shocks, generating positive forecast errors, before over-extrapolating and producing negative forecast errors after about a year. This pattern is almost identical to that documented for French firms and highlights the role of information frictions: firms are not fully informed when forming expectations (Coibion and Gorodnichenko, 2012), and their subsequent overreaction is consistent with dispersed information and over-extrapolation

[6]Data reported in the *Study on Energy Prices and Costs* of the European Commission.

Figure 2: Impact of carbon policy shocks on firms' expectations and pricing decisions



Notes: The figure plots the response to a carbon policy shock, normalized to increase the HICP energy by 1 percent on impact, for the firm-level inflation expectations at different forecast horizons, own price growth expectations and the realized price growth as well as price forecast errors. Price forecast errors are measured as the difference between the realized and the expected price growth. The black lines are the point estimates and the shaded areas are the 90 and 68 percent confidence bands (for the bottom left panel the 90 percent confidence bands are reported). The horizontal axis is in quarters.

(Angeletos et al., 2020).

In sum, the Italian evidence corroborates the French results of Hensel et al. (2024). The SIGE survey, however, offers several advantages that allow me to extend the analysis: it covers longer expectation horizons, permits a decomposition of the transmission channels, provides rich information on firm heterogeneity, and allows the study of disagreement and information provision.

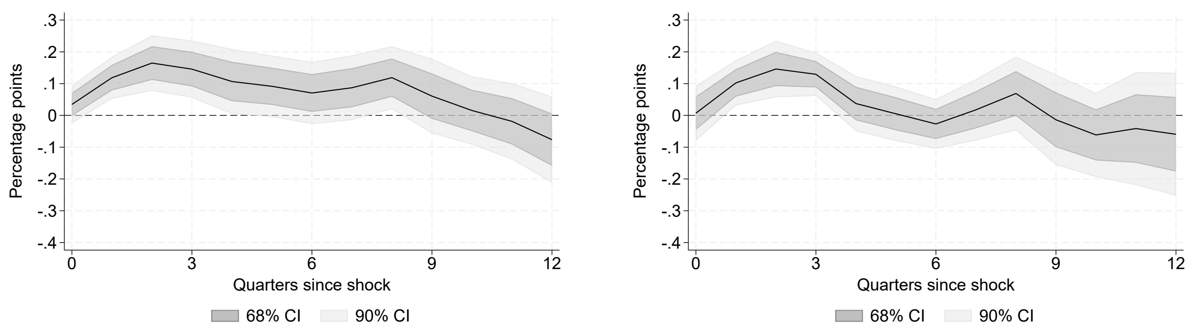
3.2 Medium- to long-term firms' inflation expectations

The richness of the SIGE survey allows for an extension of the results on short-term inflation expectations to longer-term expectations. The responses of the 24-month ahead inflation expectations and the average 36-60 months ahead expectations are reported in Figure 3. Both expected inflations series respond positively following the shock. While the magnitudes of the responses are smaller relatively to the responses of the short-term expectations, peaking slightly above 0.1 percentage points, the significance and persistence of the effects are comparable to those observed for the 12-month ahead expected inflation.

Figure 3: Impact of carbon policy shocks on medium- to long-term firms' expected inflation

Panel A: 24 months ahead

Panel B: Average 36-60 months ahead



Notes: The figure plots the response to a carbon policy shock, normalized to increase the HICP energy by 1 percent on impact, for the firm-level inflation expectations at different forecast horizons. The black lines are the point estimates and the shaded areas are the 90 and 68 percent confidence bands. The horizontal axis is in quarters.

These findings are particularly concerning for central banks. The empirical evidence suggests that an exogenous increase in the price of carbon leads to a rise in firms' expected inflation. Furthermore, the effects are not limited to short-term inflation; even medium- to long-term expectations—often the focus of many monetary authorities' mandates—are not immune to the inflationary effects of carbon pricing, despite the fact that the effects on actual inflation dissipate after 4-5 quarters.

3.3 Direct and indirect effects on inflation expectations

Carbon policy shocks are found to affect both energy prices (Section A of the Appendix) and firms' inflation expectations (Figure 2 and 3). A key question is whether firms revise their expectations directly in response to carbon pricing, or indirectly through the induced increase in energy costs.

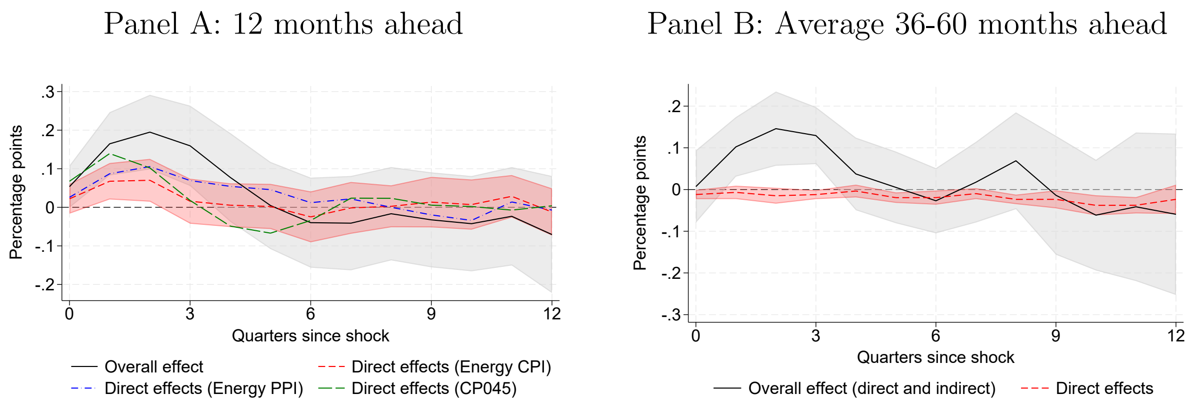
To address this, I decompose the overall effect of carbon policy shocks on expected inflation into a direct component (the immediate impact of the policy shock on inflation expectations) and an indirect component (operating through higher energy prices that in turn feed into expectations). The decomposition follows the approach in Holm et al. (2021), who study the direct and indirect effects of monetary policy shocks on household consumption. Formally, I estimate:

$$E^i_{t+h}y^i_{t+h} = \alpha^i_h + \beta_h CPS_t + \mu_h z^i_{t+h} + \sum_{p=1}^{P} \theta^p_h X^i_{t-p} + \varepsilon^i_{t,h}, \tag{2}$$

where the only difference relative to the baseline model (4) is the inclusion of the additional controls $\mu_h z^i_{t+h}$, capturing changes in the Energy CPI over the impulse response horizon. To make the exposure firm-specific, I interact changes in the Energy CPI with the share of intermediate inputs over total costs, as obtained from the firms' balance sheet data. As robustness checks, I also use alternative measures of energy price changes, i.e., the energy component of the PPI and the Electricity, Gas, and Other Fuels component of the CPI obtaining consistent results. Once these firm-level energy cost changes are controlled for, the indirect channel is effectively shut down, and the coefficients β_h capture the direct effect of carbon policy shocks on inflation expectations. Comparing the responses from Equations (2) and (1) highlights the central role of the indirect energy price channel.

Panel A of Figure 3 shows that, at the peak (two quarters after the shock), 12-month ahead inflation expectations increase by 0.2 percentage points. Of this, only 0.07 percentage points reflect the direct effect, while the remainder is driven by the indirect energy price

Figure 4: Direct and indirect effects of carbon policy shocks on firms' expected inflation



Notes: The figure plots the response to a carbon policy shock, normalized to increase the HICP energy index by 1 percent on impact. The left panel reports firms' 12-month ahead expected inflation responses with and without controlling for energy price changes. The right panel reports average expected inflation 36–60 months ahead, with and without controlling for 12-month ahead expectations. Solid and dashed lines are point estimates; shaded areas are 90 percent confidence bands. The horizontal axis is in quarters.

channel. By the following quarter, the effect operates entirely through energy prices. These findings suggest that carbon price shocks have limited direct effects on firms' inflation expectations, apart from the higher energy costs they induce. A similar conclusion is reached considering alternative measures of energy prices as shown by the green and blue lines in Panel A of Figure 3.

An additional question for policymakers is what drives the response of long-term inflation expectations. If expectations are not fully anchored, longer-term beliefs can move in response to short-term expectations (Lyziak and Paloviita, 2016). I therefore estimate specification (2) with long-term expectations as the dependent variable and the 12-month ahead expectations included as controls. Panel B of Figure 3 shows that, once the short-term expectations channel is accounted for, long-term expectations do not respond to carbon policy shocks. This indicates that the entire effect on long-term expectations operates indirectly, through the rise in short-term expectations induced by the shock.

Overall, these findings highlight that the transmission of carbon policy shocks to firms' inflation expectations operates almost entirely through their impact on energy prices and short-term expectations. Direct effects of carbon pricing on expectations are limited. For policymakers, this implies that the anchoring of long-term inflation expectations depends crucially on limiting the pass-through of energy price shocks into short-term expectations. In practice, effective communication and complementary measures that reduce volatility in energy markets may therefore play a key role in ensuring that climate policy objectives are achieved without jeopardizing inflation stability.

