Firms' Price, Cost and Activity Expectations: Evidence from Micro Data*

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Abstract

Firms' expectations play a central role in modern macroeconomic models, but little is known empirically about how these are formed or whether they matter for economic outcomes. Using a novel panel data set of manufacturing firms' expectations about prices and wage rates, new orders, employment and unit costs for the United Kingdom, we document a range of stylized facts about the properties of firms' expectations and their relationship with recent experience. There is wide dispersion of expectations across firms. Expected future price and wage growth are influenced by firm-specific factors but macroeconomic factors also matter. Expectations of employment and new orders are influenced by firm-specific measures of past orders while expected unit costs seem to be influenced more by firm-specific cost pressures and aggregate import prices. After controlling for a wide range of variables we find a significant connection between past expected price and wage increases and their out-turns. But there is also strong evidence that firms' expectations are clearly not rational.

JEL classification: C23; C26; E31

Key words: Firm expectations, price setting, rationality, survey data, inflation expectations

*The views expressed in this paper are solely those of the authors and should not be taken to represent the views of the Bank of England (or any of its committees) or Barclays. Tomasz's analytical contribution was completed while employed at the Bank of England. The data on individual firms used in our paper are proprietary and are obtained under licence from the Confederation of British Industry (CBI). The licensing contract permits Bank of England staff to use the data for research purposes. This work also contains statistical data from ONS which are Crown Copyright. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates. We are grateful for comments and advice from our editor Hans-Joachim Voth, two anonymous referees, Sophocles Mavroeidis, Oliver Linton and Hashem Pesaran, and participants at the conference of the European Economic Association and the International Association of Applied Econometrics in 2015.

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1 Introduction

Expectations play a central role in modern economics. The question of how to model expectations revolutionized macroeconomics in the 1970s and has, of course, been the subject of several Nobel Prizes. Expectations now play a key role in our understanding of business cycles and the design of policy institutions. The beliefs of firms are particularly important: Firms' expectations about prices and costs may affect their current pricing decisions and influence aggregate inflation dynamics. Different expectations about economic activity may lead to different outcomes today. And, by influencing these beliefs, monetary policy-makers may be able to affect the economy, an aspect of the monetary transmission mechanism that has featured heavily in the recent policy debate around the zero lower bound and the use of forward guidance policies (see, e.g., Woodford (2012)).

But, despite decades of theoretical emphasis on expectations in macroeconomics, there is still relatively little empirical evidence about what influences firms' expectations or whether these matter in reality. This is particularly important in light of the growing theoretical literature which deviates from traditional assumptions of representative agents, complete information and rational expectations in macroeconomics.[1] This empirical gap, in part, stems from data limitations. Ideally expectations need to be measured and although there is a range of well-used datasets that contain information on household and financial market expectations, data — and therefore empirical evidence — on the firm-side are much more scarce. We fill this gap using a data set on firms' expectations in manufacturing from the Confederation of British Industry (CBI) in the United Kingdom. Using this dataset, our contribution is to document a range of stylized facts about the degree of heterogeneity in firms' expectations about a range of price, cost and activity measures, the factors most correlated with these expectations, whether these matter for current outcomes and whether these expectations are rational. We thus provide a body of evidence to help inform economic theory.

To understand how firms' expectations line up with the common theoretical assumptions, we structure our analysis around three key issues: information, forward-looking behaviour and rationality. First we ask: How homogeneous are firms' beliefs and what factors can explain the variation in expectations across firms and across time? We show that there is considerable dispersion in beliefs across firms in the UK. Furthermore, there are important differences in the extent to which past outcomes are associated with price, wage, activity and cost expectations. We show that firm-specific influences are important for price and wage growth expectations. Aggregate factors also seem to matter for wage growth and,

[1] A growing literature considers non-rational expectations in macroeconomics, for example Garca-Schmidt and Woodford (2015), Gabaix (2016), Farhi and Werning (2017). Deviations from complete information include Nimark (2008) who introduces private information into firms' pricing decisions and shows how this affect aggregate inflation dynamics and Angeletos and Lian (2018) who study forward guidance policies under incomplete information.

to a lesser extent, price growth expectations. Expectations of new orders and employment are more associated with firm-specific activity measures, but cost expectations are correlated with both firm-specific cost pressure and aggregate import price growth. Given the relatively limited existing work on what determines expectations, the precise regression specification for exploring the determinants of price, wage and cost expectations is unclear. In our attempt to uncover firms' inflation expectation function, we therefore also use Bayesian Model Averaging to explore 16,384 models, and find that the aforementioned results are robust to model specification. Overall, our analysis therefore suggests important heterogeneity in the attention paid to different indicators when forming expectations about specific variables.

Secondly, we explore whether firms' expectations matter for current pricing decisions. This mechanism is at the heart of many forward-looking macro models; for example the New Keynesian Phillips Curve relates current price inflation to expected future price changes and real marginal cost. The micro-foundations of this type of Phillips Curve can be derived from several firm-price setting problems (e.g. see Roberts (1995)) and, as illustrated in the Appendix, the Rotemberg (1982) formulation delivers a pricing equation where firms' current prices are set with reference to their expectations of their own future price increases. Although our data do not allow us to estimate a Phillips Curve directly, due to lack of firm-specific marginal cost data, our firm level panel data on firms' own prices and their expectations of their own future price movements allow to test whether firm's expectations matter for their pricing decisions. We use linear regressions and Bayesian Model Averaging to show that price expectations are an important determinant of actual price setting in 99 percent of the more than 131,072 regression specification we explored.

Thirdly, we explore whether firms' expectations are rational — a central tenet of many macroeconomic models in recent decades. We show that the null hypothesis of rationality is rejected for most, if not all, of the expectations variables. Taken together, these results cast doubt on a range of the informational and behavioural assumptions typically made in macroeconomics. Our evidence therefore provides a range of motivating evidence for future theoretical developments.

Several novel features of the CBI's survey facilitate our analysis. In particular, the panel structure and the rich set of expectation and out-turn variables make the survey ideal for our purposes. These data contain expectations and outcomes for price growth, wage growth, new orders, employment and costs. A valuable and distinctive feature of the data described here is that the CBI survey describes firms' expectations of their own future circumstances and allows us to relate these to their reports of past out-turns. This allows us to explore what factors seems to matter for firms' expectations of their own

trading situation, while controlling for a range of other influences. As far as we are aware, we are the first to examine the role of firms' expectations of their own outcomes.[2] We are also able to exploit the dynamics in the data, for example, by examining whether past realizations affect expectations today and whether expectations about the future matter for current pricing decisions. Our panel approach allows us to use a range of fixed-effects and firm level controls to deal with possible confounding effects.

As noted above, the way in which expectations are formed has recently attracted much attention and we therefore contribute to this growing empirical literature. On the household side, for example, Armantier et al. (2015) conduct an experiment to shed light on how inflation expectations affect decisions made by consumers. They document that expectations about the future affect decisions today but there is a significant amount of heterogeneity. Ichiue and Nishiguchi (2013) show that during the zero lower bound episode in Japan, households that expected higher inflation in the future reported that their household had increased consumption compared with one year ago but intended to decrease it in the future. Bachmann et al. (2015) conduct a similar study using US data but do not find any significant relationship between inflation expectations and consumer spending.

Turning to work on firms, the closest paper to our work is probably Coibion et al. (2018) who collect new survey data on firms' inflation expectations for New Zealand. Their paper provides evidence against full information and rationality of firms' inflation expectations, including evidence of dispersion which seems to be related to inattention about recent macroeconomic conditions.[3] By providing some firms with information about the aggregate inflation target, the paper also shows that the associated change in beliefs did not seem materially to affect prices and wages at the firm level, but did have an effect on employment and investment. Our focus is on firm-level expectations about their own variables and we the relationship between expectations and outcomes.

