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FIRM INFLATION UNCERTAINTY

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ABSTRACT

We introduce a new measure of own-price inflation uncertainty using firm-level data from a large and representative survey of UK businesses. Inflation uncertainty increased significantly from the start of 2021 and reached a peak in the second half of 2022, even as a similar measure of sales uncertainty declined. We also find large cross-sectional differences in inflation uncertainty, with uncertainty particularly elevated for smaller firms and those in the goods sector. Finally, we show that firms which are more uncertain about their own price expectations experience higher forecast errors 12 months later. These findings suggest that studying inflation uncertainty at the firm level may be an important new dimension to understanding firm performance.

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I. Introduction

During 2022, inflation rates in advanced economies reached the highest levels in 40 years. In October 2022, annual Consumer Price Index (CPI) inflation was 11.1% in the UK and 7.8% in the US. Understanding the drivers of this increase since 2021 has been the subject of extensive research (e.g. Ball et al. 2022, Bunn et al. 2022, Hilscher et al. 2022). Authors have emphasized the importance of energy prices, tight labor markets, as well as lingering supply disruptions for driving inflation rates above pre-pandemic levels. A smaller subset of research has also discussed the rising dispersion of inflation rates and rising inflation volatility (e.g. Davies 2021, Hall 2023). This paper highlights a third, related, trend since 2021 – rising uncertainty about future inflation at the level of individual firms.

We introduce a new measure of own-price inflation uncertainty at the *firm level* using a large and representative survey in the UK. Using this measure, we present four new findings. First, after an initial spike during the onset of the pandemic, inflation uncertainty continued to rise and reached a peak in the second half of 2022. This is in contrast to a similar measure of (nominal) sales uncertainty, which has declined significantly from its peak in 2020, and is close to pre-pandemic levels at the start of 2023. Second, we find large cross-sectional differences in inflation uncertainty, with smaller firms and those in the goods sector experiencing higher uncertainty over the past year. Third, we show that firms which are more uncertain about their price expectations experience higher forecast errors 12 months later. Finally, we find significant negative correlations between price forecast errors, inflation uncertainty, and measures of firm performance, including profit margins and productivity. Although we do not claim these relationships are causal, they suggest inflation uncertainty may limit firms' ability to plan ahead and allocate resources efficiently.

This paper relates to several literatures. First, we relate to the large literature on measuring and assessing the impact of uncertainty. Numerous measures of uncertainty have been proposed in recent years, including news media (Baker et al. 2016), earnings calls (Hassan et al. 2019), stock-market volatility (Bloom et al. 2007), and survey-based indices (Altig et al. 2020b, Dovern 2023). A consistent finding from this literature is that higher uncertainty is negatively correlated with economic performance, at both the macro and micro levels. We introduce a new measure – own-price inflation uncertainty at the firm level – and discuss potential implications of heightened uncertainty about future prices for firm performance.

Second, we relate to a literature which focuses on the potential costs of high inflation volatility and inflation uncertainty. This literature goes back to Friedman (1977), who argued that

inflation volatility reduces economic efficiency by distorting relative prices and may lead to higher unemployment. Empirical work since then has considered the impacts of inflation volatility and inflation uncertainty on output, economic growth, and investment (e.g. Froyen and Waud 1987, Judson and Orphanides 1999, Huizinga 1993). More recently, Williams (2022) emphasizes inflation uncertainty (particularly at longer time horizons) as a key criterion for anchored inflation expectations. Due to data limitations, most of the previous research has constructed measures of inflation volatility or uncertainty using aggregate time series or cross-sectional variation. One exception is Kumar et al. (2022), who use a survey experiment with information treatments to show higher uncertainty about aggregate growth can have causal negative effects on firms' decisions, such as employment and investment. We complement this literature by introducing a precise measure of inflation uncertainty at the individual firm level for a large sample of UK businesses.

Finally, we also contribute to the growing literature using business surveys to evaluate the impact of major shocks, including Altig et al. (2020a), Bhandari et al. (2020), and Candia et al. (2022). Business surveys have provided timely data to understand economic developments as well as to make better forecasts for the future.

The rest of the paper is structured as follows: Section II discusses the DMP data and our measure of firm-level inflation uncertainty, Section III presents the main results, Section IV analyses the evidence for 'learning-through-survey' effects in the panel, and Section V concludes.

II. Data and Methodology

We use firm-level data from the Decision Maker Panel (DMP) survey. The DMP is a large and representative survey of CFOs in UK businesses. It was established in 2016 and is run by the Bank of England in partnership with the University of Nottingham and Stanford University. The survey is carried out online and receives around 2,500 responses each month (Figure 1).[3] Aggregate data series are updated every month and published on the DMP website: https://decisionmakerpanel.co.uk. In the survey, firms are asked how the average price they charge has changed over the last year. Although the survey data cover economy-wide prices, the DMP inflation data closely track the official UK CPI and producer price index (PPI) inflation rates (Figure 2, Panel A). Firms are also asked how they expect their own prices to

[3] The DMP is frequently used to study business trends across the UK and to advise policymakers, including on the impact of uncertainty around Brexit (Bloom et al. 2019) and the impact of Covid-19 on firms (Bloom et al. 2023).

change over the year ahead. In Figure 2, Panel B we plot firms' expected own-price growth against their realised price growth a year later. The observations lie close to the 45-degree line, suggesting firms, on average, have a good sense about the evolution of their prices in the short-term.[4]

A. Measuring subjective uncertainty

Rather than asking firms for point estimates of expected outcomes, the DMP asks firms to provide a five-point distribution over expectations.[5] For example, firms are asked to provide five scenarios for the lowest, low, middle, high, and highest price growth which they expect for their own business over the next 12 months, and then assign probabilities to each of the five scenarios.[6] The responses to this question allow us to calculate not only average expected price growth but also higher-order moments of expectations (e.g. standard deviation, skewness, kurtosis) at the firm level. In particular, inflation uncertainty is calculated as the standard deviation across the five scenarios, weighted by the probability assigned to each scenario. Formally, this is shown in Equation 1 below, where $\pi^{e}_{i,t,j}$ is the expected own-price growth for firm i, in month t, and scenario j. The corresponding probability is denoted by $p_{i,t,j}$. Similar measures of uncertainty can also be calculated for sales, employment, capital expenditure, unit cost growth, and wage growth expectations in the DMP.

$$\pi^{SD}_{i,t} = \sqrt{\frac{\sum_{j=1}^{5} p_{i,t,j}\left(\pi^{e}_{i,t,j} - \pi^{e}_{i,t}\right)^{2}}{100}} \qquad (1)$$

Using distributional questions to analyze expectations is not a unique feature of the DMP. Similar questions have been asked for sales, employment, and investment expectations in the Survey of Business Uncertainty (SBU) organized by the Federal Reserve Bank of Atlanta (Altig et al. 2020b) and to study investment uncertainty in the context of the US Management and Organizational Practices Survey (MOPS) (see Bloom et al. 2022). Our main contribution is to analyze the dynamics of own-price inflation uncertainty, particularly in the current high-inflation environment, and its relationship with firm performance.

[4] Table 1, Column 2 shows that this relationship between expected price growth and realized price growth remains robust to the inclusion of both firm and month fixed effects.
[5] Figure 3 shows a screenshot of a five-point distribution question about expected price growth.
[6] Figure 4 shows the average values of each of the five scenarios for price growth expectations and the associated average probabilities assigned.

III. Main Results

After calculating the firm-level measures of uncertainty, we take the average across firms to construct measures of 'subjective' uncertainty. The series for sales and inflation subjective uncertainty are presented in Figure 5, Panel A. Relative to the average levels in 2019, sales uncertainty increased dramatically in the first year of the pandemic, before decreasing gradually in 2021.[7] By the start of 2023, sales subjective uncertainty was almost back to pre-pandemic levels. The evolution of subjective own-price uncertainty has been quite different. After increasing by less in the initial stages of the pandemic, uncertainty about expected prices within firms continued to grow and reached a peak in the second half of 2022. At the start of 2023, subjective inflation uncertainty has started to fall back but remains around 50% above pre-pandemic levels.

The increase in inflation uncertainty since the start of 2020 occurred in two very different inflation environments. During the first year of the pandemic, aggregate inflation in the UK fell modestly. For example, annual CPI was 0.2% in August 2020. This was also reflected in the decline in realized price growth among firms in the DMP (Figure 2, Panel A). The initial spike in inflation uncertainty during this period was caused by a decline in the left tail of the distribution, as firms revised down their expectations for year-ahead price growth (Figure 5, Panel B). In contrast, the subsequent rise in uncertainty starting in 2021 has been driven by higher inflation expectations, particularly in the right tail of the distribution.

In addition to the time series variation in inflation uncertainty, we find significant cross-sectional differences across firms. Figure 6 plots the evolution of inflation uncertainty across different percentiles of the distribution. Although inflation uncertainty has increased across all percentiles, the increase has been much more substantial in the right tail of the distribution, with uncertainty in the 90th percentile around 5% in 2022, relative to an average of 2.7% during the same period (dashed line). We additionally find that smaller firms have higher inflation uncertainty, on average (Figure 7, Panel A) and firms in the goods sector have experienced higher inflation uncertainty since the start of 2022 relative to services sector firms (Figure 7, Panel B). Finally, in Figure 8, we show the evolution inflation uncertainty since 2018 for selected industries. Uncertainty regarding future price growth increased significantly for the

[7] It should be noted that this measure refers to uncertainty regarding *nominal* sales, which includes both volumes (i.e. real sales) and prices. Without additional assumptions, it is not straightforward to construct a within-firm measure of real sales uncertainty, as this would require individual scenarios for real sales growth expectations and associated probabilities.

Accommodation and Food sector in 2020, as this was one of the worst-hit in the first year of the pandemic. Inflation uncertainty for other sectors remained relative unchanged during this period relative to 2019 averages. A more broad-based increase in subjective inflation uncertainty started in 2021, and has continued through the end of 2022, when uncertainty remained approximately 50% above pre-pandemic levels. At the start of 2023, there are initial signs of easing inflation uncertainty across some, but not all, sectors.

One explanation for the rising inflation uncertainty reported by firms could be higher uncertainty regarding their input costs. Since May 2022, firms have been asked about their realised and expected wage growth as well as unit cost growth. We can construct subjective uncertainty for wage growth and unit cost growth similar to our measure of inflation uncertainty. There is a positive and statistically significant relationship between inflation uncertainty and wage growth uncertainty (Figure 9, Panel A) as well as between inflation uncertainty and unit cost growth uncertainty (Figure 9, Panel B).