3.4 Disagreement about future inflation

The significant positive response of forecast errors to a carbon policy shock reported in Panel D of Figure 2 strongly indicates the presence of information frictions in the firms' expectation formation processes. This data-driven evidence allows us to reject the hypothesis that firms are fully informed. However, positive forecast errors are a common feature across different models of information rigidities. A variable that can differentiate among these models is forecast disagreement among agents.

As shown by Coibion and Gorodnichenko (2012), in response to a shock, both full-information rational expectations models and noisy information models (Lucas, 1972, Sims, 2003, and Woodford, 2003) predict that disagreement should not change. In the former class of models, agents have access to all available information when making their forecasts. Therefore, they immediately update their information sets in response to a shock in fundamentals, resulting in no change in either their forecast errors or disagreement. In the latter class of models, agents observe only noisy signals about the economy. As they continuously update their information sets, shocks do not affect forecast disagreement.

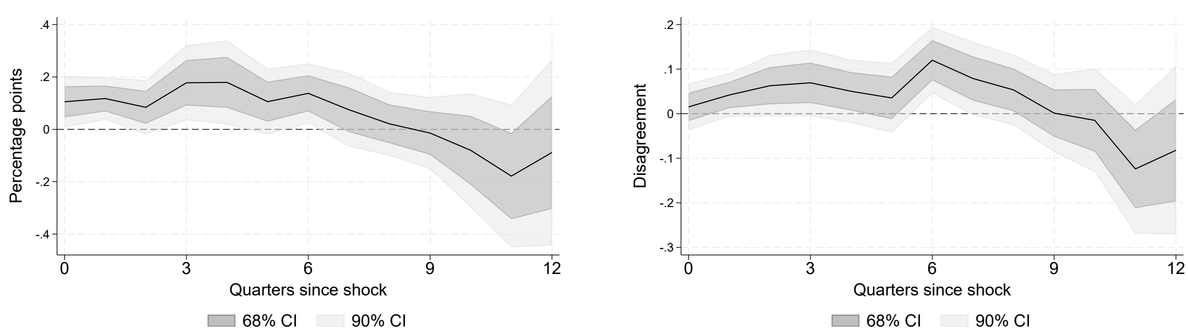
The opposite is true for the sticky information models (Mankiw and Reis, 2002 and Reis, 2006) and rational inattention models (Sims, 2003, Sims, 2006, Bartosz and Wiederholt, 2009, and Afrouzi, 2016). In the first class of models, agents update their information sets infrequently because acquiring and processing new information is costly. Therefore, in the first periods after an economic shock, only a subset of agents will be informed about it, leading to an increase in forecast disagreement. In the second class of models, agents allocate limited cognitive resources to process information optimally, leading them to focus only on aspects they deem most relevant while ignoring others. A shock like carbon pricing might be more relevant to some firms than others. For example, Hensel et al. (2024) document that high-energy intensive firms tend to be more responsive to this kind of shocks. This selective attention creates differences in expectations and an increase in disagreement.

By examining the response of forecast disagreement to carbon policy shocks, we can gain insights into which class of information rigidity models better describes firms' expectations formation processes. If forecast disagreement increases following a shock, it supports the sticky information and rational inattention models. Conversely, if disagreement remains unchanged, it aligns more closely with full-information rational expectations or noisy information models.

Figure 5: Impact of carbon policy shocks on the inflation expectations disagreement

Panel A: 90th-10th percentiles

Panel B: IQR



Notes: The figure plots the response to a carbon policy shock, normalized to increase the HICP energy by 1 percent on impact, for the disagreement across firms regarding the 12-month ahead expected inflation. Disagreement is measured as the difference between the 90th and 10th percentiles (left panel) or the interquartile range (IQR) (right panel) of the inflation expectations. The lines are the point estimate, and the shaded areas are the 90 and 68 percent confidence bands. The horizontal axis is in quarters.

To analyze how firms' disagreement in inflation expectations responds to a carbon policy shock, I rely on two measures: the difference between the 90th and 10th percentiles and the interquartile range (IQR) of the 12-month ahead inflation expectations. The IQR, in particular, helps control for potential outliers that might bias the results. As models predict that disagreement should either increase or remain unchanged irrespective of whether the shock is inflationary or deflationary, I estimate Equation (1) using the absolute value of the shock.[7]

Figure 5 reports the responses of disagreement to a carbon policy shock. Following the shock, both measures of disagreement rise. Three quarters after the shock, the difference between the 90th and 10th percentiles increases by 0.2 percentage points, while the interquartile range rises by 0.06 percentage points. These are sizable effects given that, over the sample period, disagreement was relatively low and stable, with an average and standard deviation of 1.2 and 0.4 percentage points for the first measure, and 0.6 and 0.22 percentage points for the second. Thus, a carbon policy shock leads to an increase of about half a standard deviation in the 90–10 measure of disagreement.

The rise in disagreement and forecast errors contradicts the hypothesis that firms are fully informed, as fully informed agents would immediately update their information sets, leaving no change in disagreement. Moreover, the observed increase in disagreement does not align with the predictions from noisy information models, where continuous updating of information sets would result in no change in forecast disagreement. The positive response in disagreement is consistent with the predictions from sticky information and rational inattention models. Firms update their information sets infrequently or only partially due to the costs associated with acquiring and processing economic information. Therefore, it takes time for all firms to become aware of the shock and incorporate it into their forecasts. This leads to an initial increase in disagreement about future aggregate price movements, which takes around 7 to 8 quarters to converge back to zero.

[7]The dependent variables are the time series of the two different measures of disagreement so Newey and West (1987) standard errors are adopted.

3.5 Information treatment and firms' responsiveness to shocks

In recent years, central banks have increasingly relied on communication to manage the expectations of economic agents. By providing households and firms with information about the current economic environment, as well as projections for future developments, monetary authorities have adopted communication strategies as a key tool in policy. In this section, I evaluate the causal impact of providing firms with information about inflation on the firms' responsiveness to an exogenous increase in carbon prices.

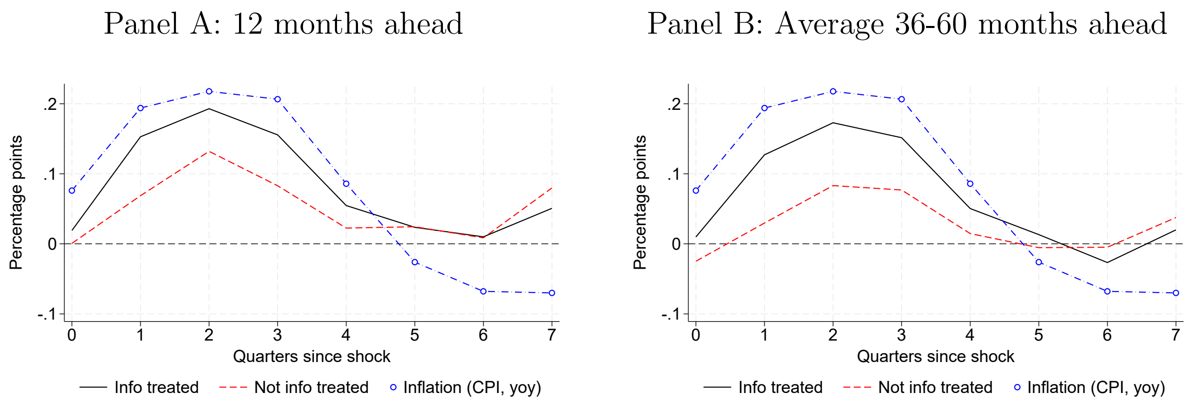
At irregular intervals, firms in the SIGE are randomly assigned to one of two groups. The first group is asked to report their inflation expectations for the next 12 months without receiving any additional information. The second group is asked the same question but only after being informed about the most recent inflation rates in both Italy and the euro area. Firms remain in their assigned groups until the next reshuffling, meaning that between reassignments, some firms consistently receive updated information while others do not. Before the third quarter of 2012, all firms were provided with identical information about recent inflation rates. Beginning in 2012q3, approximately one-third of firms were randomly assigned to the group that did not receive any information. In 2012q4 firms were reshuffled across the two groups and remained in their new assignments until 2017q2, when another reshuffling occurred. A final reassignment took place in 2019q4.

The unique prolonged duration of the treatment makes the SIGE an ideal setting for examining how providing firms with information about actual inflation influences their expectations and decision-making.[8] As illustrated in Figure 16 in the Appendix, the treatment significantly improves the alignment of treated firms' inflation expectations with actual inflation. Moreover, the treatment has been shown to impact not only the expectations of these firms but also their decisions regarding hiring and investment.

I examine whether the pass-through of carbon policy shocks to firms' expectations is influenced by their exposure to the information treatment. Figure 6 presents the responses

[8] See Coibion et al. (2020), Bottone et al. (2021), Ropele et al. (2022), and Ropele et al. (2024b).