Also for New Zealand, Kumar et al. (2015) document the lack of anchoring of firms' inflation expectations around the inflation target and show that firms' expectations are quite dispersed. Afrouzi (2017) develops a model of oligopolistic competition and strategic inattention and shows that this can account for several facts about firms' expectations in New Zealand, including the dispersion in inflation expectations and the disagreement between industry and aggregate level expectations. Coibion and Gorodnichenko (2015) document that survey expectations of professional forecasters, firms, households and FOMC members are heterogeneous and react sluggishly to news, in keeping with the predictions

[2] Other recent work, which we discuss below, on firms' expectations have focused on expectations of macroeconomic aggregates such as inflation, e.g. Coibion et al. (2018), Coibion and Gorodnichenko (2015) and Kumar et al. (2015) which we discuss below.

[3] They also provide evidence that inattention can be explained by firms' incentive to track different macroeconomic indicators, consistent with rational inattention models where firms pay particular attention to news in variables that matter the most.

from noisy information models. Bryan et al. (2014) use the FRB Atlanta's Business Inflation Expectations (BIE) survey of firms in the Sixth Federal Reserve District over three years. They evaluate how well these expectations compare to professional forecasters, how the content of these data compare to households' inflation expectations and how well these expectations predict future inflation. Gennaioli et al. (2016) examine how corporate investment plans and investment are well explained by CFOs expectations of earnings growth. Like our paper, they also ask whether expectations affect behaviour and whether expectations are rational. Our focus is, however, different from these existing papers: we explore a range of expectations variables, including but not limited to prices and wages, and seek to provide a range of stylized facts about the determinants of expectations and whether they matter for pricing outcomes.

In exploring the link between expectations and outcomes, our paper also connects to the large time-series literature on the New Keynesian Phillips Curve (for example, Gali and Gertler (1999), Sbordone (2002) and Sbordone (2005)). In aggregate data, price expectations of firms are not observable. Estimation hence needs to rely on the rational expectations hypothesis and the method of instrumental variables. But, in an exhaustive survey of this literature covering more than one hundred papers, Mavroedis et al. (2014) argue that the time-series literature is subject to weak instrument problems. This means that the results are not robust to even minor perturbation of the set of instruments. Unlike with macroeconomic data, we actually observe individual firm expectations of their own future price changes together with their subsequent out-turns. Conditional on fixed effects, we use Bayesian model averaging to show that price expectations are a robust determinant of actual price setting in 99 percent of the 131,072 possible combinations of our model.

The remainder of the paper proceeds in the following way: In the next section we describe the survey in more detail, discuss its reliability and describe some broad trends in firms' expectations. Section 3 then explores influences on expectations formation. The link between past price increases and expected future price increases is explored in Section 4. Finally, Section 5 evaluates the rationality of firms' expectations. Section 6 concludes.

2 The Industrial Trends Survey and its Properties

2.1 The ITS survey

Our data come from the UK's Confederation of British Industry (CBI). The CBI runs a number of surveys but the most detailed for our purpose is the the quarterly *Industrial Trends Survey* (ITS) which covers manufacturing firms. Although the full survey began in 1958, it was only in 2008 that the

survey started to collect quantitative rather than purely qualitative data on past and expected future price movements. Our sample period is therefore from 2008Q3 to 2016Q3[4], although some variables are only available for part of the sample.[5]

As noted above, one of the advantages of ITS is its panel structure. We have eight years of quarterly data and, in principle, the cross-section dimension is large with around four to five hundred firms. That said, there is variation in the frequency for firms' responses and not all firms appear in the survey every quarter. Figure 1a shows the distribution of the maximum number of consecutive quarters each firm is observed. There is a sizable number of firms for which we observe data for a few consecutive quarters and the panel is therefore unbalanced.[6] Moreover, as figure 1b shows, the response pattern of large firms (those reporting at least two hundred employees in their first return) is not very different from that of small firms (those reporting fewer than two hundred employees in their first return). A slightly higher proportion of large firms, however, responds to the survey only once.

For both large and small firms, the number of exits and re-entrants is large relative to the sample size (there are periods of substantial, although often temporary, non-response by firms). In large part, the reason for this is that the ITS is intended to provide a rapid snap-shot of the state of the economy. Therefore, late respondents are only followed up within a set time frame after the official closing date of the survey. That time period usually amounts to one or two days.

The nature of the data therefore places two restrictions on our analysis. First, to exploit the panel structure of our data, we restrict attention to firms who appear for four or more consecutive quarters.[7] Secondly, there is an inconsistency in the time horizon for different variables. The data are quarterly but some variables refer to three month changes and others to twelve month changes (this is particularly true of the wage and price data). In order to avoid the risk of spurious results generated by serial correlation, we limit our analysis of the twelve-month variables to periods which do not overlap. Taken together, these factors mean that the number of usable observations per firm is somewhat smaller than would be the case were a complete quarterly panel available.

We start by noting that, as is implicit above, the survey asks businesses to report the number of employees in one of nine categories [8]. The categorical nature of these data limits their use in estimation,

[4]Very few data were collected in 2008 Q1 or 2008 Q2 so for practical purposes our data begin in 2008Q3.

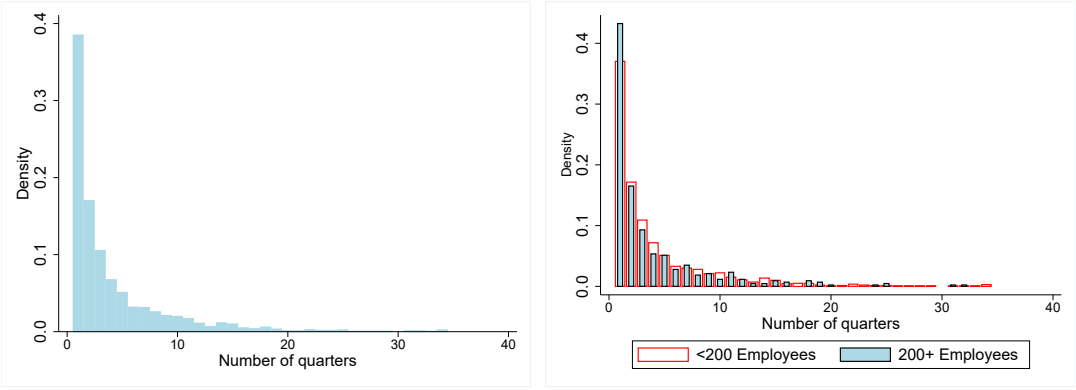
[5]Data on output relative to capacity are, for example, available only from 2011Q1. Similarly, although the qualitative data on new orders, employment and costs have been collected for many years, they are available on a basis coherent with the data on price and wage expectations only from 2011Q1.

[6]Over the twenty-six quarters between 2008 and 2016 (for the price growth expectations variable) the average number of quarterly returns from each respondent is 7.5 but the median is 4. Out of the 1919 firms which reply to the survey over this period, only four firms provide complete records for the full sample period.

[7]We view the choice of four quarters as a reasonable trade-off. A larger number will limit the sample size, but with fewer we will not be able to exploit the panel fully.

[8]0-49, 50-99, 100-199, 200-249, 250-499, 500-999,1000-1999,2000-4999 and 5000+ employees

Figure 1: The Distribution of the Maximum Number of Consecutive Observations



(a) All Respondents (b) By Size of Firm when first observed

Source: CBI data
Notes: The figure shows the distribution of the maximal number of consecutive observations we observe for each firm.

but they allow us to compare the size structure of our sample with that of the manufacturing sector as a whole.

The survey responses of which we make use are as follows:

Prices and Wages: Given the attention paid to inflation and wage expectations in modern macroeconomic theory, we are particularly interested in the quantitative measures of firms' expected and actual price and wage changes. The panel element to these questions is one of the most interesting aspects of this survey. But, the survey also contains useful information about firms' perceptions of price and wage changes over the past year. The key questions about prices are:

- What has been the percentage change over the past 12 months in your firm's own average output price for goods sold into UK markets?
- What is expected to occur over the next 12 months?

Similar questions are asked about wages:

- What has been the percentage change over the past 12 months in your firm's wage/salary cost per person employed (including overtime and bonuses)?
- What is expected to occur over the next 12 months?