Uncertainty about own-price inflation might matter if firms make less accurate predictions when uncertainty is high. Indeed, we find that larger forecast errors (measured as the difference between realized price growth and expectations a year ago) are positively associated with greater inflation uncertainty at the point the expectations are made (Figure 10).[8] This relationship is present for both positive and negative forecast errors. It is also robust to the inclusion of firm and monthly fixed effects (Table 1, Column 4).

Larger forecast errors, in turn, may limit a firm's ability to plan ahead and allocate resources effectively. Tanaka et al. (2020), for instance, show that firms making errors in forecasting aggregate GDP also exhibit lower profitability and productivity. In Table 2 we carry out a similar exercise, but focusing instead on own price forecast errors. To do this we collapse the DMP data down to annual form, taking averages across all variables within a financial year, and match up with annual accounting data from Bureau van Dijk, since profits and productivity are not asked about in the DMP. We find that when firms make errors in forecasting their own future prices this is typically associated with lower profits and productivity (column 1 and column 3 of Table 2). These equations include firm fixed effects, and so this result should not just be explained by better-managed firms always making more accurate forecasts and also

[8] This finding is also related to Bachmann et al. (2013), who find a strong correlation between ex-ante forecast disagreement and ex-post forecast errors in survey data for Germany and the US.

being more profitable and productive.[9] Uncertainty at the time the forecast was made is also associated with subsequent lower profits and productivity (columns 2 and 4 of Table 2). Although these relationships are not causal, they suggest that further work may be warranted to understand the relationship between inflation uncertainty, forecast errors, and firm performance.

IV. Learning-through-survey effects

Recently, research by Kim and Binder (forthcoming) find evidence of large 'learning-through-survey' effects in household survey data. They show that in surveys with a panel dimension, repeat participation itself can have a significant effect on inflation expectations and inflation uncertainty. We can check for similar effects in the DMP, using the following specification:

$$\ln Uncert_{itj} = \alpha_i + \beta_t + \sum_{j=0}^{41} \gamma_j + \varepsilon_{itj} \qquad (2)$$

On the left-hand side, we include the natural logarithm of our subjective uncertainty measures. In particular, we focus on sales growth and inflation subjective uncertainty, as we have the longest time series from these in the panel. We also winsorise the subjective uncertainty measures at the 5th and 95th percentiles. The main explanatory variables are the dummies, γ_j, which capture 'survey tenure' in the DMP. Specifically, these dummies measure the number of times a firm has responded to a survey panel with any five-bin distribution question.[10] We top-code this measure to 41 months to avoid noise from small samples in the right tail; only around 7% of our sample is represented by firms answering more than 41 surveys (out of a maximum of 77). Finally, we control for firm fixed effects, α_i, and month fixed effects, β_t, in our regressions. The standard errors, ϵ_{itj}, are clustered at the firm level.

Figure 11 presents the estimates from Equation 2 as coefficient plots for sales subjective uncertainty (Panel A) and inflation uncertainty (Panel B). In both cases, there is a downward sloping relationship between survey tenure and subjective uncertainty. This would suggest there are some 'learning-through-survey' effects present in the sample. However, these tend to be quantitatively small and not statistically significant for the majority of the sample. For example, Panel A suggests that even after two years in the survey, average sales subjective

[9] Nevertheless, we are not able to rule out the influence of time-varying management in driving both forecast accuracy and firm performance. Indeed, Bloom et al. (2021) show that well-managed firms in the UK have more accurate forecasts, lower subjective uncertainty, as well as higher productivity and profitability.

[10] Because of the DMP's rotating panel structure, firms are not asked about their expected sales or expected price growth every month. However, five-bin distribution questions are present in every survey panel. Therefore, we include these months as well as in our estimation of 'learning-through-survey' effects.

uncertainty is around 5% lower compared with firms which just joined the panel. The effects on inflation uncertainty (Panel B) are even smaller.

In order to get a better sense of the quantitative impact of survey tenure on our measures of subjective uncertainty, we construct 'de-biased' measures of subjective uncertainty. To do this, we estimate Equation 2 with our raw measures of uncertainty on the left-hand side. Then, we use the coefficients on survey tenure to partial out the 'learning-through-survey' effects from our raw measure. This approach is more precise than estimating a single coefficient for survey tenure, and therefore should allow us to assess the importance of survey learning effects with greater confidence. Figure 12 presents the results for sales and inflation uncertainty, showing both the raw measures and the adjusted measure for learning effects. For sales uncertainty (Panel A), these measures a very similar for the majority of the time series. By the start of 2023, a small gap has emerged between the two; the de-biased measure suggests sales growth uncertainty is around 8% higher than what our raw measure would suggest. Interestingly, Panel B suggests our raw measure of uncertainty has generally been *higher* than the de-biased measure, and at the end of 2022, the difference between two was less than 1%. Overall, we conclude that although there is some evidence of learning-through-survey effects around subjective sales and inflation uncertainty, these are small and do not have a material impact on the interpretation of the data.

V. Conclusion

The recent rise in inflation has prompted significant research on its drivers and consequences. This paper introduces a new measure of own-price inflation uncertainty calculated at the firm level using a large and representative survey of UK businesses. We find that inflation uncertainty increased significantly since the start of 2021 and reached a peak in the second half of 2022, even as a similar measure of sales uncertainty has declined. The increase has been widespread across sectors of the economy, with smaller firms and firms in the goods sector experiencing particularly strong increases. Furthermore, inflation uncertainty is highly correlated with price forecast errors at the firm level. In turn, both own-price forecast errors and inflation uncertainty are negatively correlated with firm profit margins and productivity. These findings suggest that studying inflation uncertainty may be an important new dimension to understanding firm performance.

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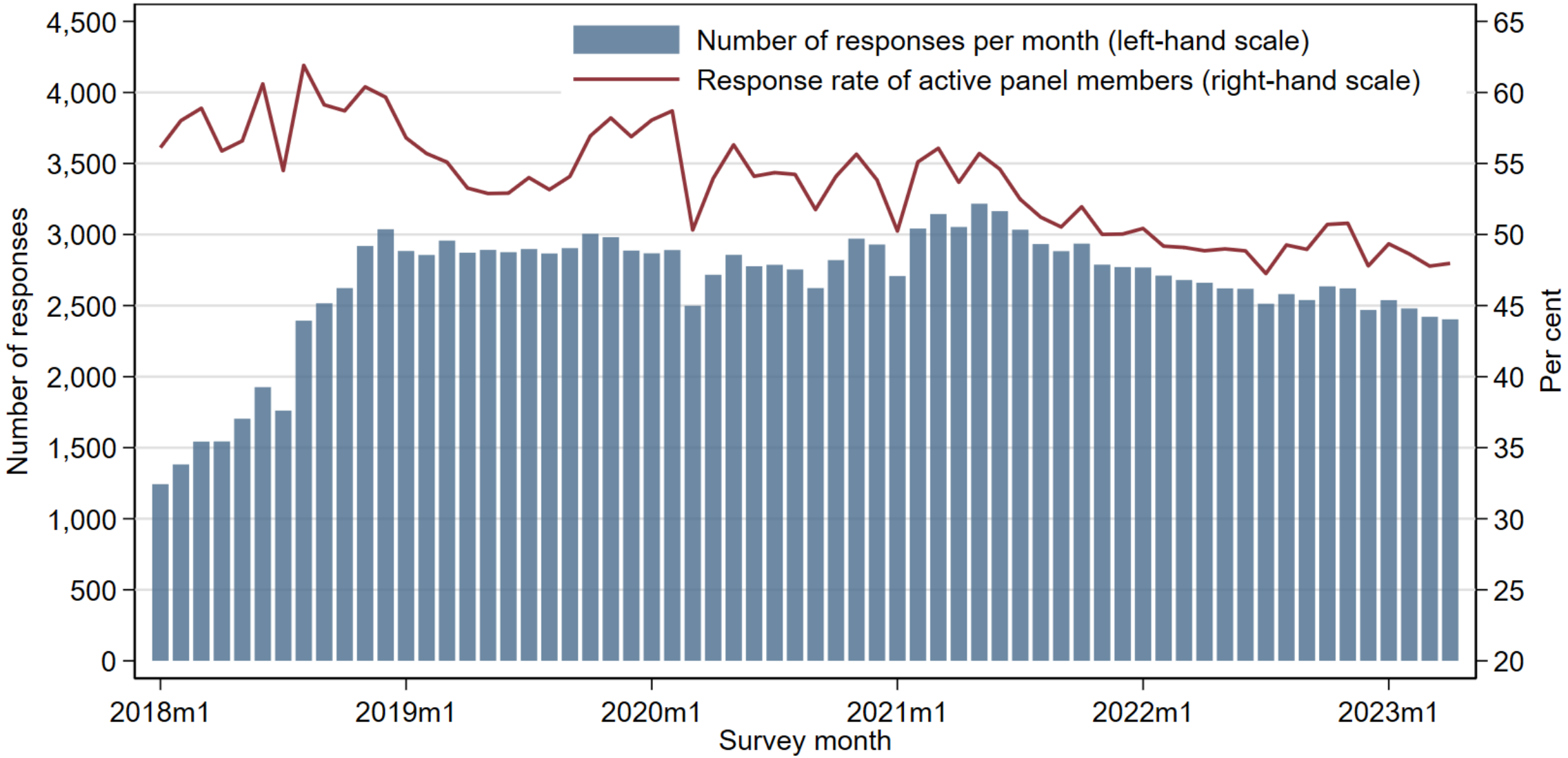
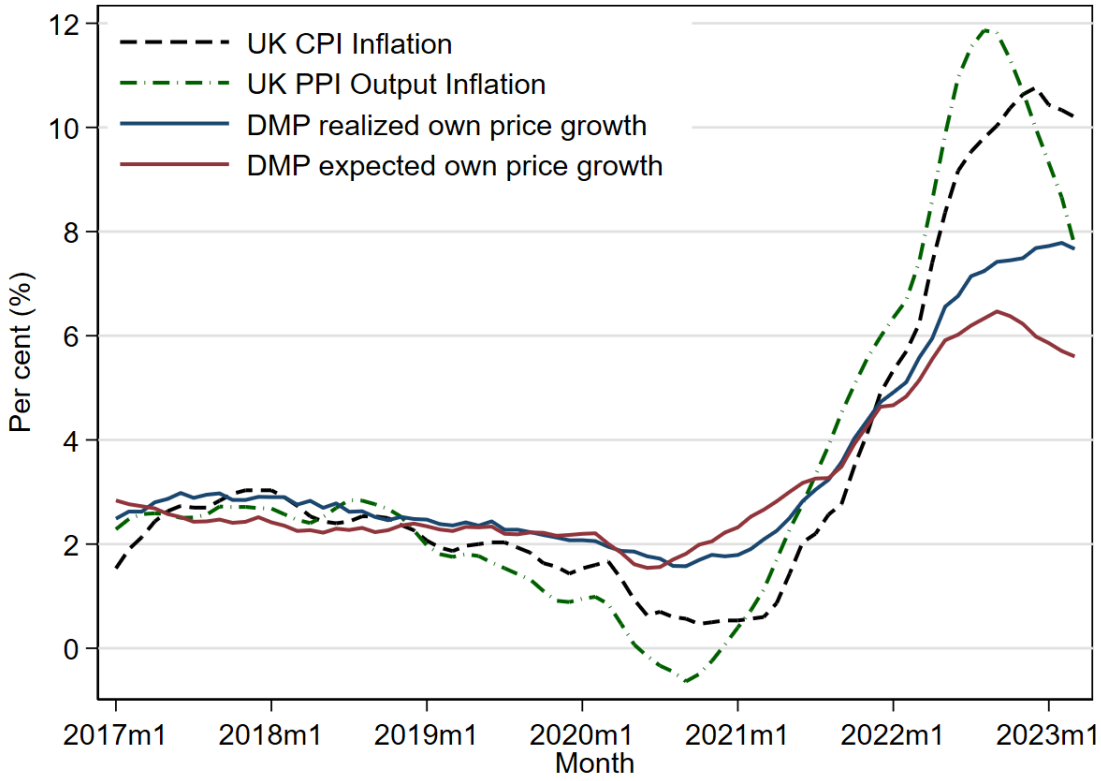
Figure 1 DMP response rate