Figure 6: Impact of carbon policy shocks on inflation and firms' expectations by treatment status



Notes: The figure plots the response to a carbon policy shock, normalized to increase the HICP energy by 1 percent on impact, for the firm-level expectations. The black lines are the point estimates for the firms which received the information treatment, the red lines for those which do not and the blue lines are the responses of aggregate CPI inflation in Italy. The horizontal axis is in quarters.

for treated (black lines) and untreated firms (red dashed lines), while the blue lines represent the response of aggregate CPI inflation in Italy to a carbon policy shock. Panel A reveals that the 12-month-ahead inflation expectations of treated firms respond more strongly to a carbon policy shock. The statistical significance of this difference is tested and confirmed in Figure 17 in the Appendix, where it is shown for all types of expectations. The figure displays the coefficients of the interaction between the carbon policy shocks and a dummy variable indicating whether a firm received the treatment.

At first glance, it may seem puzzling that providing firms with information about the current inflation rate actually increases their sensitivity to carbon policy shocks. However, this result is a consequence of the treatment's effectiveness in shaping firms' expectations. Specifically, since the response of actual inflation to a carbon policy shock is stronger than the response of firms' expected inflation, the expectations of treated firms align more closely with the actual inflation response. As a result, the treatment generates a notable difference in expected inflation, with a gap of nearly 0.1 percentage points two quarters after the shock.

The result extends beyond 1-year ahead expectations. Providing firms with information about the current inflation rate also increases their long-term inflation responsiveness to carbon policy shocks, as shown in Panel B. As reported in Figure 17 in the Appendix, no significant difference is documented between treated and not treated firms for their expected and realized price growth.

Firms' inflation expectations respond strongly to the provision of information about actual inflation. Following an inflationary shock, expectations align more closely with actual inflation, leading to a stronger response in the treated group compared to the control group. It is important to emphasize that this does not suggest central banks should refrain from adopting a transparent and widespread communication strategy directed at households and firms. On the contrary, better-informed firms are able to allocate their resources—capital, labor, and inputs—more efficiently (Ropele et al., 2024b). Furthermore, these firms are better equipped to anticipate potential shocks, such as supply chain disruptions, and can adjust more swiftly to changes in fiscal or monetary policy.

3.6 Effects on the perceived and expected economic situations

The SIGE survey offers a uniquely rich dataset, not only capturing firms' expectations regarding price developments but also providing detailed information on their perceptions of, and expectations about, broader macroeconomic conditions in Italy as well as their own business environment. To better understand the transmission of carbon pricing to the real economy, I estimate the effects of an exogenous increase in the price of carbon on several forward- and backward-looking indicators.

Specifically, I focus on the following survey questions:

- *Compared with 3 months ago, do you consider Italy's general economic situation is better, the same or worse?*
- *How do you think the business conditions for your company will be in the next 3 months:*

Better, the same or worse?

Each of these qualitative variables is coded to take values in $-1, 0, 1$, indicating whether firms perceive or expect conditions to worsen, remain unchanged, or improve, respectively. Since the responses are categorical, the estimated coefficients reflect the average shift in firms' stated expectations in response to the shock. In addition to these variables, firms are also asked about the probability that business conditions will worsen in the next 3 months and in the next 3 years, providing a probabilistic measure of perceived downside risk over different horizons.

The results, displayed in Figure 7, show that an exogenous increase in the price of carbon has a significant and persistent negative effect on firms' perceived and expected economic conditions (Panels A and B). All indicators respond immediately and persistently to the shock. Overall, the findings suggest that following a carbon price shock, firms anticipate a deterioration in both national economic conditions and their own business outlook.

Panels C and D of Figure 7 present the estimated effects on the probability that firms expect worsening conditions in the near (3-month) and medium-to-long term (3-year) horizons. These probabilities increase significantly, indicating that firms perceive the impact of carbon policy as both adverse and long-lasting. This reinforces the interpretation that carbon price shocks are viewed as negative supply-side disturbances: they raise inflation expectations while simultaneously depressing firms' economic outlook.

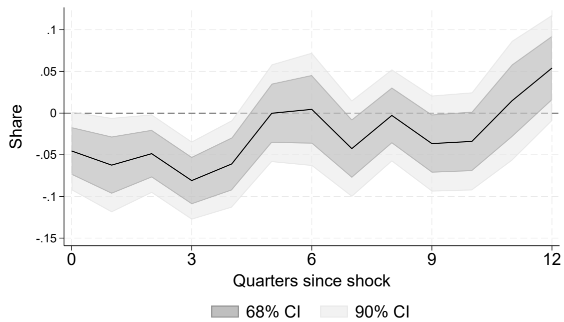
To deepen the analysis, I examine how firms revise their perceptions of key determinants of investment and operational decisions. I consider the following additional survey questions from SIGE:

- *Your firm's total number of employees in the next 3 months will be lower, unchanged, or higher?*

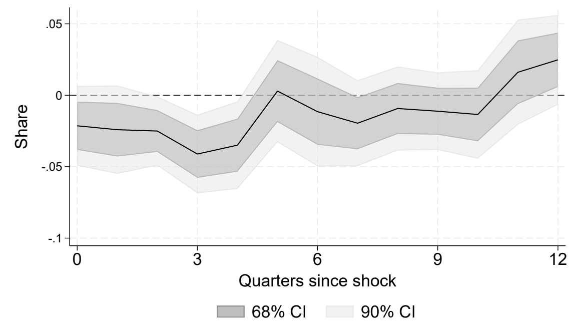
- *Compared to 3 months ago, do you think conditions for investment are better, the same or worse?*

Figure 7: Impact of carbon policy shocks on firms' economic expectations and perceptions

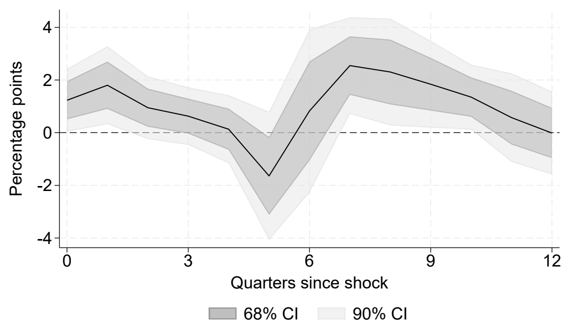
Panel A: Italian economic situation



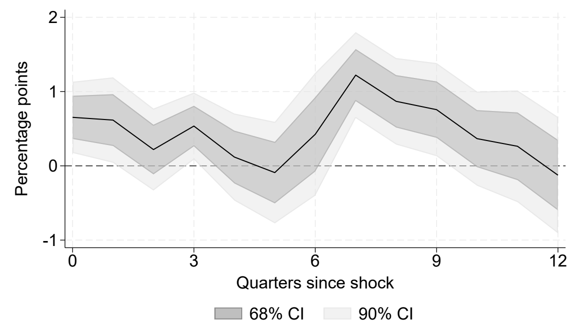
Panel B: Own business conditions



Panel C: Worse business cond. (3 months)



Panel D: Worse business cond. (3 years)