Firms can answer the price questions by choosing one of ten buckets covering the range -10% to 10%, by answering zero or by entering their own answer manually. This gives a good degree of granularity.[9]

[9]Specifically, the buckets are −8.1 to −10%; −6.1 to −8%; −4.1 to −6%; −2.1 to −4%; −0.1 to −2%; no change; 0.1

Respondents to the wage question are given a choice of eleven buckets [10] Manual answers largely still fall within these ranges and to harmonize the reporting, we assign each manual answer to its corresponding bucket. If the manual answers lie outside the bucket ranges, they are allocated to the largest bucket on either side.[11]

In addition to the data on expected and past changes in wages and prices, the survey collects a range of qualitative information about the past and near future. Four topics in particular are of interest here.

New Orders: Excluding seasonal variations, what has been the trend over the last three months (expected trends for the next three months) with regard to the volume of new orders?

Employment: Excluding seasonal variations, what has been the trend over the last three months (expected trends for the next three months) with regard to the volume of employment?

Unit Costs: Excluding seasonal variations, what has been the trend over the last three months (expected trends for the next three months) with regard to costs per unit of output?

In contrast to the questions on wages and prices, the responses to the questions on new orders, employment and unit costs are qualitative. Respondents answer "Down", "No change" or "Up". As noted earlier, these questions relate to periods of three months rather than periods of a year (the case for the price and wage variables). These quarterly data therefore do not refer to overlapping periods.

We also make use of a question the survey asks on capacity:

Capacity utilisation: What is your current rate of operation as a percentage of full capacity? The response to this is quantitative.

Other questions: Finally we should record that the survey asks a range of questions on topics such as investment intentions and business confidence which we do not explore in this paper.

to 2%; 2.1 to 4%; 4.1 to 6%; 6.1 to 8% and 8.1 to 10%.

[10] With ranges −2% to −1.1%; −1% to −0.1%; 0%; 0.1% to 1%; 1.1% to 2%; 2.1% to 3%; 3.1% to 4%; 4.1% to 5%; 5.1% to 6%; 6.1% to 7% and 7.1% to 8%.

[11] This does not affect our results as fewer than 1% of all answers are entered manually.

2.2 A first look at the data

We begin by presenting summary statistics for the variables we study. Table 1 shows the mean and standard deviation of the continuous variables collected in the survey together with the relevant macroeconomic variables we use. Table 2 then shows the proportion of responses in each category for the discrete variables. It is noticeable that firms report, on average, slightly lower rates of price increase than measured by the output price indices for manufacturing as a whole. In contrast, expected and past wage growth are both close to each other and close to the rate of growth of Average Weekly Earnings (AWE), the official measure of aggregate wages. For the discrete variables, we can see that, when describing past experience, more firms report rises or falls than they did in expectation. This is entirely consistent with outturns being subject to shocks not anticipated when expectations were formed. The effect is particularly marked for growth in new orders. We will return to the issue of forecast errors when we look at the rationality of firms' expectations.

Table 1: Summary Statistics for Continuous Variables % p.a.

Variable name	**Mean**	**S.D.**	**N**
Survey variables			
Expected price growth	1.01	2.53	2,163
Expected wage growth	1.96	1.30	2,179
Past price growth	0.80	3.00	2,179
Past wage growth	1.97	1.45	2,176
Rate of operation (%)	79.43	16.17	2,179
Macroeconomic and industry-level variables			
Output price growth (2-digit)	1.22	2.78	
BoE *Inflation Report* inflation forecast	1.96	0.61	
BoE *Inflation Report* growth forecast	2.43	0.43	
Consumer Price Index inflation	1.95	1.54	
Average Weekly Earnings growth	1.80	0.86	

Source: CBI and ONS data
Notes: The Table reports mean, standard deviation and number of observations for the continuous variables used in our analysis. Wage and price growth rates are shown over four quarters.

Table 2: Summary Statistics for Categorical Survey Variables

Variable name	**Fall**	**No Change**	**Rise**	**N**
Expected new orders growth	19.3%	55.5%	25.2%	2,179
Expected employment growth	13.9%	67.4%	18.7%	2,179
Expected unit cost growth	9.1%	67.0%	23.9%	2,179
Past new orders growth	30.1%	40.4%	29.5%	2,179
Past employment growth	16.8%	59.5%	23.7%	2,179
Past unit cost growth	10.0%	64.5%	25.5%	2,179

Source: CBI data
Notes: The Table reports the percentage of fall, no change and rise for the categorical survey variables used in our analysis.

Table 3 shows the correlations between the survey variables, both continuous and categorical. We use polyserial correlations between continuous and discrete variables and polychoric correlations between pairs of discrete variables (Olsson (1979)). There are strong correlations (± 0.4 or greater)between past and expected future price increases, and between past and expected future increases in wage rates and unit costs. There is also a clear correlation between movements in employment and new orders, both past and future, as might be expected. The rate of operation is also negatively correlated with the below-capacity working as are past changes in the volume of new orders.

Lower, but still material correlations, in the range of ± 0.3 to ± 0.39 are found between expected movements in costs and expected movements in firm prices, and also between expected movements in employment and expected movements in wages. Past cost increases are correlated with expected movements in prices and with past price movements. There is also an element of persistence in employment growth. Finally past increases in sales volume are correlated with a higher rate of operation, and firms with past employment growth are less likely to report below-capacity working. These correlations are interesting

Table 3: Correlations between Survey Variables

	Exp. price growth	Exp. wage growth	Exp. cost growth	Exp. empl. growth	Exp. orders growth
Variable type	C	C	Q	Q	Q
Exp. wage growth	0.25				
Exp. cost growth	**0.35**	0.12			
Exp. empl. Growth	0.19	**0.32**	0.03		
Exp. orders growth	0.14	0.23	-0.02	**0.47**	
Past price growth	**0.58**	0.2	0.24	0.14	0.06
Past wage growth	0.13	**0.53**	0.03	0.16	0.1
Past cost growth	**0.33**	0.12	**0.61**	0	-0.01
Past empl. Growth	0.19	**0.3**	0.07	**0.37**	0.24
Past orders growth	0.2	0.29	0	**0.4**	**0.43**
Rate of operation	0.09	0.19	0.02	0.17	0.12

	Past price growth	Past wage growth	Past cost growth	Past empl. growth	Past orders growth
Variable type	C	C	Q	Q	Q
Past wage growth	0.2				
Past cost rise	**0.31**	0.05			
Past employment rise	0.15	0.26	0.06		
Past orders rise	0.13	0.16	-0.04	**0.49**	
Rate of operation (C)	0.09	0.19	0.01	0.26	**0.32**

Source: CBI and ONS data

Notes: The table shows correlations between the variables used from the Industrial Trends Survey with correlations of at least ±0.3 in bold. Variables treated as continuous are marked (C) and qualitative variables (Q). The table shows Pearson correlations between variables when both are continuous, polyserial correlations when one is continuous and the other qualitative and polychoric correlations between qualitative variables. The correlations are estimated only for observations at least four quarters apart in order to avoid the risk of spurious correlation for those variables which relate to one year in the past or future. All correlations are estimated from the same sample.

and seem consistent with common theoretical views that activity measures are likely to be correlated with the rate of operation and the output gap. They do not, however, show material connections between the rate of operation (capacity utilisation) and expectations of price increases.