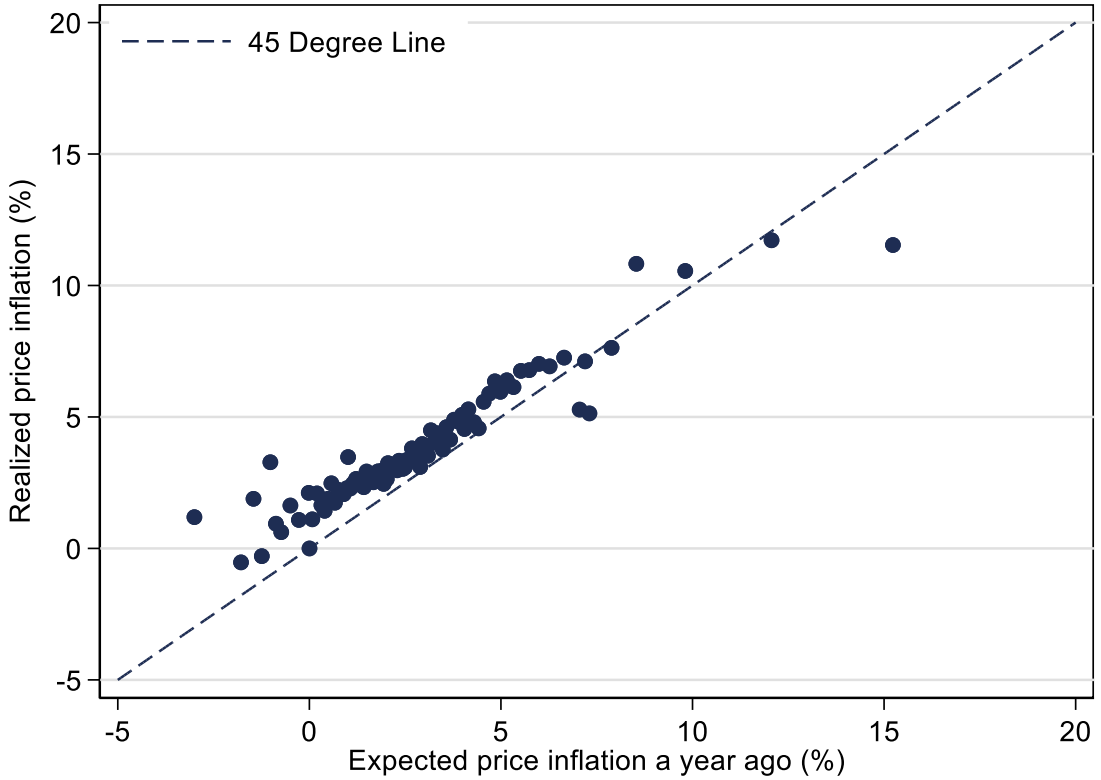
Notes: The response rate of active panel members is calculated as the percentage of panel members who had completed at least one survey over the last twelve months who responded to the survey in a given month.

Figure 2 Inflation outturns and inflation expectations

Panel A: Aggregate and firm-level price growth



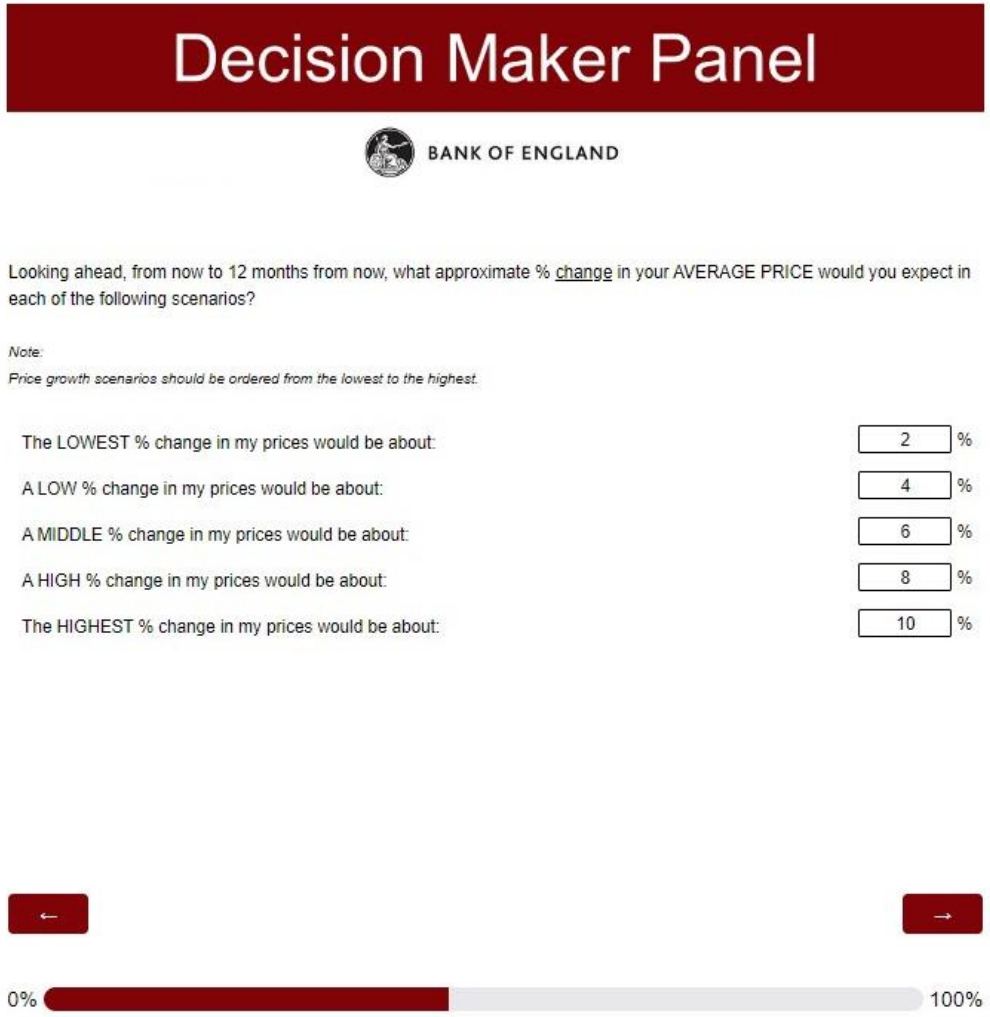
Panel B: Realized and expected price growth



Notes: In Panel A, the series for are three-month moving averages. Data on UK CPI and PPI output inflation are obtained from the Office for National Statistics. 'UK PPI output inflation' is constructed as a weighted average goods sector and services sector PPI. Panel B is a binned scatterplot, where each dot represents 1% of observations grouped along the horizontal axis. The figure in Panel B covers the period November 2017 to April 2023.