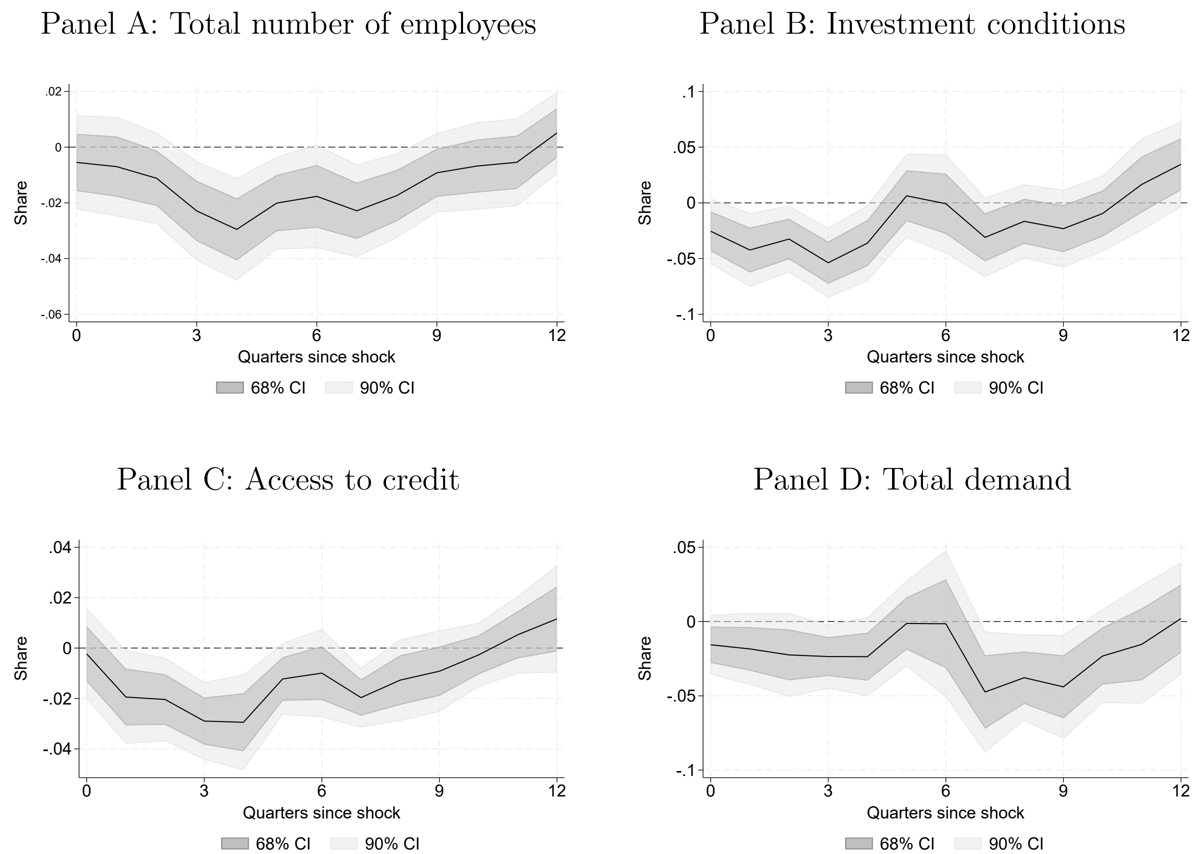
Notes: The figure plots the responses to a carbon policy shock, normalized to increase HICP energy by 1 percent on impact, for firms' expectations about aggregate and business-specific conditions. Variables in Panels A and B take values {-1, 0, 1} (decrease, same, increase). Variables in Panels C and D range from 0 to 100. Black lines are point estimates; shaded areas are 90 and 68 percent confidence bands. The horizontal axis is in quarters.

- *Compared with 3 months ago, do you think the credit access conditions for your company are better, the same, or worse?*
- *Compared with 3 months ago, how has the total demand for your products changed? Decreased, remained the same, or increased?*

These variables are also coded as $-1, 0, 1$.

Figure 8 presents the estimated responses. The results indicate that, following a carbon policy shock, firms report significantly more pessimistic expectations and perceptions:

Figure 8: Impact of carbon policy shocks on firms' economic expectations and perceptions



Notes: The figure plots the responses to a carbon policy shock, normalized to increase the HICP energy by 1 percent on impact, for the firms' economic expectations and perceptions. The variables take values {-1, 0, 1} if expected to decrease, stay the same or decrease. The black lines are the point estimates and the shaded areas are the 90 and 68 percent confidence bands. The horizontal axis is in quarters.

anticipated reductions in employment, tighter credit access, lower total demand, and worsening investment conditions. These effects are both statistically significant and economically meaningful, with a persistence that underscores the lasting impact of such shocks on firms' outlook and decision-making.

Taken together, the results provide strong evidence that firms view carbon price increases as contractionary, not only because they raise costs, but also because they weaken demand and credit access. These shocks are perceived as supply-side in nature, prompting upward revisions in inflation expectations and downward revisions in economic expectations. Moreover, the evidence highlights the role of expectations and financial conditions in the transmission of climate policy to the real economy.

3.7 Heterogeneous responses across firms' characteristics

One might expect firms to not be homogeneously exposed to changes in energy costs. Sectoral and individual characteristics could significantly influence the propagation of an increase in carbon price to the firms' expectations and decisions. Hensel et al. (2024) document that low energy-intensive firms are worse at forecasting the impact that carbon policy shocks will have on the evolution of their prices and that firms operating in more competitive environments expect to be less able to pass the increased costs to the final price of their products.

I explore how the pass-through of carbon policy shocks is affected by the factor considered important by each firm in influencing their own price. I exploit a question in the SIGE which asks to what extent they believe different factors will affect their own prices in the next 12 months. The factors I focus on are labor costs, the competitors' pricing strategies, and total demand. Firms report whether the factor has a positive (+1), neutral (0), or negative (-1) effect on the evolution of their prices as well as the intensity of the effect (from 1 to 3). Therefore, the variables range from -3 to +3. As there are not many observations on each distinct value, to have enough power I transform the categorical variables into dummies D_t^i which identify firms which believe the factor is an important driver of their future prices developments, i.e., the dummy is equal to one for values different from 0 and zero otherwise.[9]

The other firms' demographic characteristics I consider are the geographical area based on the firm's administrative headquarters and the sector in which they operate. The data are not particularly granular but they still provide interesting insights into the heterogeneous effects of carbon policy shocks. Firms are classified based on whether their headquarters is

[9]Almost identicial results are obtained defining the dummy equal 1 for values below -2 and above 2 and 0 otherwise.

based in the northwest of Italy, the northeast, the center, or the south and the islands.[10] The sector variable classifies firms into manufacturing, commerce, services or construction.

To explore how firms are heterogeneously affected by carbon policy shocks, I extend the baseline specification of Equation (1) by introducing a variable D_t^i which identifies different firms' characteristics and which is interacted with the carbon policy shock $CPShock_t$:

$$E_{t+h}^i y_{t+h}^i = \alpha_h^i + \gamma_h D_t^i + \delta_h \, CPS_t + \beta_h^D D_t^i \, CPS_t + \sum_{p=1}^{P} \theta_h^p X_{t-p}^i + \varepsilon_{t,h}^i, \tag{3}$$

where the coefficient β_h^D captures how firms are heterogeneously affected by the shocks according to their demographic characteristics. For the different factors, D_t^i is defined as a dummy equals one for firms that believe the factor has an effect on their future prices and zero otherwise.[11] For the geographical area and the sectors, D_t^i is a categorical variable identifying the different regions and sectors.[12] The interaction coefficients can be interpreted as the differential response to a carbon policy shock relative to the baseline group. The different baseline groups are firms that believe a factor has no effect on their future prices, firms whose headquarters is located in the northwest of Italy, and firms in the manufacturing sector.

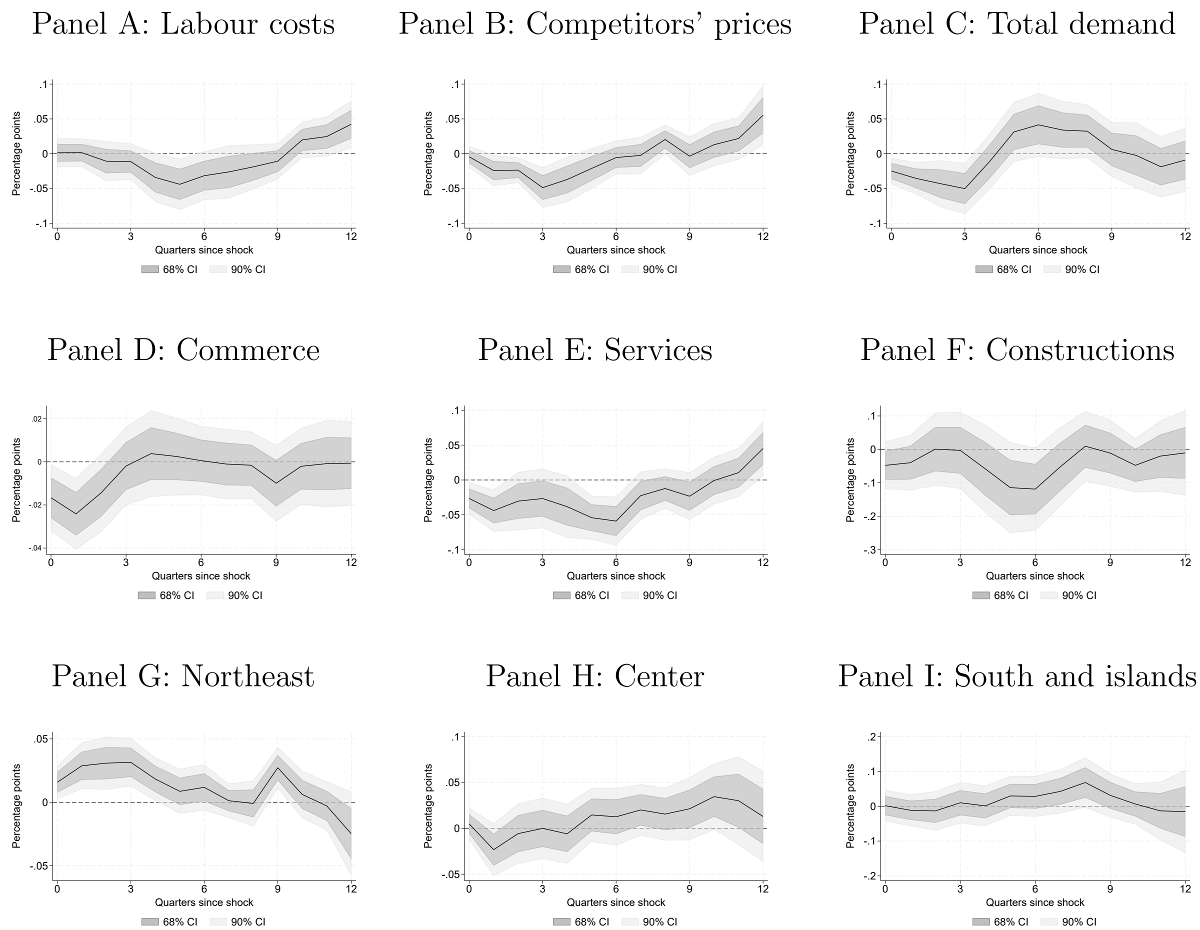
The heterogeneous effects of carbon policy shocks on firms' expectations by firm characteristics are reported in Figure 9, which plots the interaction coefficients β_h^D. Panel A shows that firms that consider labor costs important for their future pricing exhibit a smaller pass-through to inflation expectations relative to those that do not. This is intuitive: energy shocks are not expected to directly affect labor costs, so the greater the weight a firm places on labor costs in its pricing decisions, the weaker the impact of carbon policy shocks on its