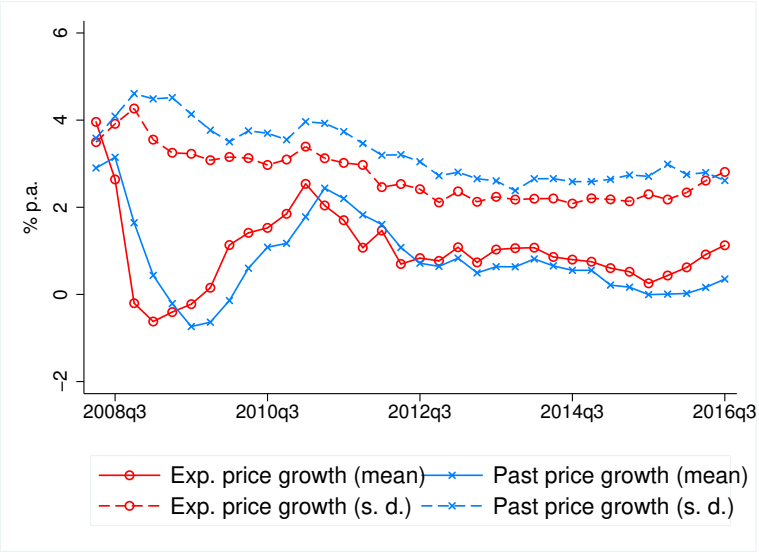
Overall, these correlations reveal several important facts about data. It is noteworthy that even in the absence of any more sophisticated econometric analysis, the correlations are strongest where intuition and theory suggest they should be, such as between price expected price growth and past price growth. Indeed, the strength of these 'raw' correlations is likely responsible for the robustness of the econometric results we present later on in this paper.

2.3 The distribution of price and wage growth expectations

Of course, an interesting feature of microeconomic data, missing from macroeconomic aggregates and simple descriptive statistics, is the heterogeneity in the individual data. In fact, there is significant dispersion in firms' expectations and perceptions of price growth. Figure 2 shows the standard deviation of expected and past firm price growth in the ITS. The means of these series are reported again for reference. It is interesting that the degree of dispersion is relatively stable over time, despite the aggregate fluctuations in inflation and the large movements in average expectations and actual price growth during the recession period, which is consistent with empirical findings for the US reported by Nakamura et al. (2018). But, to explore the dispersion further, figures 3a and 3b show the distribution of expected price and wage growth in the ITS. Most of the responses are between 0 and 5 percent, which seems very reasonable given the medium-term inflation target of 2 percent and the shorter-term variation in inflation observed over this period. There are however, a sizable minority of price responses outside this range, both negative and positive, and there is clear evidence of clustering at zero. Very few firms, however, expect the wages that they pay to fall.

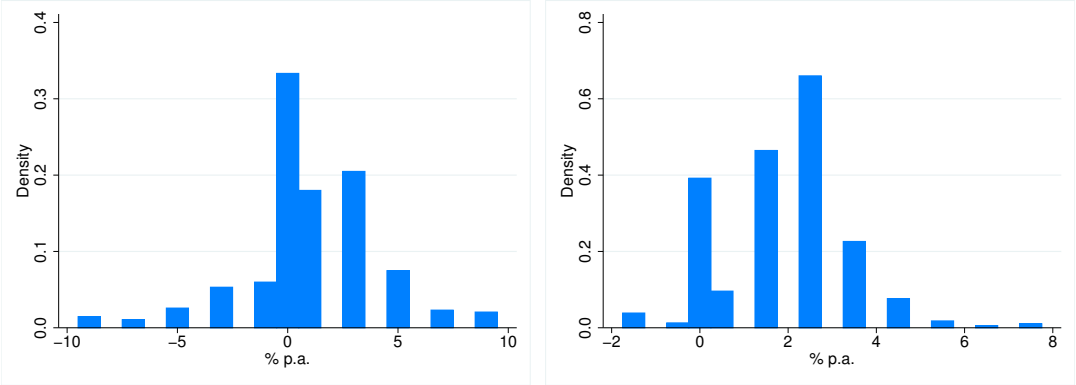
This variation does not necessarily mean that the dispersion is noise or error, but instead that there are likely to be genuine reasons for why firms' price movements differ (different firm level shocks, different markets etc). Bryan et al. (2014), Kumar et al. (2015) and Afrouzi (2017) also provide evidence of dispersion in firms' inflation expectations, and this also seems to be the case for UK manufacturing firms'. Coibion et al. (2018) identify inattention to recent conditions as a primary source of differences in expectations.

Figure 2: Cross-section Averages and Standard Deviations of Expected and Perceived Past Price Growth



Source: CBI data

Figure 3: The Distribution of Expected Price and Wage Growth



(a) Expected Price Growth (b) Expected Wage Growth

Source: CBI data

2.4 A comparison with other manufacturing data

Before proceeding with any formal analysis, it is useful to provide some preliminary evidence regarding the reliability and representativeness of the data. We do this in three parts. First we show that, while the ITS survey reports disproportionately on large firms, in terms of regional and sectoral coverage it is reasonably representative of the sector. Secondly, we show that the aggregated survey data on prices and wages line-up with aggregate time-series trends from official statistics. Thirdly, we examine a number of specific features of the survey.

2.4.1 How representative is the ITS survey for the UK manufacturing sector?

As with many non-statutory surveys, the respondents are drawn from a range of trade directories and related databases. They are not limited to members of the CBI. But of course participation is voluntary, and an important question is therefore how far the CBI survey is representative of manufacturing firms in the UK. As noted earlier, the panel dimension is somewhat unbalanced and the survey is intended to be a snap-shot of the economy each quarter. It is possible that these features might bias our results. In this section we explore this further. Overall, we find that, relative to the Government's Business Statistics Database, the sampling frame for official surveys, the data are broadly reflective of the actual distribution of UK manufacturing firms by sector and the overall economy by geography.

Tables 4 to 6 show how the sample[12] of firms in the CBI survey compares with the distribution of enterprises in the UK economy as a whole. As can be seen from Table 4, the ITS has very good coverage across different sized firms. The survey does, however, have an over-representation of large enterprises but this feature, of course, ensures that a relatively small sample can cover a fairly large proportion of the economy and, to the extent that the experiences of large firms are different from those of small firms, is likely to enhance the ability of the survey to represent the circumstances of the economy as a whole. In the last column of table 4 we show the proportion of people employed across firms in different size categories. While it is true that small firms are under-represented relative to their number in the economy in the ITS, they are, in fact, over-represented relative to their importance as employers. Table 5 considers the subcomponents of manufacturing. We can see that there is some broad consistency between the ITS and there is good coverage across sectors. That said, it is inevitable that some sectors are over-represented and others are under-represented.

[12]The statistics for the CBI survey are calculated from the distribution of those observations used in our statistical analysis. These are a subset of the full set of responses. The distribution was not, however, materially different when the full set of responses was considered. The data for the UK economy are the averages of the relevant shares for each year from 2008 to 2016 and are derived from the Business Statistics Database. Secure access is provided to this by the Office of National Statistics for approved researchers.

Another dimension of interest is whether the ITS is representative geographically. The regional distribution, shown in table 6 is close to that of the economy as a whole[13], although the South-East and East Anglia are somewhat under-represented (with the other regions then over-represented).

The tables in this section reassure us that the ITS provides good coverage across size, region and subsector. That said, there are some under- and over-representation, particularly with respect to smaller firms as one might expect. When we want to compare the survey with aggregate data it is helpful to adjust for the fact that the sample is not fully representative. We do that on the basis of the composition by industrial subsector as shown in Table 5, reweighting by employment as described in Appendix B. These reweighted data are used to construct figures 4 and 5.

Otherwise we treat each respondent equally in our analysis so as to build up a picture of average firm behaviour. This is in line with our focus on testing the hypotheses of efficient information processing, rationality and forward-looking behaviour at the firm level in this paper.

[13] A small number of firms in the Business Statistics Database are not classified to a region.

Table 4: The Distribution of Enterprises by Number of Employees

	CBI survey	UK economy	Employment
1-199	78.48%	99.01%	53.66%
200-499	12.48%	0.67%	12.86%
500-4999	8.03%	0.30%	22.50%
5000+	1.01%	0.02%	10.97%

Source: CBI and ONS data.
*N*otes: The first two columns show the distribution of the number of firms classified by employment in the CBI survey and the British economy. The third column shows the proportion of people employed in firms in each size category.