Figure 3 Expected inflation questions

Panel A: Scenarios



Panel B: Probabilities

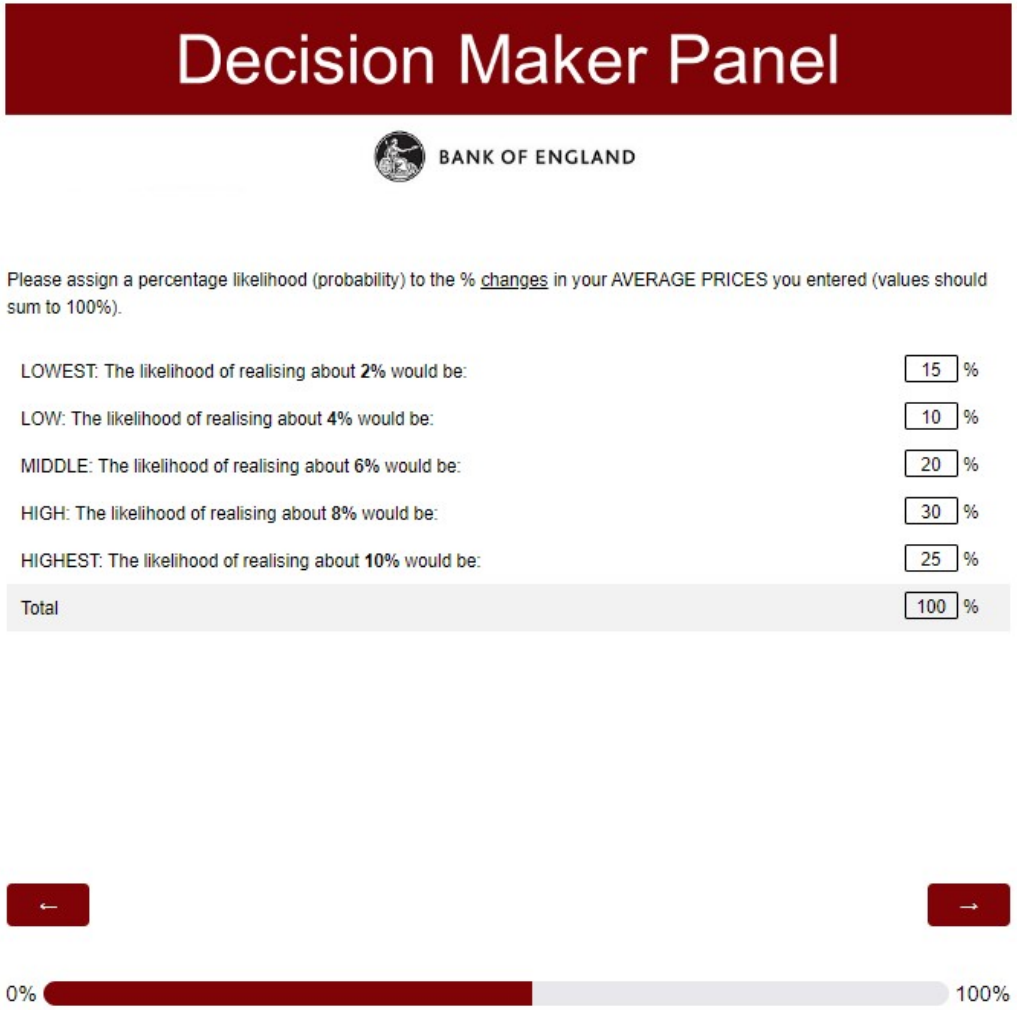
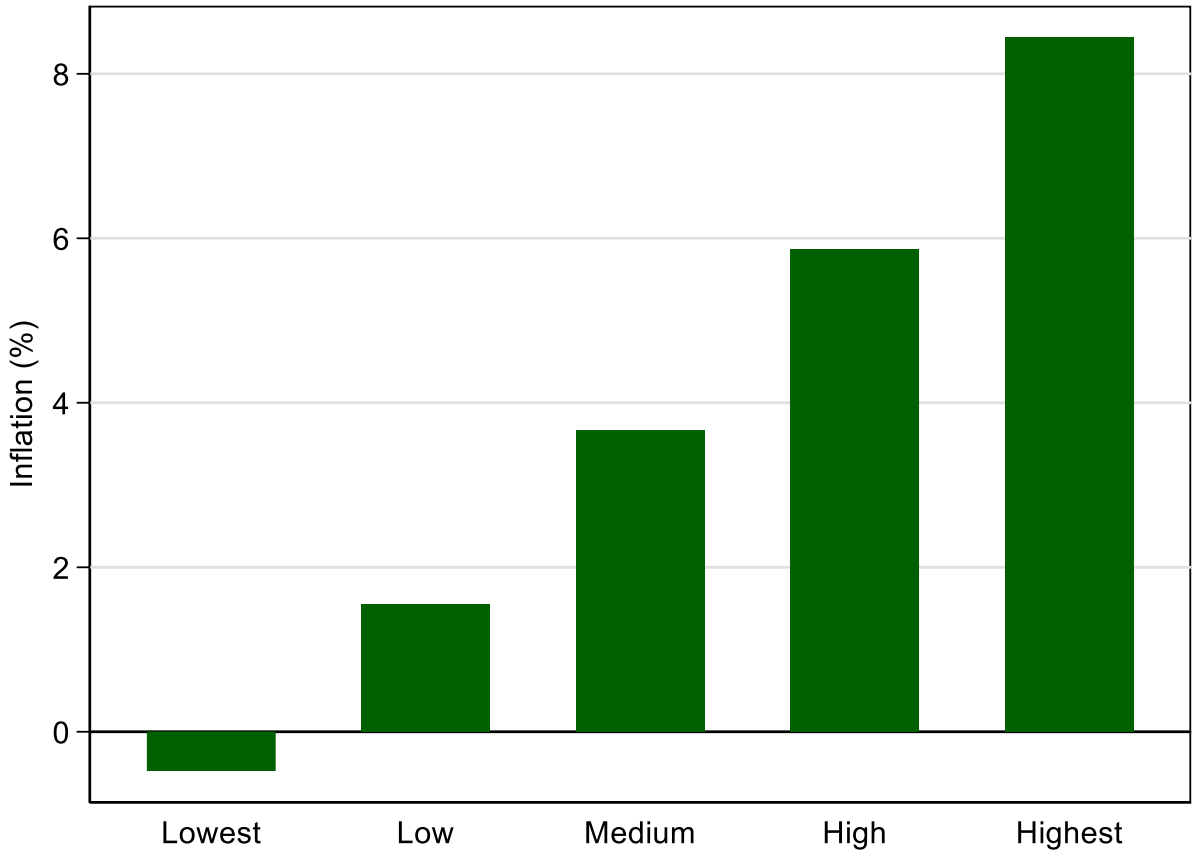
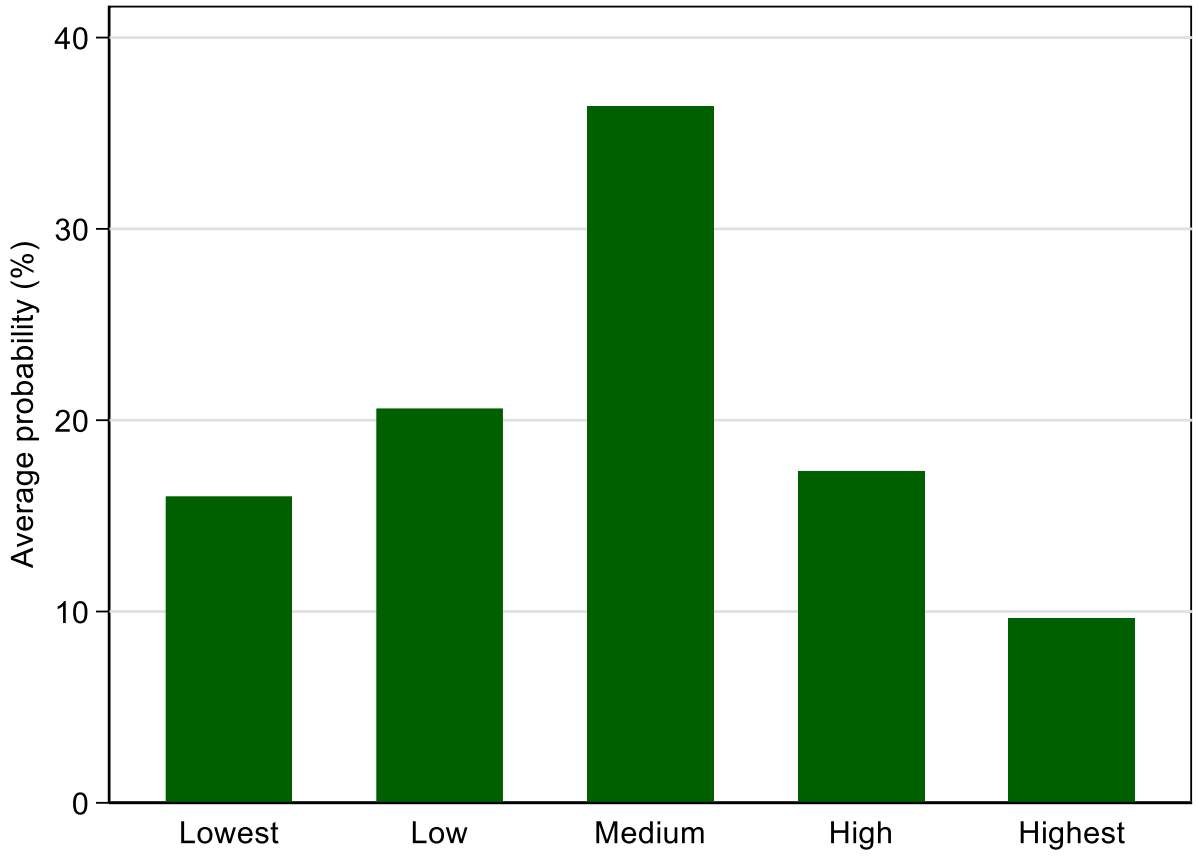