[10]Italian regions are classified as follows. Northwest: Aosta Valley, Liguria, Lombardy, and Piedmont. Northeast: Emilia-Romagna, Friuli-Venezia Giulia, Trentino-Alto Adige/Südtirol and Veneto. Centre: Lazio, Marche, Tuscany and Umbria. South and islands: Abruzzo, Apulia, Basilicata, Calabria, Campania, Molise, Sardinia and Sicily.

[11]To avoid endogeneity concerns, the dummy variable is defined using data lagged one quarter. However, using contemporaneous data does not materially affect our results.

[12]The dummies and the two categorical variables are included one at the time but adding them all at the same time does not influence the results.

Figure 9: Impact of carbon policy shocks on firms' inflation expectations by characteristics



Notes: The figure plots the response to a carbon policy shock for the firms' 12-month ahead inflation expectations across different demographic characteristics. The coefficients reported are the interactions between the carbon policy shocks and the dummy identifying firms for which the different factors are important for the evolution of their prices as well as the categorical variables for the geografical area and the sector. The coefficients can be interpreted as the differential responses relative to the baseline categories, i.e., firms who consider the factor not important, firms from the northwest of Italy, and firms in the manufacturing sector. The black lines are the point estimates and the shaded areas are the 90 and 68 percent confidence band. The horizontal axis is in quarters.

inflation expectations.

Panel B highlights the role of strategic complementarities. Firms that place more weight on competitors' pricing strategies display lower sensitivity to carbon policy shocks. The mechanism is straightforward: while higher energy costs may push a firm to raise prices, those that closely follow competitors are reluctant to adjust unilaterally for fear of losing market share. As a result, their expectations of aggregate inflation are dampened, since they anticipate competitors may not increase prices to the same extent. This aligns with the view that strategic complementarities can mute the pass-through of cost shocks. Empirical evidence on the role of competitors' prices remains limited, with notable exceptions in Amiti et al. (2019) and Gagliardone et al. (2023) for Belgian manufacturing firms, and Albagli et al. (2025) for Chilean firms. This paper contributes to that literature by showing that, for Italian firms, the strength of strategic complementarities conditions the pass-through of carbon policy shocks to inflation expectations.

Finally, Panel C shows that firms whose pricing is primarily demand-driven also revise their inflation expectations less in response to carbon policy shocks. For these firms, demand sensitivity constrains the ability to pass higher costs on to consumers, further limiting the transmission of input shocks into expected inflation.

Regarding sectoral heterogeneity, the pass-through of carbon prices to 12-month-ahead inflation expectations is comparable for firms in construction and those in manufacturing (the baseline category), as shown in Panel F. By contrast, the effect is significantly more muted for firms in commerce and services (Panels D and E). This pattern is consistent with the findings of Hensel et al. (2024), who show that the sensitivity of expectations to carbon policy shocks increases with the share of energy costs in total inputs. Since energy costs represent a smaller share of input costs for service-sector firms than for firms in construction and manufacturing, their inflation expectations are less responsive to changes in carbon prices.

The results across geographical areas are presented in the bottom panels. Compared to the baseline category of firms located in the northwest of Italy, only those in the northeast exhibit a slightly more vigorous response to a carbon policy shock (Panel G). Firms based in the central regions or in the south and the islands show no statistically significant difference in their responses (Panels H and I). The heterogeneous responses across regions most likely reflect differences in the industry composition. In conclusion, firms' characteristics and their perceptions of factors influencing their prices significantly impact the extent to which carbon policy shocks affect their inflation expectations.

4 Robustness

In this section, I perform several robustness checks to further validate the main findings. First, I analyze the response of firms' expectations to carbon policy shocks using only the data from the period when all measures of inflation expectations are available, i.e., from 2014q1 onward. Second, I include firm-specific and macroeconomic controls in the specification. Third, to assess whether outliers or the survey composition might influence the results, I re-run the analysis using the cross-sectional averages of the firms' inflation expectations as the dependent variable.

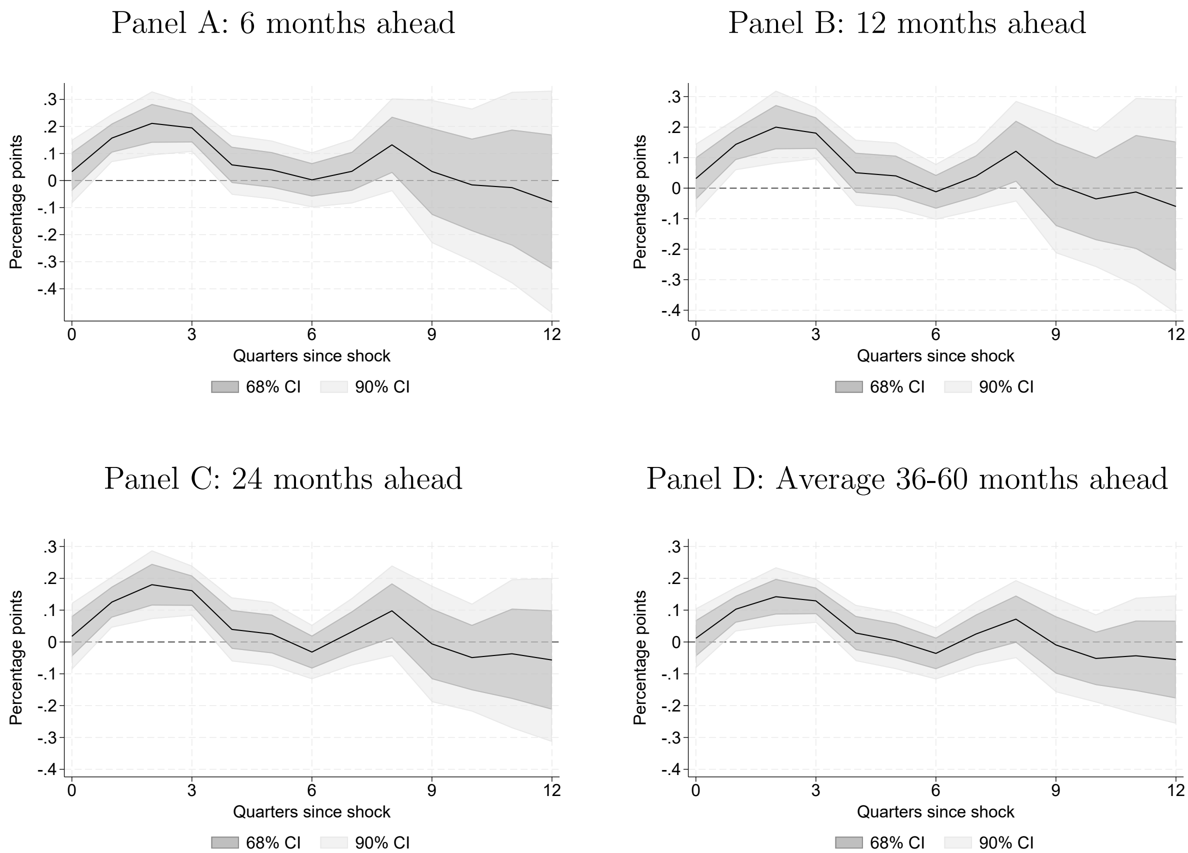
As the first robustness check, I re-estimate Equation (1) starting the sample from 2014q1. As previously noted, only the 12-month ahead inflation expectations are available from 1999, with questions about other forecast horizons being introduced later, the last being the long-term forecast in 2014q1. Therefore, I control that restricting the sample to the period in which all variables are available does not alter the baseline results.

The results, presented in Figure 10, confirm that the main findings remain unchanged. An exogenous increase in the price of carbon still leads to a significant rise in firms' inflation expectations across all forecast horizons.