Table 5: The Distribution of Enterprises by Broad SIC

	Food Drink Tobacco	Textiles Clothing	Wood Paper Printing	Chemicals etc	Metals Computers Electrical	Machinery Transport	Other Manuf.
2-digit SIC	10-12	13-15	16-18	19-23	24-27	28-30	31-33
CBI Survey	6.5%	7.6%	8.5%	19.8%	30.7%	21.1%	5.9%
UK Economy	6.0%	7.0%	18.5%	10.0%	28.7%	10.5%	19.3%
Employment	15.4%	4.3%	10.5%	16.9%	23.6%	18.7%	10.6%

Source: CBI and ONS data.
*N*otes: The first two rows show the distribution of the number of firms classified by broad SIC category in the CBI survey and the British economy. The third column shows the proportion of people employed in firms in each industrial category.

Table 6: The Distribution of Enterprises by Region

	CBI Survey	UK Economy	Employment Count
North	13.4%	14.3%	15.0%
Yorks & Humbs	11.4%	9.0%	10.2%
E Midlands	10.6%	8.9%	9.6%
W. Midlands	13.6%	11.0%	11.9%
E Anglia	5.6%	10.3%	9.5%
London and South-East	19.9%	24.6%	21.9%
South-West	9.5%	8.8%	7.6%
Wales	6.0%	4.1%	4.9%
Scotland	8.1%	6.4%	6.5%
N. Ireland	1.9%	2.7%	2.9%

Source: CBI and ONS data.
*N*otes: The first two columns show the distribution of the number of firms classified by broad SIC category in the CBI survey and the British economy. The third column shows the proportion of people employed in firms in each region.

2.4.2 How does the ITS survey compare to official data?

Prices and wages. As another reliability check, it is useful to explore how well averages of these price and wage survey data line-up with other, official, time series. Figure 4a reports average expected and perceived price growth from the ITS together with output price growth over the last four quarters in the manufacturing sector (based on the official producer price index) and aggregate consumer price inflation (from the Office for National Statistics) over the same period. The picture presented by the ITS data is similar to that shown by the producer price output index. At the beginning of the financial crisis, expected and perceived price changes fell sharply to about -0.5% which is about the same as the observed value of producer price inflation in the manufacturing sector at this time.

Compared to output price inflation, the co-movement between expected and perceived price growth and official consumer price inflation is weaker, although the broad dynamics over the period are still similar. In particular, there is a noticeable level difference between the ITS average measures and the aggregate CPI inflation series. Firms' expected own price changes average around 1%, which is below realized consumer price inflation rates during the period in question.[14] In terms of this level gap, which is evident in Figure 4a, the largest factor accounting for this difference is probably that output prices were less affected than consumer prices by the sharp rise in import prices following sterling's depreciation in 2007-8 together with the subsequent increase in raw material prices. Producer prices are also net of Value Added Tax.

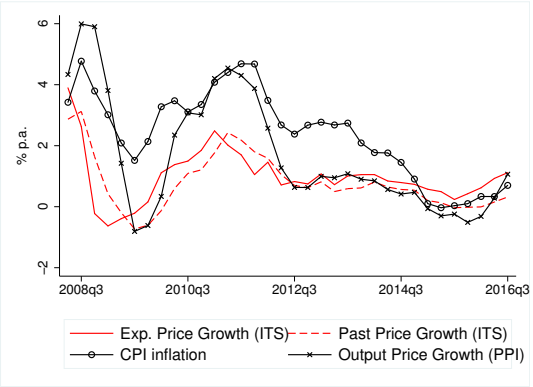
Turning to the wage data, Figure 4b compares the survey data averages for actual and expected wage growth with the UK Office for National Statistics measure of Average Weekly Earnings for the private sector. The aggregate data cover regular pay only, which removes the volatility associated with bonus payments.[15] Even though the survey does not fully mirror the short-term movements shown by Average Weekly Earnings, it reflects the general decline in pay growth after the financial crisis.

The congruence between the aggregate properties of the ITS and the official data reassures us of the reliability of the survey, and echoes Lui et al. (2011). They examined the firms' responses about output movements in the period before the 2008-2009 recession, and showed that the qualitative answers were coherent with the answers the same firms provided in quantitative returns to the UK Office for National Statistics.

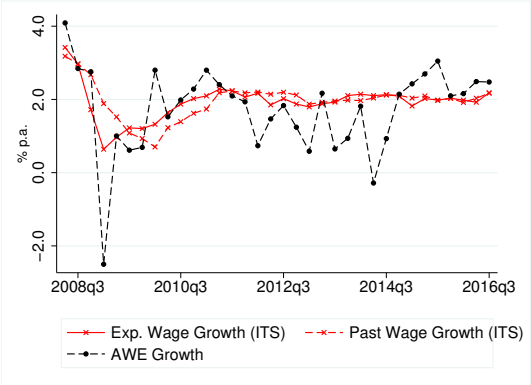
[14] A similar asymmetry has been documented for firms in New Zealand who systematically expect inflation to materialize above actual inflation (Coibion et al. (2018)).

[15] The effect of bonus payments is present even in the seasonally adjusted data.

Figure 4: Perceptions and Expectations of Output Price and Wage Growth



(a) Price growth perceptions and expectations and inflation



(b) Wage growth perceptions and expectations

Source: CBI and ONS data

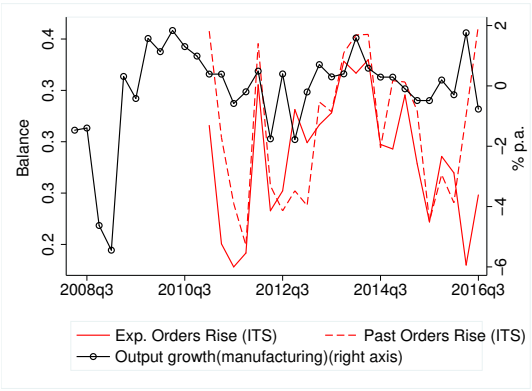
Activity and unit costs. We are similarly interested in the survey data on orders, employment and costs. Although these are ordinal, Panels (A) to (C) of Figure 5 show respectively the proportions of firms reporting past and expected future increases in employment, new orders and unit costs. In each graph the left-hand axis indicates the proportions of the sample reporting a past or expected increase in the variable in question, while the right-hand axis shows the growth in the macro-economic variable to which we might expect the survey response to be related. Panel (D) shows the sample average figures for capacity utilisation on the left-hand axis with the unemployment rate on the right-hand axis. For the first three of these variables, the co-movement between recent firm experience and expectations is striking, but, except for unit costs, the relationship to aggregate data is less obvious. It is noticeable that movements in reported capacity utilisation seem quite unrelated with the aggregate unemployment rate. To the extent that firms' marginal costs depend on their capacity utilisation, this suggests that labour market conditions may not be a good proxy for marginal cost.

2.4.3 Four further comparisons

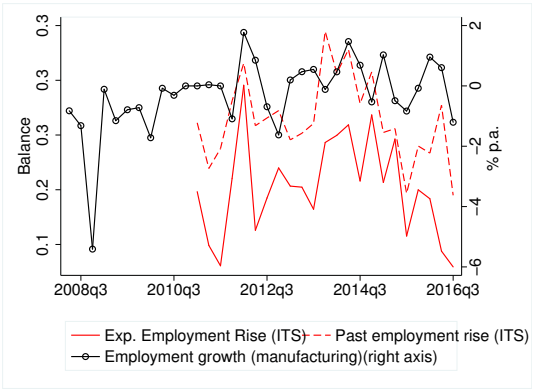
In this section we consider four additional issues to help ensure the reliability of the survey and the validity of our approach. First, we count the number of firms that always provide the same answer.[16] A high incidence might lead us to question the accuracy of the reporting, but this does not seem to be the case. Of the 1004 firms which respond three or more times, 63 give the same answer to the question about past price increases on every occasion. Out of the 672 which give six or more answers, twenty-one provide the same answer to the question each time. Forty-four of the sixty-three respondents in the

[16] A study of qualitative survey data for output in the Netherlands found that about fifteen per cent of firms always gave the same answer. On discovering this, the Netherlands Bureau of Statistics approached respondents to ask why that was the case.