Figure 4 Average response to expected inflation questions

Panel A: Scenarios



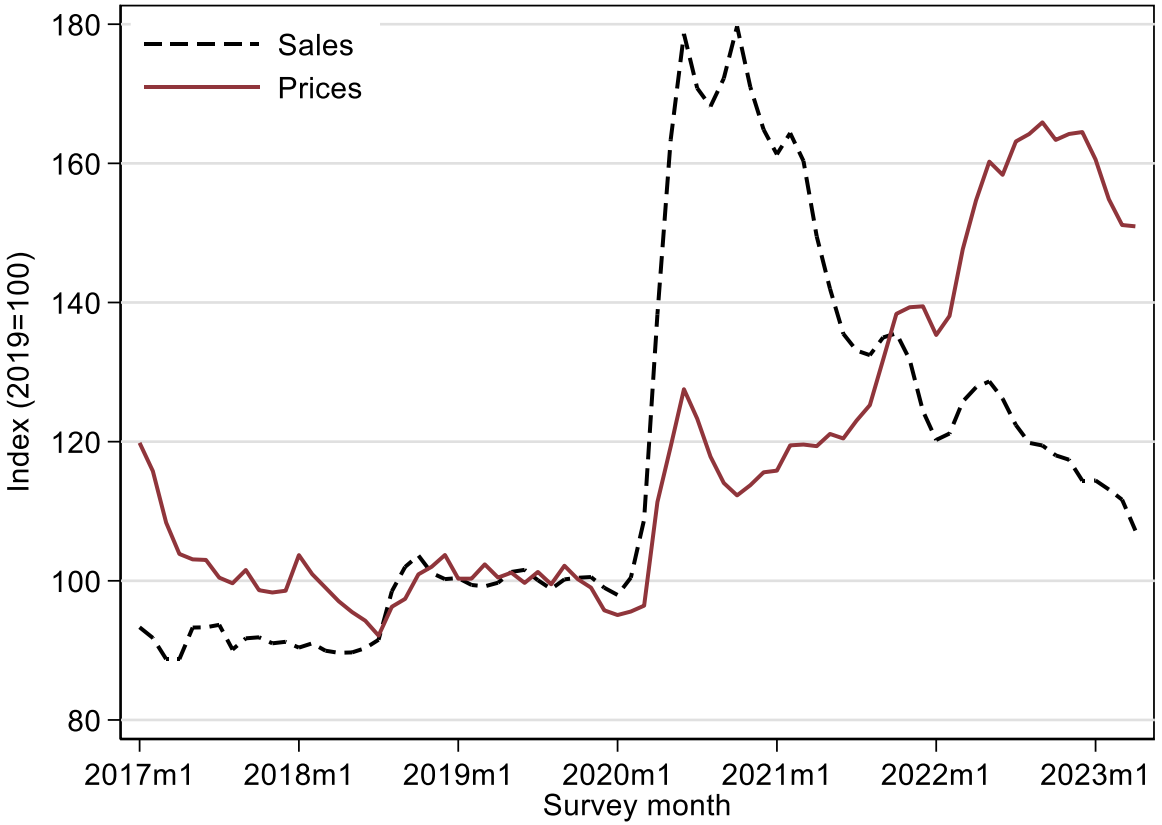
Panel B: Probabilities



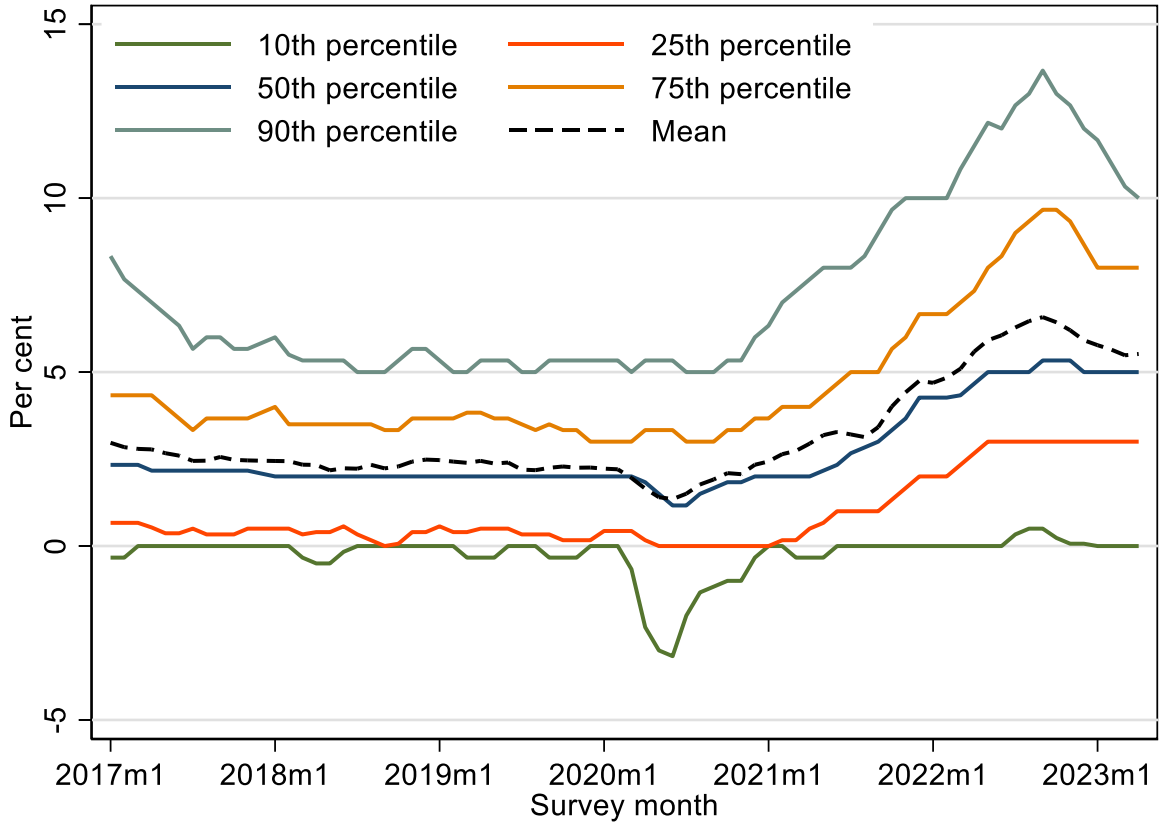
Notes: The data in Panels A and B cover the period January 2017 to April 2023.

Figure 5 Sales and inflation subjective uncertainty

Panel A: Subjective uncertainty about sales and inflation

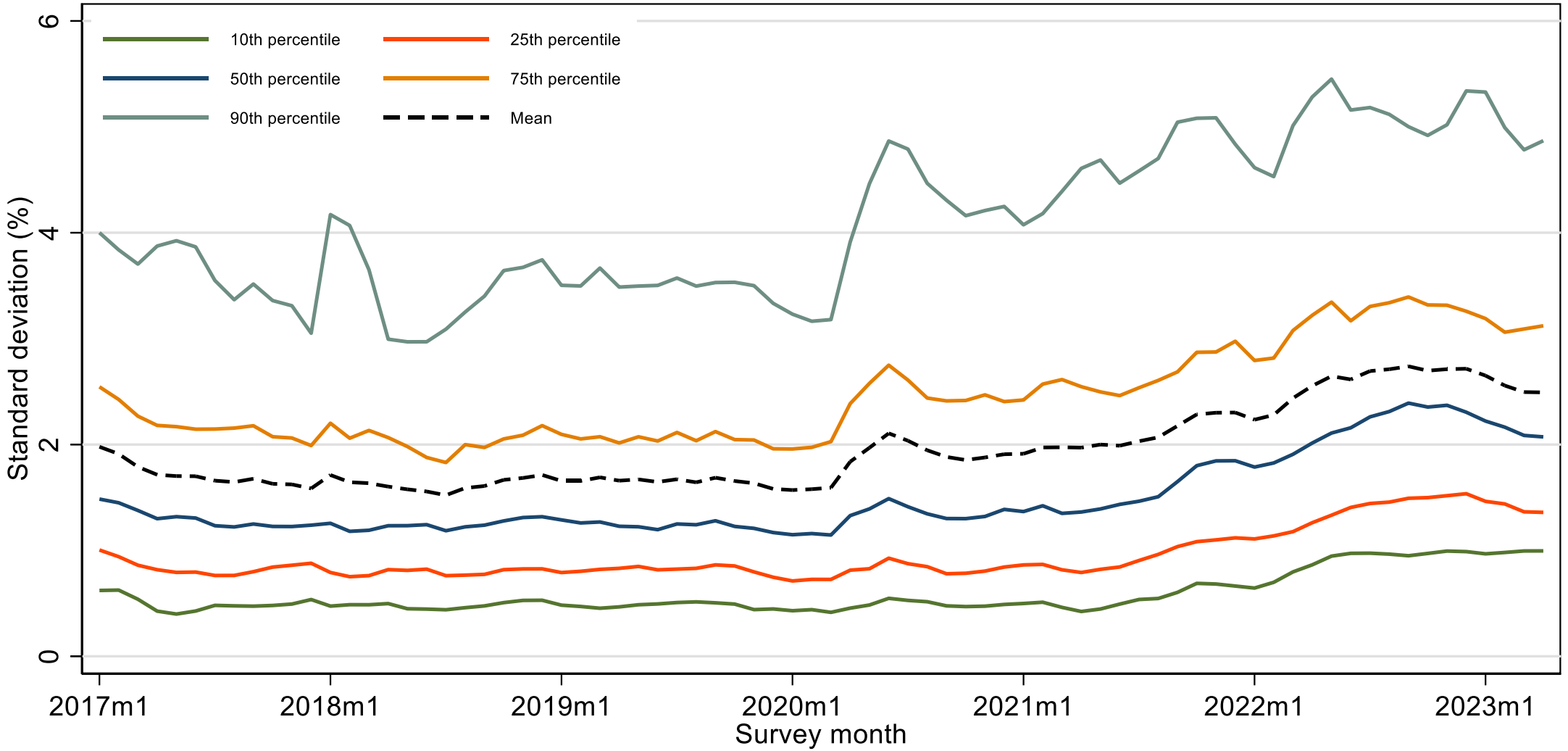


Panel B: Distribution of expected price growth



Notes: The series in Panels A and B are three-month moving averages.

Figure 6 Distribution of inflation uncertainty

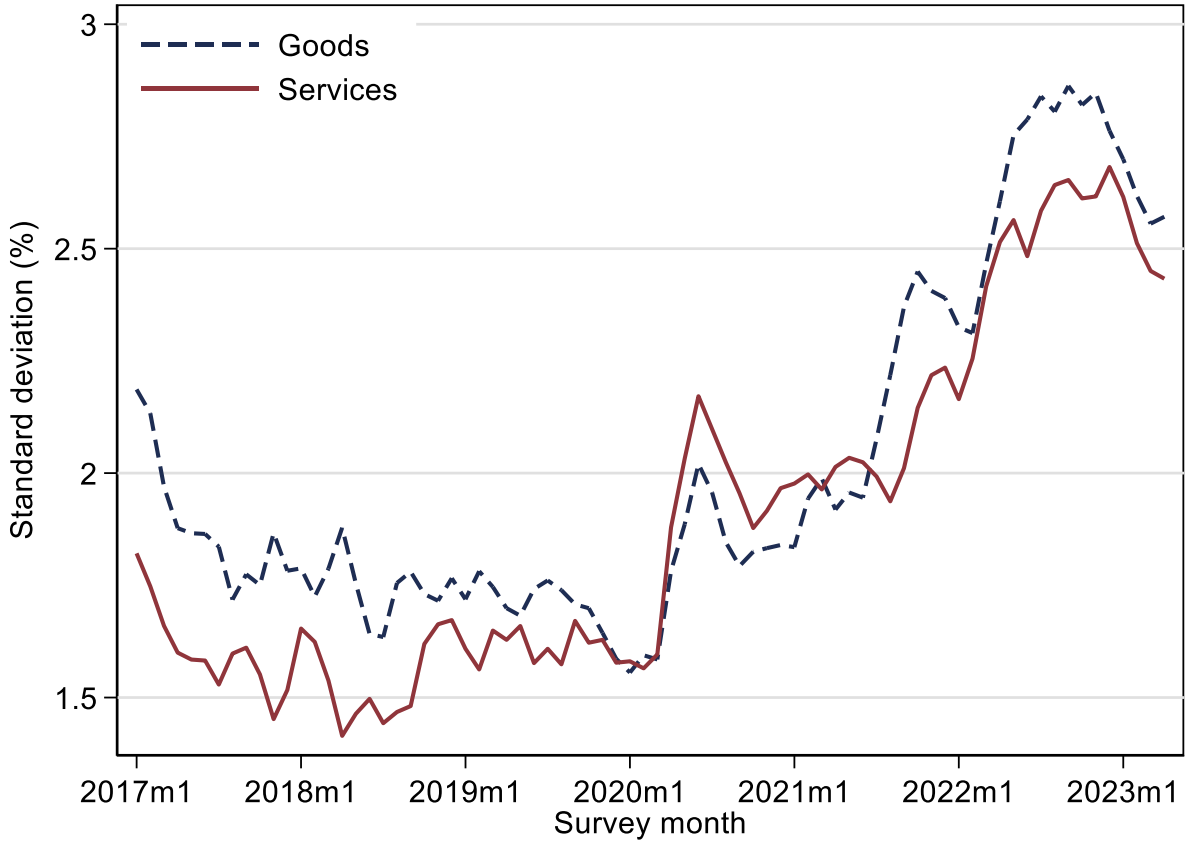


Notes: The series are three-month moving averages.