The shocks are constructed to be orthogonal to Euro Area economic conditions. Therefore, controlling for macroeconomic developments specific to Italy might be important for the estimated results. As additional robustness check, I extend the baseline specification by including Italian CPI inflation and unemployment rate, the European Central Bank policy rate as well as quarter fixed effects to absorb seasonality.

The results are reported in Figure 11. Controlling for aggregate macroeconomic variables and quarter fixed effects has virtually no impact on the responses of 12-month-ahead expected

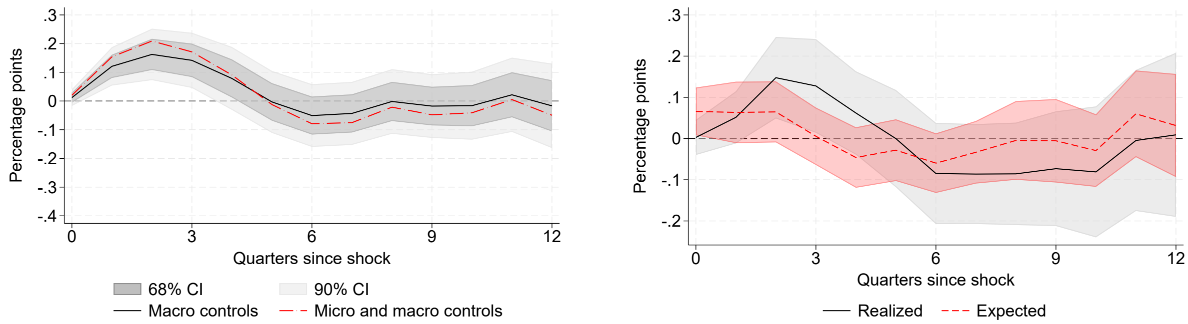
Figure 10: Impact of carbon policy shocks on firms' inflation expectations, common period



Notes: The figure plots the response to a carbon policy shock, normalized to increase the HICP energy by 1 percent on impact, for the firm-level inflation expectations at different forecast horizons. The time period considered spans from 2014q1 to 2019q4 when all the different horizons are available. The black lines are the point estimates and the shaded areas are the 90 and 68 percent confidence bands. The horizontal axis is in quarters.

Figure 11: Impact of carbon policy shocks on firms' expectations, macro controls

Panel A: 12 months ahead inflation　　Panel B: Expected and realized price growth



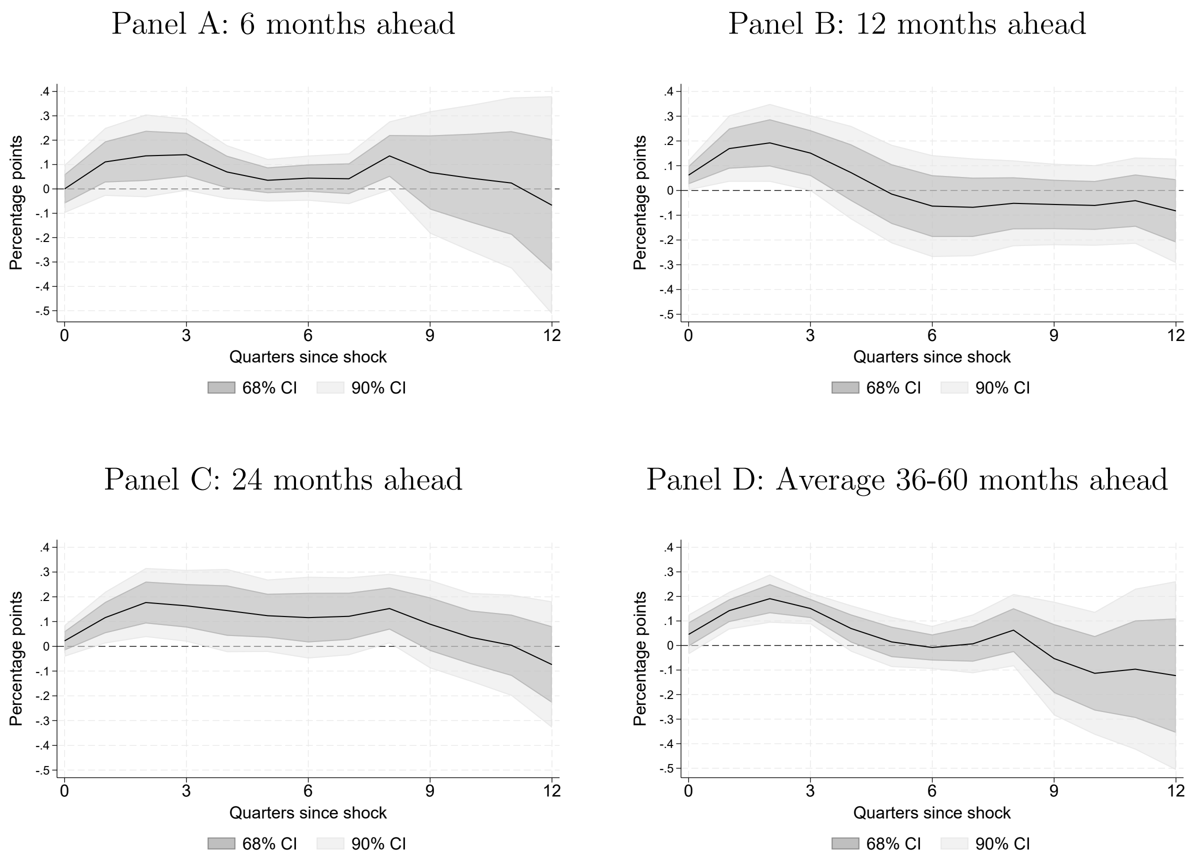
Notes: The figure plots the response to a carbon policy shock, normalized to increase the HICP energy by 1 percent on impact, for the firms' 12-month ahead expected inflation as well as the realized and expected own price growth. The specification also includes the Italian CPI inflation and unemployment rate, the European Central Bank policy rate as well as quarter fixed effects. The lines are the point estimate, and the shaded areas are the 90 and 68 percent confidence bands. The horizontal axis is in quarters.

inflation (Panel A), nor on realized and expected own-price growth (Panel B). The findings are also robust to any possible combination of these controls. In Panel A, I further augment the specification with firm-level controls—including sector, size, and region fixed effects, past price growth, and firms' expectations about the aggregate economy and their own business conditions. The results remain unchanged.

Finally, concerns about outliers or variations in survey composition potentially biasing the results are addressed by re-estimating the baseline specification using the cross-sectional average of firms' inflation expectations as the dependent variable.[13] The responses are presented in Figure 12. This approach, which mitigates the influence of outliers and survey composition changes, confirms that the baseline results are robust. Carbon policy shocks continue to show a significant impact on both short-term and long-term inflation expectations.

[13]Similar results are obtained using the median.

Figure 12: Impact of carbon policy shocks on aggregate firms' inflation expectations



Notes: The figure plots the response to a carbon policy shock, normalized to increase the HICP energy by 1 percent on impact, for the cross-sectional average of the firm-level inflation expectations at different horizons. The black lines are the point estimates and the shaded areas are the 90 and 68 percent confidence bands. The horizontal axis is in quarters.

5 Discussion of the results

Following the post-COVID surge in inflation, partly driven by supply shocks, researchers and central bankers are revisiting how monetary authorities should manage energy shocks. This issue is becoming increasingly pressing as such shocks are expected to become more frequent with climate change, while policies aimed at addressing it—such as carbon pricing—can themselves generate inflationary pressures. Traditional monetary economics suggests that central banks should "looking through" supply shocks, as they are temporary and relative price adjustments can enhance allocative efficiency (Aoki, 2001; Guerrieri et al., 2022; Rubbo, 2023). Indeed, the aggregate macroeconomic effects of carbon policy shocks dissipate within 4–5 quarters. However, this reasoning becomes fragile once we allow for information frictions and deviations from rational expectations. As shown in this paper, firms' inflation expectations—both short- and medium-term—respond strongly to carbon price shocks, even when aggregate inflation quickly reverts.

The empirical findings provided have important policy implications. First, persistent increases in short-term expectations can fuel second-round effects, amplifying the original shock. Second, the finding that medium- and long-term expectations move in response to carbon price shocks, despite their limited aggregate inflationary impact, raises concerns about potential de-anchoring from the inflation target. Anchoring expectations is central to monetary policy credibility, so overlooking these dynamics may entail significant risks.

Moreover, the observed rise in forecast errors and disagreement following shocks is consistent with models of sticky information and rational inattention. Firms update imperfectly and asymmetrically, implying that shocks can propagate more strongly through expectations than through actual inflation. The heterogeneity in pass-through across firms—depending on cost structure, demand conditions, and strategic complementarities—further complicates the task for policymakers.

These findings highlight two key policy implications. First, monetary authorities cannot treat climate-related supply shocks as irrelevant for price stability: their indirect effects through expectations may warrant a policy response, even if the direct impact on inflation is temporary. Second, communication is crucial. Empirical evidence shows that firms receiving official information about current inflation adjust their expectations more in line with fundamentals. Clear, transparent communication on both inflation dynamics and the anticipated impact of climate policies can help dampen misperceptions, reduce disagreement, and keep long-term expectations anchored.