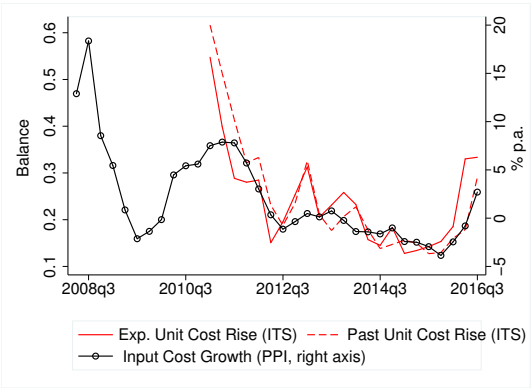
Figure 5: Cross-sectional Averages of Survey Data on New Orders, Employment, Unit Costs and Capacity Utilisation, together with Related Macroeconomic Variables



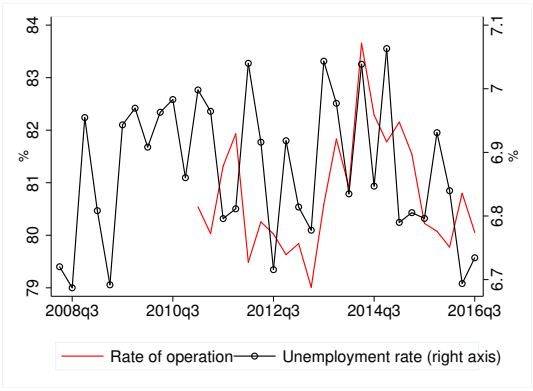
(a) Past and Expected New Orders Volume, and Manufacturing Output



(b) Past and Expected Future Employment Growth



(c) Past and Expected Future Unit Cost Growth and Manufacturing Input Price Growth



(d) Rate of Operation (Capacity Utilisation) and Unemployment

Source: CBI and ONS data

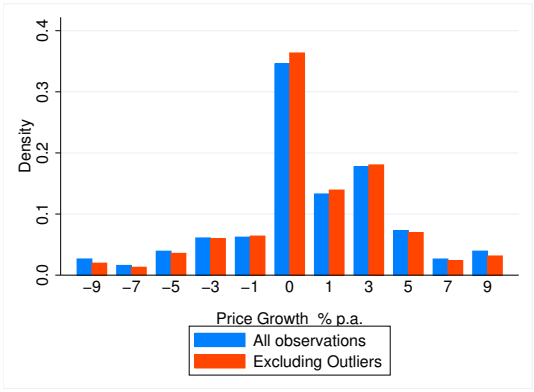
first case and nineteen in the second case reported zero on each occasion.

Secondly, we consider whether some respondents may misinterpret the questions by answering "no change" when they mean that the rate of inflation rather than the price level has not changed. A recent answering practices survey conducted by the CBI suggests, however, that this is not the case. This pattern of answers suggests there is little evidence that the survey is contaminated by firms providing formulaic responses.

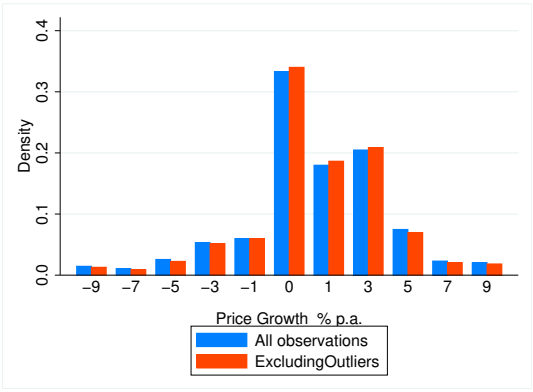
The two final checks in Figure 6 examine the full distribution of price and wage growth expectations and compare these with more restricted sub-samples. In panels 6a and 6b we exclude outlier firms which we define as those reporting a change in past/expected price growth from one wave of the survey to the next in the extreme upper and lower one per cent of the distribution in at least one response.[17] The purpose

[17]Such firms reported a decrease in expected price growth of at least ten per cent or an increase of at least nine per cent from one quarter to the next

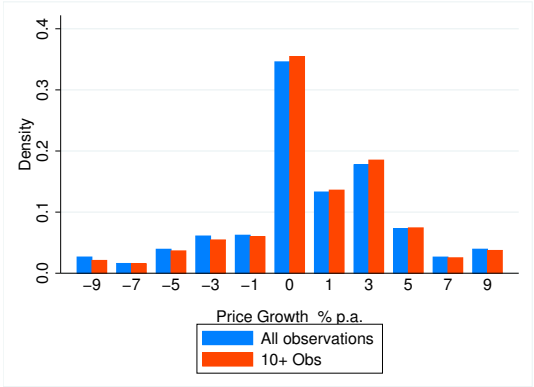
Figure 6: The Distribution of Past and Expected Price Growth for Subsamples of the Full Data Set



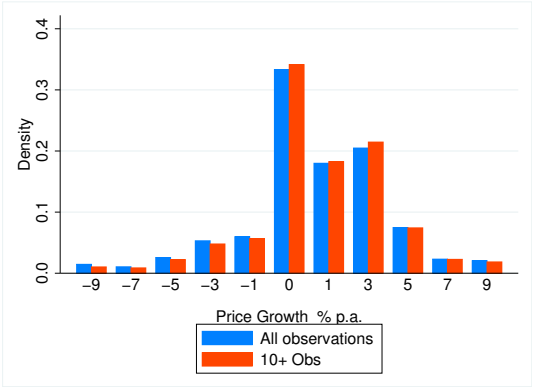
(a) Past Price Growth



(b) Expected Price Growth



(c) Past Price Growth



(d) Expected Price Growth

Source: CBI data

*N*otes: The figures compare the distributions of past and expected price and wage growth using the full sample with the distribution based on subsamples. The subsamples are: (i) *Excluding outliers:* this subsample excludes firms that report a change in past/expected price or wage growth from one wave of the survey to the next in the extreme upper and lower one per cent of the distribution in at least one response, (ii) *10 + observations*: this subsample uses only firms which provided more than ten responses over the whole sample.

of this is to show that firms with unusually volatile changes are not distorting the overall distribution.[18] For example, if changes in the respondent materially affected the reporting for a particular firm, this firm would be likely to show up as an outlier here. The distribution still looks similar when outliers are excluded and our regression results are also robust to using this sample.

Given the unbalanced nature of the panel dimension, figures 6c and 6d examine whether there is something special about firms who report more frequently. We distinguish firms which provided more than ten responses over the whole sample. Reassuringly, the distributions still look very similar. And, in any case, our use of firm fixed effects below will help addresses this and we will re-run our results on the restricted sample as a robustness check.

3 What influences firms' expectations?

In this section, we explore what factors might influence firms' price, wage, activity and cost expectations. Our interest is in the information that seems most relevant for the formation of different expectations. In many standard representative agent models there is no distinction between aggregate and firm level information, and rationality means firms fully make use of all information available. In this section we ask two questions. First, do firms make use of all available information when forming expectations about particular variables (e.g. price growth or new orders), or are some factors more relevant than others? Secondly, do firms focus on aggregate conditions, or are firm-specific variables more relevant for their expectations formation?[19]

3.1 Expectations of Wage and Price Growth

How well can price and wage growth expectations be predicted by actual (reported) firm-level out-turns (e.g. new orders, employment, costs etc)? And are these more or less important than macroeconomic conditions in shaping firms' expectations? To answer these questions we consider the following unweighted regression:

$$E\pi_{i,t} = \alpha + \beta X_t + \gamma Z_{i,t} + \nu_i + e_{i,t} \tag{1}$$

where $E\pi_{i,t}$ is the specific measure of firm-level expected price or wage growth. X_t are industry-level and macroeconomic variables designed to capture the influence of aggregate factors. To capture macroeconomic conditions, we include CPI inflation, aggregate wage growth as measured by Average

[18] Below, we will also re-run our regressions on this restricted sample as a robustness check.

[19] Afrouzi (2017) develops a model with oligopolistic competition and strategic inattention where firms may pay less attention to aggregate developments when forming their expectations.