Figure 7 Cross-sectional differences in inflation uncertainty

Panel A: Inflation uncertainty by firm size

Panel B: Inflation uncertainty by goods vs. services sector firms



Notes: The series in Panels A and B are three-month moving averages.

Figure 8 Inflation uncertainty for selected industries

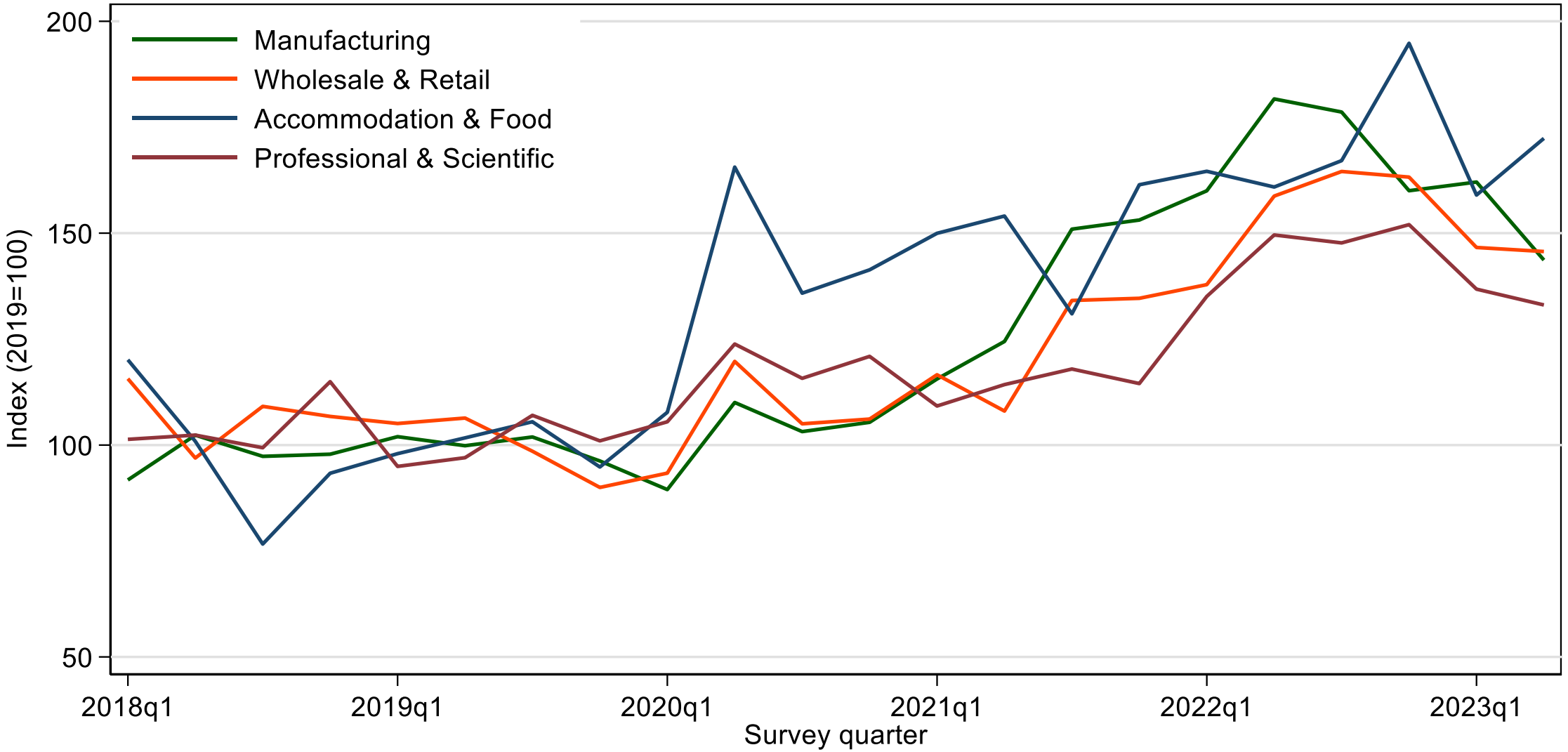
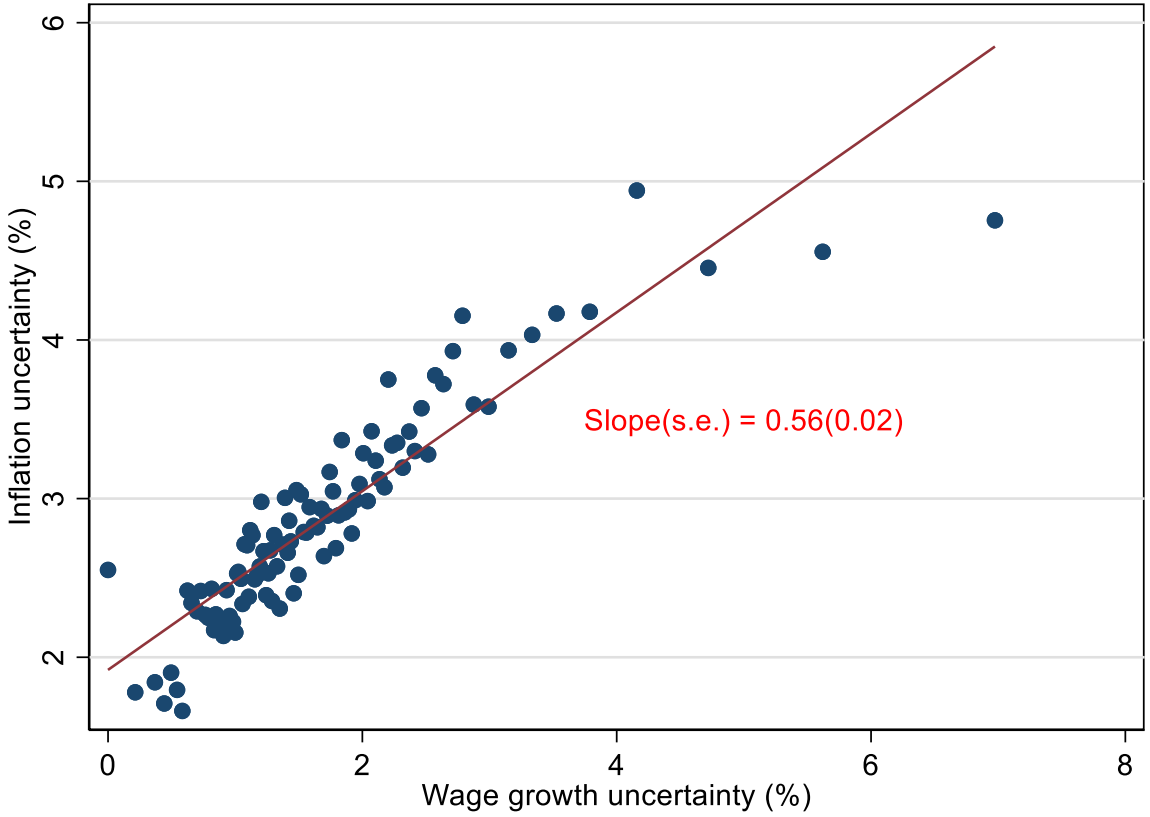
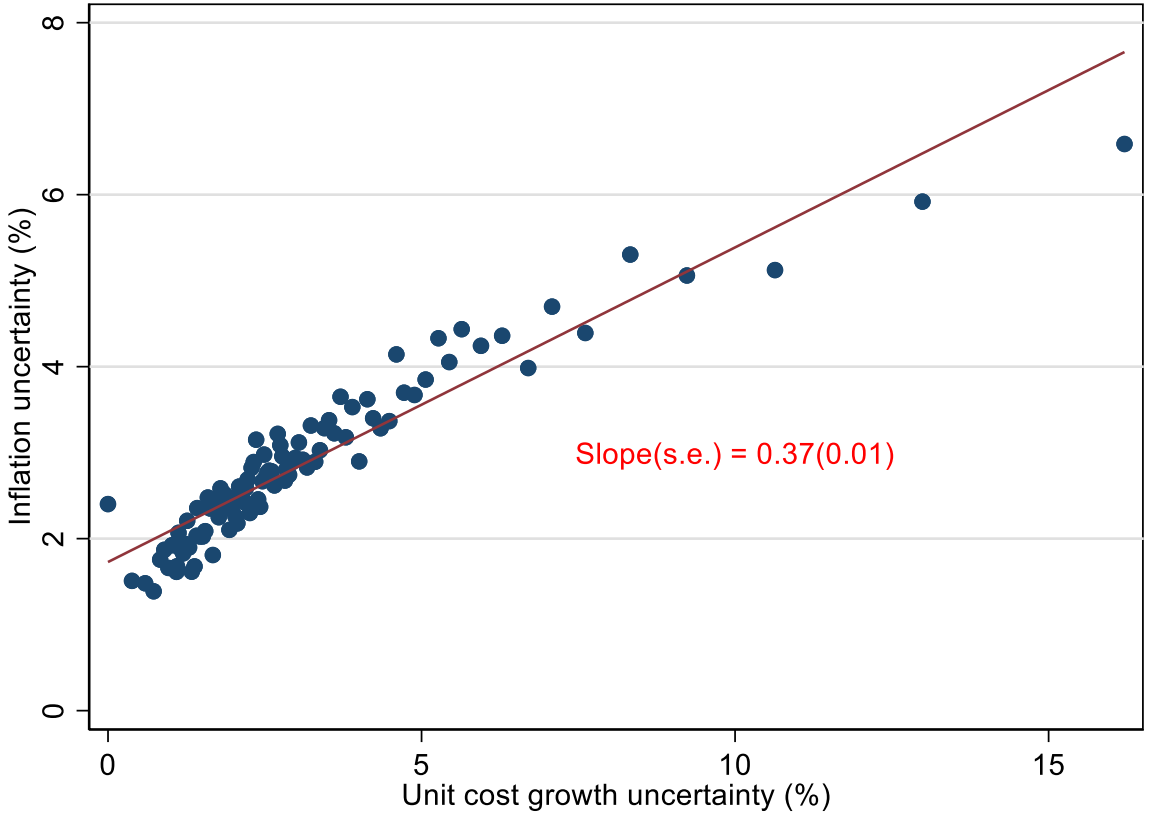