In sum, as the global economy transitions toward greener practices, central banks face a dual challenge: safeguarding price stability while accommodating the structural adjustments induced by climate policy. Achieving this balance requires not only vigilant monitoring of inflation expectations, but also active communication strategies to mitigate information frictions and prevent climate policy from inadvertently undermining monetary policy credibility.

6 Conclusion

The role of central banks in addressing climate change remains a vibrant area of debate. On one hand, mitigating the adverse impacts of climate change is a collective responsibility. On the other hand, the potential inflationary effects of climate policies might create tensions with the central banks' core mandate of maintaining price stability.

This paper demonstrates that carbon pricing leads to increased inflation expectations among firms. By combining carbon policy shocks developed by Känzig (2023) with Italian firm-level survey data, it is shown that these shocks not only raise firms' expectations of their own price growth but also influence realized price growth, price forecast errors, and disagreement among firms. Furthermore, the pass-through effect is stronger for firms that receive information about the current level of inflation, and the shocks are found to significantly worsen firms' perceptions and expectations of both their own business conditions and the broader economic environment.

A key finding is that the transmission of carbon policy shocks to inflation expectations operates primarily through indirect channels. At the peak, only a small share of the response of 12-month ahead expectations reflects direct effects of carbon pricing, while the majority is driven by higher energy prices. This indicates that the inflationary relevance of carbon pricing stems less from its direct cost effects and more from the way it propagates through energy markets and expectations. The results also reveal significant heterogeneity across firms. Firms that consider labor costs or competitors' pricing behavior central to their price-setting show a muted pass-through from carbon policy shocks, while demandconstrained firms are less able to incorporate higher energy costs into their expectations. Sectoral differences matter as well: firms in energy-intensive sectors such as manufacturing and construction display higher sensitivity to shocks compared to those in services and commerce. These findings emphasize that the inflationary consequences of climate policy are unevenly distributed across the economy.

While carbon pricing generally results in temporary effects on overall inflation, the substantial information frictions in firms' expectations, their indirect transmission through expectations, the persistence of inflationary pressures in the long-term expectations and their heterogeneous impact across firms and sectors suggest that central banks cannot simply disregard these energy shocks. There is a risk that short-term increases in inflation expectations could lead to higher actual inflation rates and also affect longer-term expectations, complicating the central banks' efforts to maintain price stability. Vigilant monitoring of energy-driven inflation dynamics, combined with transparent communication to reduce information frictions, will be essential to prevent the de-anchoring of expectations. In practice, effective communication and complementary policies that reduce energy price volatility can help reconcile the objectives of climate policy with the central banks' mandate of price stability.

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Appendix

A Macroeconomic variables and carbon policy shocks

The carbon policy shocks, derived following the approach of Känzig (2023), are computed using Euro Area-level variables. Therefore, as a first step, it is important to evaluate the aggregate effects of these shocks on the Italian economy. This is done by estimating the following local projection à la Jordà (2005):

$$y_{t+h} = \alpha_h + \beta_h CPShock_t + \sum_{p=1}^{P} \theta_h^p y_{t-p} + \epsilon_{t+h}, \tag{4}$$

for $h = 1, ..., 12$. y_{t+h} is the dependent variable at time $t + h$, $CPShock_t$ are the carbon policy shocks at time t extracted from the proxy-VAR[14], and ϵ_{t+h} is the error term. As control I include three lags of the dependent variable and correct for autocorrelation using Newey and West (1987) standard errors.[15] The coefficient of interest is β_h, which captures the response of the dependent variable to a carbon policy shock for each horizon h. The dependent variables are the year-on-year inflation rates of the Energy Consumer Price Index (CPI), the Producer Price Index (PPI), and the overall CPI for Italy.[16] I consider the annual growth rate rather than the log value to be consistent with the answers in the survey which report the expectations in percentage terms.

The responses to a carbon policy shock are shown in Figure 13. Following a shock that raises the energy component of the Euro Area HICP by 1 percent, the Italian Energy CPI reacts by a similar magnitude (Panel A). The shock also triggers a sizable increase in the PPI (Panel B) and a notable rise in the overall CPI (Panel C). In particular, the CPI rises by

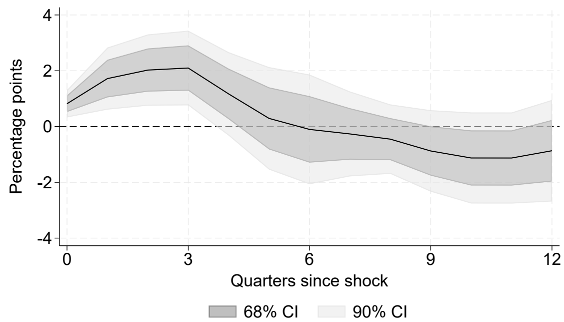
[14]The time period of the shock series is from 1999 to 2019. Restricting the sample to after the euro introduction, i.e., 2002q1 onward, does not affect the main results.

[15]In the baseline specification I do not include any European or global controls, as these are already accounted for in the monthly VAR model used to derive the shock estimate. Additionally, I do not include lags of the shock variable, as there is little evidence of autocorrelation in the shock series.

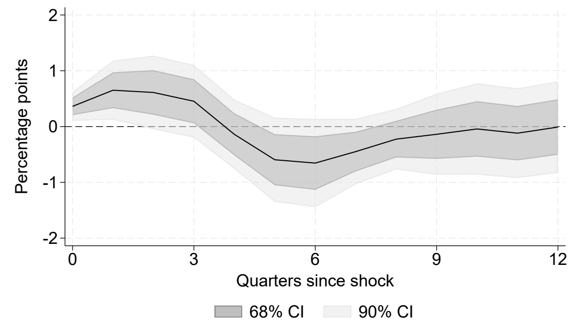
[16]Considering the Harmonized CPI delivers basically the same results.

Figure 13: Macro responses to carbon policy shocks

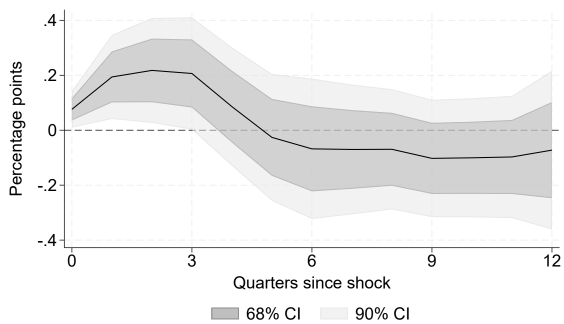
Panel A: Energy CPI inflation



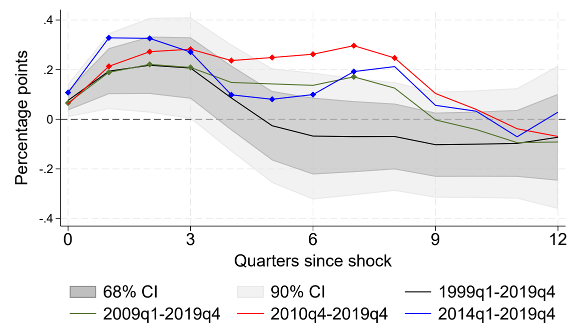
Panel B: PPI inflation



Panel C: CPI inflation



Panel D: CPI inflation, subperiods



Notes: The figure plots the response to a carbon policy shock, normalized to increase the Euro Area HICP energy by 1 percent on impact, for the the year-on-year inflation rates of the Italian Energy Consumer Price Index (CPI) (top left panel), the Producer Price Index (PPI) (top right panel), aggregate CPI (bottom left panel) and the aggregate CPI for different subperiods (bottom right panel). The black lines are the point estimates and the shaded areas are the 90 and 68 percent confidence bands. The diamond-shaped coefficients in panel D indicate the statistically significant values. The horizontal axis is in quarters.

about 0.1 percent on impact, before reverting to zero after 4–5 quarters. Given that energy accounts for roughly 10% of the CPI basket, this pattern points to an almost complete pass-through.