Weekly Earnings (AWE) growth, the unemployment rate and import price growth. At the industry-level, we include output price growth. In addition to out-turns, we also include measures of expected aggregate developments which are represented using the Bank of England's four quarter ahead CPI inflation and GDP growth forecasts from the *Inflation Report* (IR).[20]

$Z_{i,t}$ are firm specific variables. Our approach is to see which backward-looking variables, proxying the state of the firm at the time expectations are formed, seem most correlated with expectations. $Z_{i,t}$ therefore includes dummies for the change in new orders, employment and costs over the previous three months. In fact, to use each of these as an explanatory variable we need to construct two dummy variables. The first takes a value of 1 when then response is "up" and 0 otherwise. The second takes a value of 1 when the response is "No change" and 0 otherwise. Thus both dummies take values of 0 when the response is "Down". We refer to these dummies for new orders as "Past orders rise" or "Past orders unchanged" respectively, with similar labels for employment and unit costs. We also include the current rate of operation and a firm-specific fixed effect (ν_i) which should capture unobserved time-invariant firm factors.

There is relatively little previous empirical work or theory on the determinants of firm-level inflation expectations. This is why there is significant uncertainty around the benchmark regression. To address this issue and systematically explore the determinants of inflation expectations in an agnostic manner, we therefore rely on Bayesian Model Averaging.

Bayesian Model Averaging is a method designed to consider average coefficients across all possible combinations of the regressors. In our specific application there are 2^{14} or 16,384 models. In this approach, the posterior model probabilities, $p(M|y)$ where M is the model and y is the data , provide the weights for the averaging. These posterior model probabilities can be computed by means of Bayes rule, conditional on two elements. First, for each model M, the marginal likelihood, $p(y|M)$ can be derived from the posterior distribution of the parameters in each model M. The prior distribution of the models, $p(M)$, also needs to be specificed. Given these two inputs, it is possible to derive the model posterior probabilities as

$$p(M|y) \propto p(y|M)p(M)$$

As with any Bayesian approach, the results can could be influenced by the priors we set. We follow Fernandez et al. (2001) and assume an an uninformative prior on the variance of the residuals and the intercept for each model. For the remaining regression coefficients we use the g-prior of Zellner (1986), setting $g = \frac{1}{\max(N,k^2)}$. For the distribution of these models, we set a uniform prior. If the space of

[20] All growth rates are annual.

possible models is very large, the approach in the literature has been to rely on MCMC method to approximate the likelihood. Instead, since we have only up to 16,384 models, we follow Magnus et al. (2010) and evaluate each one of to obtain the exact likelihood. High posterior inclusion probabilities indicate that, irrespective of the inclusion of other explanatory variables, the regressor has a strong explanatory power and the variable is a robust predictor of the dependent variable. We argue that this is therefore an efficient and objective way to understand which variables are the most important determinants of firm pricing expectations in a systematic and agnostic manner.

Table 7 reports the results. Standard errors are calculated allowing for clustering by firm, except for Bayesian Model Averaging where this is not possible. Columns 1 to 3 report the results for expected price growth; with the models estimated over a common sample. To examine the association with aggregate factors alone, the first column reports the results including aggregate variables only. Firms' expected price increases seem to be correlated significantly with forecast GDP growth at an aggregate level (proxied by the Bank of England forecast, as noted above) over the coming year. The influence of import price growth is close to significant but not very large. Taken at face value, this suggests that general expectations about aggregate demand may be influencing firms' expected pricing behaviour.

The second column shows the effects of firm-specific influences only. As one might expect in theory, firms' expectations of future price increases are statistically significantly related to the growth in new orders, cost growth, and capacity utilisation.

The third column then shows the combined effects of the macro and micro variables, with the parameters estimated by Bayesian Model Averaging over 16,384 possible models. We can see that, of the macro variables only import price inflation is significant, while of the firm-specific variables past cost movements and the rate of operation are significant. Thus these results indicate that firms' expectations of price increases are informed by their own recent cost experience together the macroeconomic influence of import prices, possibly because movements in the latter are expected to influence costs in the near future. There is also a capacity effect, which we take to represent demand pressures. The Bayesian analysis indicates probabilities of inclusion of 1 for the firm-specific variables and 0.93 for import costs. This suggests that these three determinants robustly predict inflation expectations, regardless of the inclusion of other variables in the regression model. None of the other probabilities exceeds 0.5.

Columns 4 to 6 of Table 7 report a similar pattern for expected wage growth. At the macro level forecasts of both GDP growth and CPI inflation are significant, as is overall wage growth. Unemployment, however, does not enter significantly into the picture. at the micro level growth in demand, represented by past employment and past orders and capacity utilisation shows a strong influence. There is also an

influence from past costs, possibly reflecting some expectation of persistence of growth in labour costs. Column 6 again reports the results of Bayesian Model Averaging. This points to a role for forecast GDP growth and inflation at the aggregate level, together with demand effects at the micro level. All of the variables which are significant at 5% have probabilities of inclusion greater than 0.9 except that the dummy for past employment unchanged has a probability of inclusion of 0.64. None of the other variables have probabilities of inclusion greater than 0.3.

In summary, price and wage growth expectations seem to be associated with firm-specific factors, particularly rising new orders, rising employment, and a high rate of operation. Wage expectations are also influenced by past CPI inflation and forecast GDP growth while price expectations are modestly influenced by past import price growth. These differences may suggest a degree of bounded rationality or inattention in the formation of expectations. These findings are consistent with Coibion et al. (2018) who document that expectations of firms in New Zealand are best described by noisy information and rational inattention models. This may also have implications for how monetary policy can shape expectations. Expectations of wages and prices may be affected differentially depending on how monetary policy influences aggregate inflation and GDP. We return to the issue of rationality below.

Table 7: Determinants of Price and Wage Expectations

	(1) Exp. Price Growth	(2) Exp. Price Growth	(3) Exp. Price Growth	(4) Exp. wage growth	(5) Exp. wage growth	(6) Exp. wage growth
Output price growth (2-digit)	0.007		0.000	-0.018		-0.000
	(0.22)		(0.08)	(-1.30)		(-0.12)
IR inflation forecast	0.253		0.010	-0.090		-0.004
	(1.37)		(0.19)	(-1.02)		(-0.15)
IR GDP forecast	0.588**		0.166	0.449**		0.374**
	(3.42)		(0.78)	(4.91)		(5.11)
CPI inflation (whole economy)	0.217		0.024	0.332**		0.103**
	(1.24)		(0.27)	(3.84)		(3.13)
AWE wage growth	0.041		-0.000	0.113**		0.020
	(0.62)		(-0.02)	(3.27)		(0.55)
Unemployment rate	-0.134		-0.014	-0.102		0.002
	(-0.75)		(-0.19)	(-1.26)		(0.09)
Import price growth	0.053		0.060**	-0.028		-0.000
	(1.72)		(2.74)	(-1.87)		(-0.13)
Past orders rise		0.507**	0.085		0.460**	0.329**
		(2.85)	(0.44)		(4.92)	(3.09)
Past orders unchanged		0.414**	0.045		0.202**	0.058
		(2.67)	(0.34)		(2.60)	(0.59)
Past employment rise		0.520*	0.195		0.468**	0.394*
		(2.43)	(0.79)		(4.08)	(2.56)
Past employment unchanged		0.230	0.019		0.231*	0.169
		(1.24)	(0.21)		(2.50)	(1.18)
Past cost rise		1.987**	1.729**		0.415**	0.035
		(6.43)	(7.47)		(3.61)	(0.42)
Past cost unchanged		1.004**	0.984**		0.194	0.006
		(3.66)	(4.73)		(1.80)	(0.14)
Rate of operation		0.023**	0.028**		0.010**	0.010**
		(3.30)	(5.20)		(3.67)	(3.43)
Constant	-0.490	-2.562**	-3.530	0.883	0.478*	-1.254
	(-0.45)	(-4.36)	(-1.54)	(1.65)	(2.18)	(-1.14)
Observations	2163	2163	2163	2179	2179	2179
Adjusted R^2	0.051	0.101		0.049	0.090	

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$

Source: CBI and ONS data

Notes: The Table reports parameter estimates from estimating the determinants of firms' price and wage growth expectations controlling for firm fixed effects (equation (1)). Standard errors are clustered by firm for models (1), (2), (4) and (5) which are estimated by OLS. Models (3) and (6) are estimated by Bayesian Model Averaging.