Figure 9 Inflation, unit cost, and wage subjective uncertainty

Panel A: Wage growth and inflation subjective uncertainty

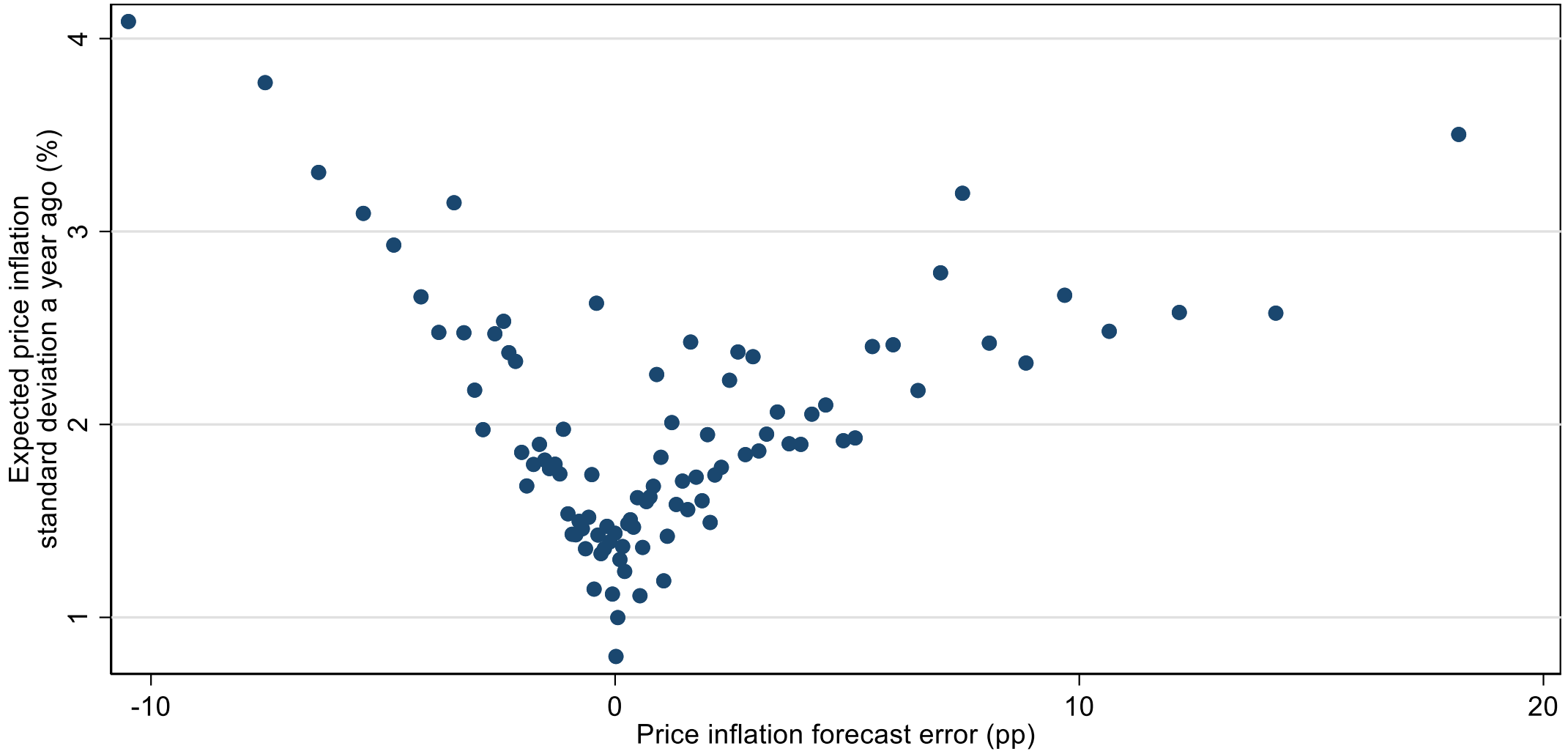


Panel B: Unit cost growth and inflation subjective uncertainty



Notes: This figure presents binned scatterplots of the relationship between wage growth uncertainty and inflation uncertainty (Panel A) and between unit cost growth and inflation uncertainty (Panel B). Each dot represents 1% of observations, clustered on the horizontal axis. The data in Panels A and B cover the period May 2022 to April 2023.

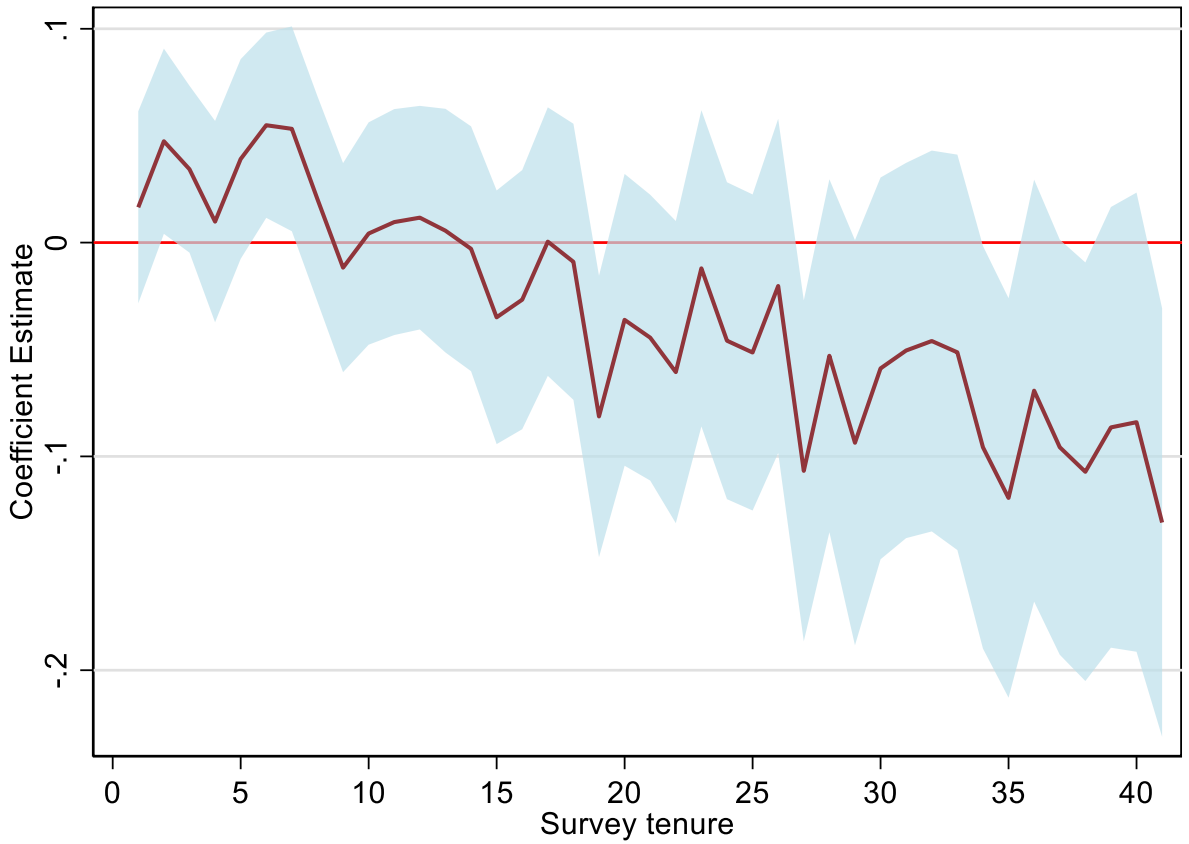
Figure 10 Inflation uncertainty and price forecast errors



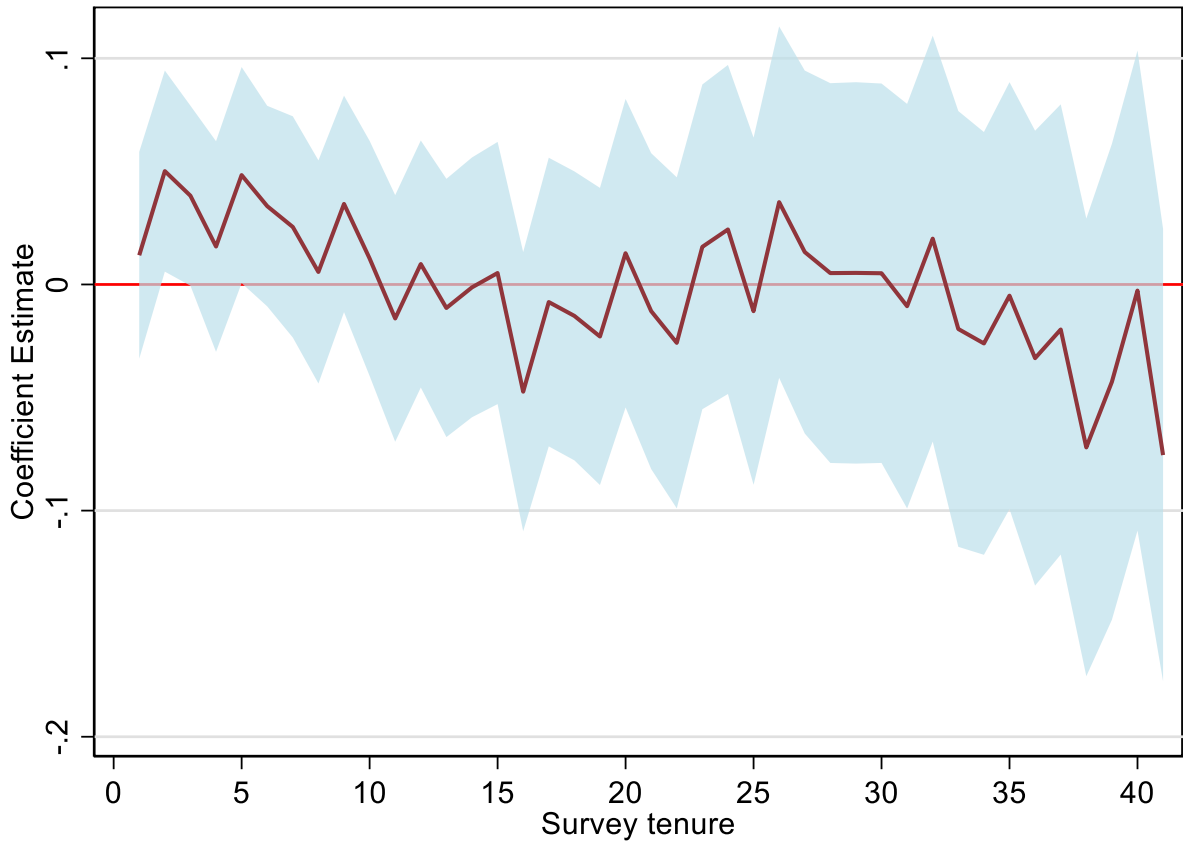
Notes: Each dot represents 1% of observations, grouped by price inflation forecast errors. The data in this figure cover the period November 2017 to April 2023.