In Figure 15 of the Appendix, I document comparable effects for alternative measures of energy prices: the single national price for wholesale electricity from the Gestore Mercati

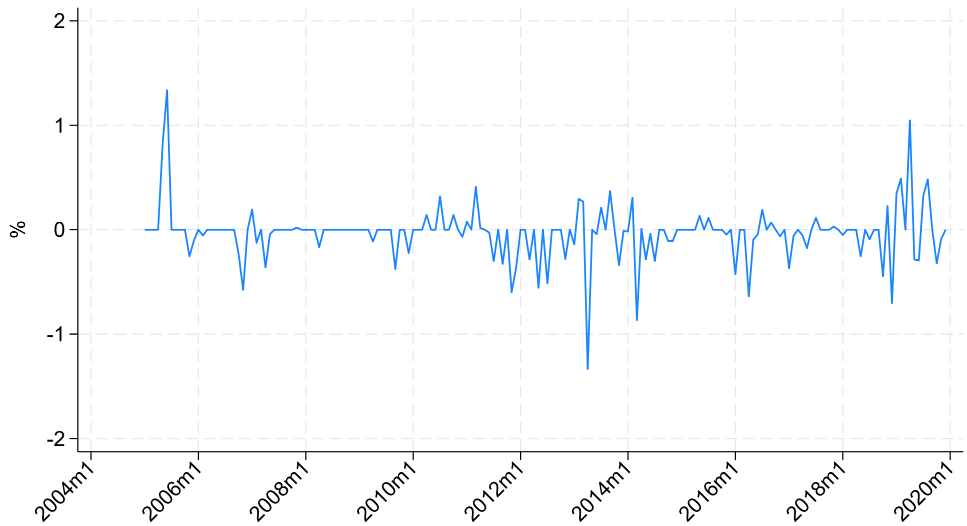
Energetici (GME)[17] and the inflation subcomponent *Electricity, Gas and Other Fuel price* (COICOP 04.5). The inflationary impacts of carbon pricing observed for Italy align with findings by Känzig (2023) and Hensel et al. (2024) for the Euro Area (19 members) and France. The effects of an exogenous increase in the price of carbon are both statistically and economically significant, albeit relatively short-term.

Finally, given that the questions regarding different forecast horizons in inflation expectations were introduced at different points in time, I assess whether the shocks remain well-identified when considering alternative subperiods. Panel D of Figure 13 shows the responses of the CPI starting from the baseline period in 1999q1, as well as from 2009q1, 2010q4, and 2014q1. The diamond-shaped coefficients indicate statistically significant values. The persistence of the effects varies slightly across subsamples, but the contemporaneous impact and the shape of the responses in the first 4 to 5 quarters are relatively consistent across different subsamples. This reassures the validity of the empirical specification adopted, even with shorter time samples.

[17]The data can be downloaded from the GME's website HERE.

B Extra figures

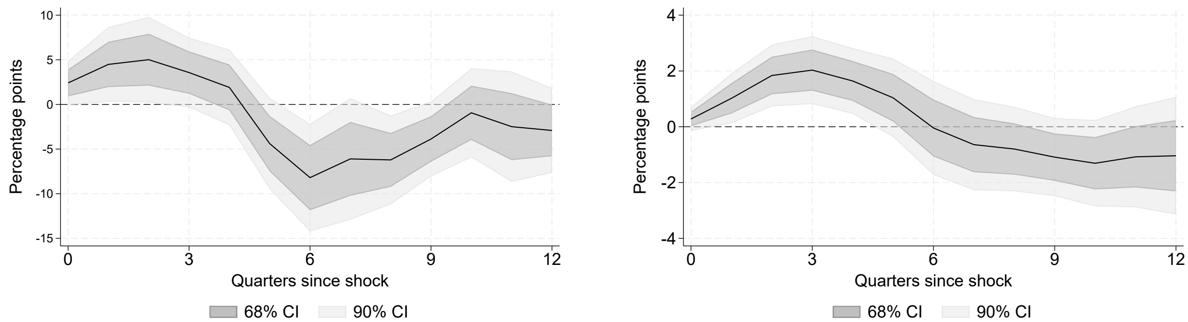
Figure 14: The carbon policy surprise series



Notes: This figure shows the carbon policy surprise series, constructed as the EUR change in carbon prices relative to the prevailing wholesale electricity price on the day before the event.

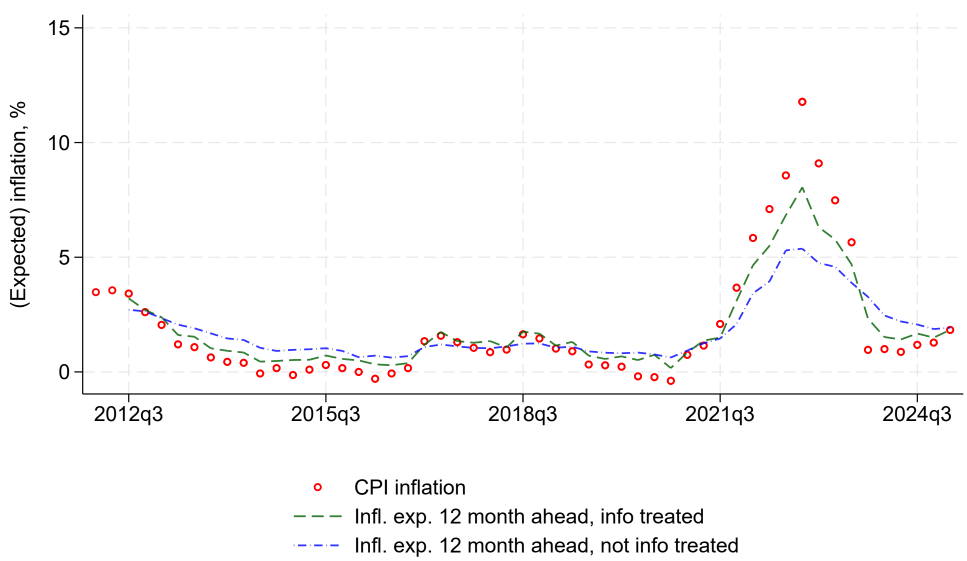
Figure 15: Impact of carbon policy shocks on energy prices

Panel A: Wholesale electricity prices Panel B: Electricity, Gas and Other Fuel price



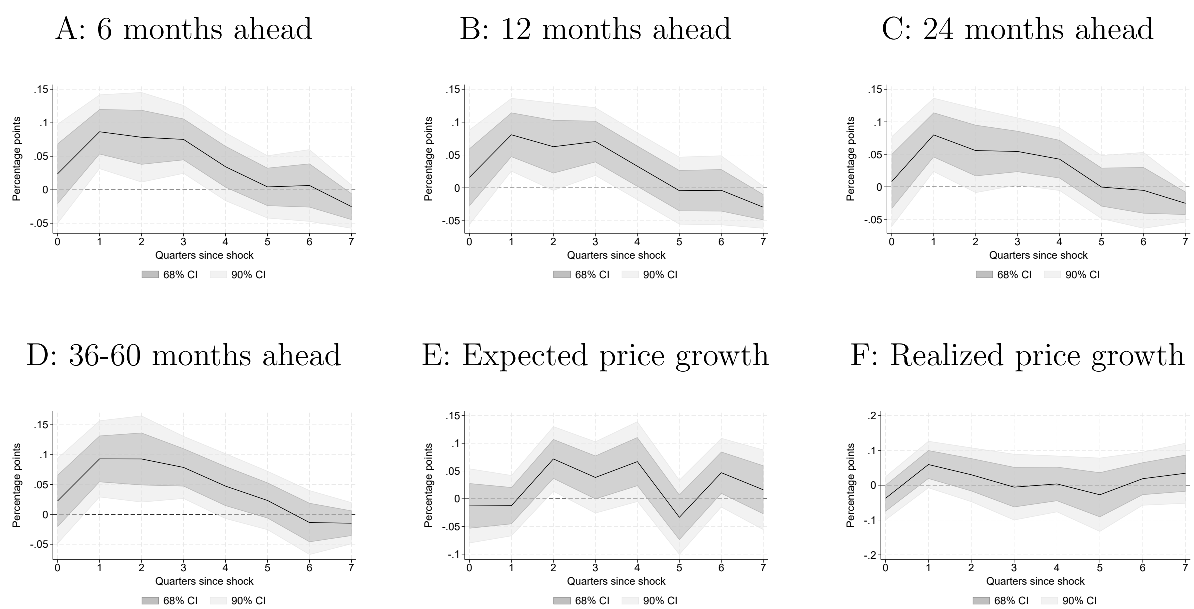
Notes: The figure plots the response to a carbon policy shock, normalized to increase the HICP energy by 1 percent on impact, on different measures energy prices. The response on the left panel are computed using as dependent variables the the year-on-year inflation rates of the wholesale electricity prices and the response on the right panel the inflation subcomponent *Electricity, Gas and Other Fuel price* (COICOP 04.5). The black lines are the point estimates and the shaded areas are the 90 and 68 percent confidence bands. The horizontal axis is in quarters.

Figure 16: Time series of the Italian CPI inflation and firms' inflation expectations by treatment status



Notes: The figure plots the time series of actual CPI growth for Italy alongside the measures of firms' 12-month ahead inflation expectations by treatment status. The firm-level data comes from the SIGE survey.

Figure 17: Differences in the expectations responses to carbon policy shocks by treatment status



Notes: The figure plots the response to a carbon policy shock for the firms' expectations. The coefficients reported are the interactions between the carbon policy shocks and the dummy identifying whether a firm has received the information treatment or not. The coefficients can be interpreted as the differential responses relative to the baseline category, i.e., firms who did not receive the information. The black lines are the point estimates and the shaded areas are the 90 and 68 percent confidence band. The horizontal axis is in quarters.