Figure 11 Learning-through-survey effects

Panel A: Sales subjective uncertainty



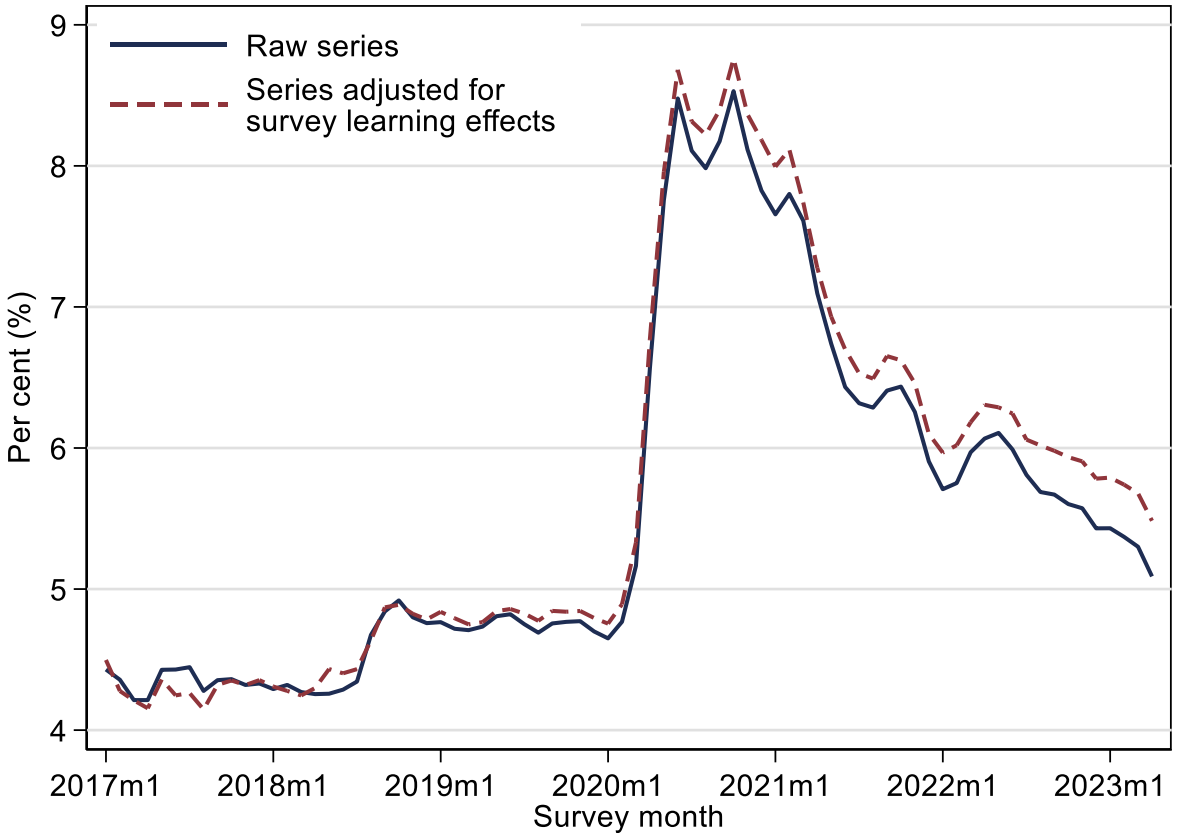
Panel B: Inflation subjective uncertainty



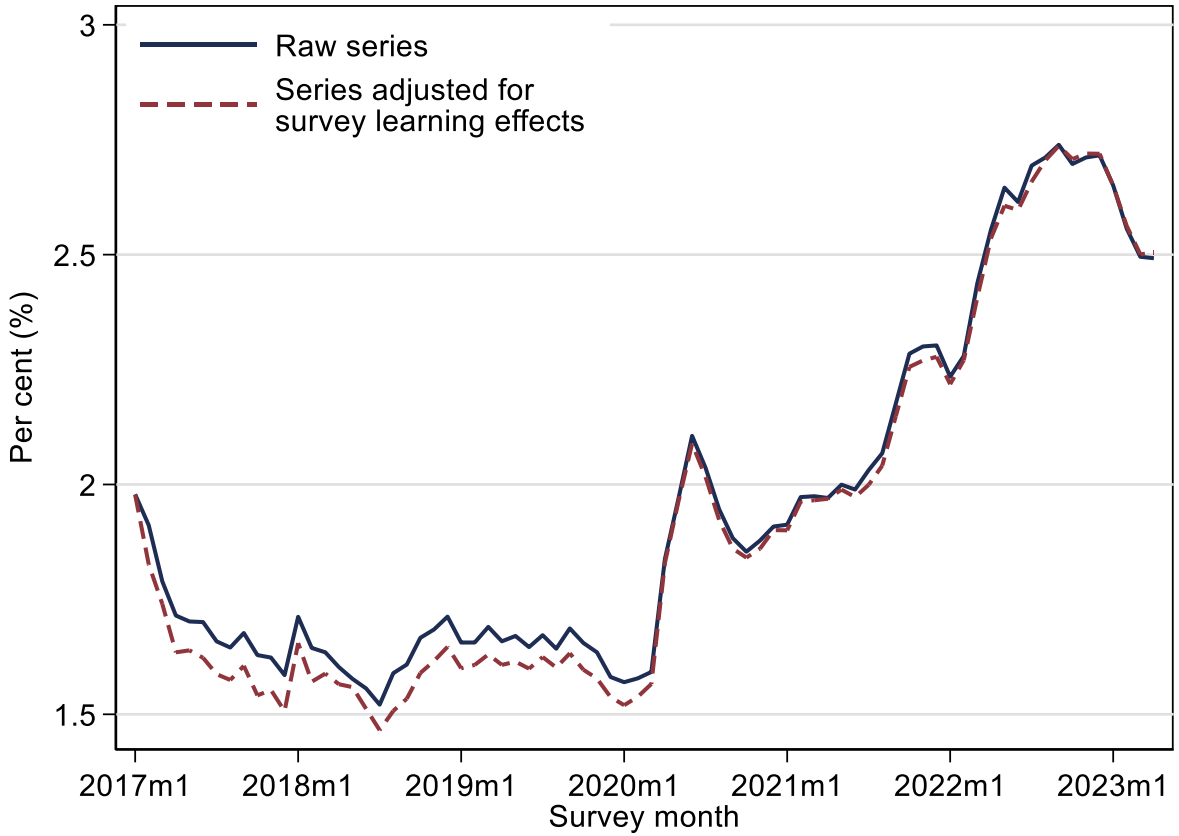
Notes: This figure presents coefficient plots of 'learning-though-survey' effects, as outlined in Equation 2. The dependent variable is the natural logarithm of sales subjective uncertainty (Panel A) and inflation subjective uncertainty (Panel B). Survey tenure is defined as the number of times a firm has responded to a survey panel with any five-bin distribution question. The data in Panels A and B cover the period November 2016 to April 2023. The regressions include firm fixed effects and month fixed effects. The shaded area denotes the 95% confidence interval, and standard errors are clustered at the firm level.

Figure 12 Raw and de-biased measures of subjective uncertainty

Panel A: Sales subjective uncertainty



Panel B: Inflation subjective uncertainty



Notes: These figures present the raw and de-biased measures of subjective uncertainty, where the latter control for 'learning-through-survey' effects. The de-biased measures are constructed from regressions of subjective uncertainty on survey tenure, firm fixed effects, and month fixed effects. Survey tenure is defined as the number of times a firm has responded to a survey panel with any five-bin distribution question. The coefficients on survey tenure are then used to construct the de-biased measures. The series in both Panels A and B are three-month moving averages.

Table 1 Regressions for forecast inflation errors

Dependent variable:	Realized price growth		Prince inflation absolute forecast error	
Sample period: January 2018 to April 2023	(1)	(2)	(3)	(4)
Expected price inflation a year ago$_{it}$	0.605***	0.263***		
	(0.0195)	(0.0248)		
Standard deviation of expected price inflation a year ago$_{it}$			0.558***	0.149***
			(0.0289)	(0.0288)
Firm fixed effects	No	Yes	No	Yes
Month fixed effects	Yes	Yes	Yes	Yes
Observations	18011	16902	18011	16902

Notes: Standard errors are clustered at the firm level and are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2 Inflation forecast errors and profits/productivity

Dependent variable:	Profit margin		Log TFP	
Sample period: 2017 to 2021 (financial years)	(1)	(2)	(3)	(4)
Price inflation absolute forecast error$_{it}$	-0.00761***		-0.00774**	
	(0.00137)		(0.00186)	
Standard deviation of expected price inflation a year ago$_{it}$		-0.00367*		-0.0101**
		(0.00135)		(0.00262)
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Observations	3509	6841	3229	6225

Notes: Driscoll–Kraay standard errors to allow for cross-sectional interdependence are reported in parentheses, clustered by firm. *** p<0.01, ** p<0.05, * p<0.1. Profit margins are defined as operating profit/sales. TFP is calculated as the residual from a production function ln(Y_{it}) = 0.63 ln (L_{it})+0.37 ln (K_{it}), normalized by five-digit industry, where Y_{it} is real value-added of firm i in year t, L is labor input (total real labor costs) and K is capital (total real fixed assets). Profit margins and TFP are annual and are calculated using accounting data from Bureau Van Dijk FAME database. Forecast errors and inflation uncertainty data are from the DMP, quarterly data are collapsed to annual averages (in financial years) and then merged with accounting data. Equations are estimated in financial years (April to March in the following calendar year).