3.2 Expectations of New Orders, Employment and Unit Costs

Having explored our quantitative measures of expected price and wage growth, we now turn to new orders, employment and cost expectations. The qualitative nature of the data for these variables means that, to examine influences on expectations, we would ideally need to use an ordered probit or logit model. It is not possible to set up such a model except by pooling the data and neglecting firm-specific effects due to the incidental parameter bias (Neyman and Scott (1948)). In studying influences on expectations, therefore, we limit ourselves to a dummy variable which takes a value of 1 if the expectation is for up and 0 otherwise; we refer to this dummy as "Expected Orders", employment or costs respectively. We then examine the influences on this using a panel logit model with fixed effects.We convert these trichotomous variables into dichotomous variables which distinguish a rise from no change/ a fall, in effect losing the distinction between no change and fall. Specifically we estimate the following logit discrete choice model that is not plagued by the incidental parameter bias:

$$P(Ey_{i,t} = 1|\mathbf{X}_{i,t}) = F(\Gamma\mathbf{X}_{i,t}) \tag{2}$$

where

$$\Gamma\mathbf{X}_{i,t} = \alpha + \beta X_t + \gamma Z_{i,t} + \nu_i + e_{i,t} \tag{3}$$

Ey_{it} is the specific measure of the change in expected new orders, employment and costs. Again, X_t are industry and macroeconomic variables and $Z_{i,t}$ are the same firm specific variables. We include the same variables as in the previous section, together with past price and wage growth. Table 8 reports the odds ratio for each variable.

As before, we examine the influence of macroeconomic variables and forecasts and then turn to the firm-specific data. In contrast to the regression models of section 3.1, however, it is not possible to correct for clustering with the panel logit model, and the R^2 is not clearly defined. So we report z-statistics relative to odds ratios of 1 and derived from robust standard errors together with the BIC information criterion.

The first three columns of Table 8 consider the factors influencing expectations of new orders. Column 1 does not identify a significant role for any of the macroeconomic variables although the odds ratio of the GDP growth forecast is close to significance. In column 2, we see that the only significant firm-specific variable is whether firms reported past growth in new orders. When the macro and micro variables are combined in the column 3, we find again that only the odds ratio on the dummy for a rise in past orders

is significant. The BIC suggests that the micro equation should be preferred to both the combined and macro equations suggesting that firms' expectations for new orders are most importantly influenced by their own recent experience.

Columns 4, 5 and 6 in Table 8 consider employment expectations. When only macro indicators are considered (column 4) the aggregate GDP growth forecast appears as a significant influence on the probability that firms will expect a rise in employment. Looking only at micro variables (column 5), past movements in new orders has a larger odds ratio, suggesting that it is more influential for employment expectations than expectations of new orders. Firms reporting an increase/no change in new orders were significantly more likely to expect employment to rise than those that reported a past fall in new orders. Past employment movements, in contrast, do not seem to exert a significant influence on expected future employment movements but past price increases do play a significant role. When macro and micro variables are both included, the micro variables retain their significance while the odds ratio for the GDP forecast is no longer significant at a five per cent level. The BIC for the micro equation is, however, materially lower than for either the macro equation or the combined equation. This suggests that expectations of employment changes are primarily influenced by firm-specific experience.

Finally, columns 7, 8 and 9 of Table 8 examine unit cost expectations. In terms of the macro variables (column 7), import price growth increases are associated significantly with the probability that firms expect costs to rise. The GDP growth forecast is not significant. In terms of the firm specific variables (column 8), the only significant indicator is whether firms have just experienced a rise in unit costs. When the macro and micro variables are combined, past movements in import prices and firm-specific costs retain their significance while some macro variables lose significance. The BIC statistics suggest that the micro equation should be preferred to the macro equation despite the significance of past import costs in the combined equation.

In summary, employment expectations seem to be most correlated with the change in past firm-level order volumes, while expected costs are correlated with the past change in firm costs and (aggregate) import price inflation. Expectations of new orders, however, seem to be most correlated with past movements in new orders at the firm-level. This suggests that aggregate factors, including monetary policy, might affect only new orders and employment expectations through their effect on firm-level variables. The exception is cost expectations where import price inflation has an impact as well. Some expectations are therefore more directly correlated with aggregate conditions (e.g. wage expectations, as discussed above) while others may be influenced only indirectly.

Table 8: Determinants of New Orders, Employment and Cost Expectations

	(1) Exp. orders rise	(2) Exp. orders rise	(3) Exp. orders rise	(4) Exp. employment rise	(5) Exp. employment rise	(6) Exp. employment rise	(7) Exp. cost rise	(8) Exp. cost rise	(9) Exp. cost rise
Output price growth (2-digit)	1.001		1.006	1.014		1.002	1.008		1.019
	(0.02)		(0.17)	(0.43)		(0.04)	(0.24)		(0.51)
IR inflation forecast	1.315		1.347	1.059		1.136	1.676*		1.352
	(1.26)		(1.33)	(0.23)		(0.49)	(2.43)		(1.20)
IR GDP forecast	1.475		1.342	1.900**		1.557	1.206		0.736
	(1.90)		(1.37)	(2.74)		(1.76)	(0.91)		(-1.26)
CPI inflation (whole economy)	0.990		0.979	1.165		1.167	0.990		0.761
	(-0.05)		(-0.10)	(0.65)		(0.62)	(-0.05)		(-0.99)
AWE Wage growth	0.892		0.851	0.919		0.914	1.090		0.944
	(-1.37)		(-1.85)	(-0.90)		(-0.89)	(0.92)		(-0.51)
Unemployment rate	0.838		0.792	1.012		0.953	0.814		0.873
	(-0.85)		(-1.09)	(0.05)		(-0.20)	(-0.90)		(-0.51)
Import price growth	1.025		1.035	0.980		0.969	1.123**		1.120**
	(0.76)		(1.01)	(-0.52)		(-0.78)	(3.14)		(2.59)
Past orders unchanged		0.820	0.782		2.032**	1.937**		1.290	1.215
		(-1.02)	(-1.25)		(2.84)	(2.61)		(1.19)	(0.89)
Past orders rise		2.080**	2.049**		4.740**	4.511**		0.933	0.896
		(3.57)	(3.44)		(5.72)	(5.47)		(-0.28)	(-0.43)
Past employment unchanged		1.018	0.987		0.700	0.655		1.156	1.242
		(0.08)	(-0.06)		(-1.41)	(-1.65)		(0.56)	(0.80)
Past employment rise		1.178	1.144		1.022	0.975		1.348	1.392
		(0.67)	(0.54)		(0.08)	(-0.09)		(0.97)	(1.03)
Rate of operation		1.001	1.001		1.009	1.009		1.003	1.005
		(0.08)	(0.14)		(1.10)	(1.02)		(0.51)	(0.78)
Past cost unchanged		0.832	0.800		1.151	1.131		1.226	1.120
		(-0.73)	(-0.87)		(0.50)	(0.43)		(0.58)	(0.31)
Past cost rise		0.641	0.577		0.972	0.898		11.206**	9.746**
		(-1.62)	(-1.91)		(-0.09)	(-0.34)		(6.69)	(6.06)
Pst. wages		1.043	1.056		0.975	0.974		0.960	0.957
		(0.73)	(0.92)		(-0.38)	(-0.39)		(-0.58)	(-0.61)
Past inflation		1.005	1.005		1.081*	1.070*		1.020	1.030
		(0.20)	(0.16)		(2.42)	(2.01)		(0.66)	(0.91)
Observations	1040	1040	1040	851	851	851	1035	1035	1035
BIC	827.4	811.6	846.2	664.8	626.6	663.9	750.3	635.7	657.0

Exponentiated coefficients; t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$

Source: CBI and ONS data

Notes: The table reports odds ratios from estimating the determinants of firms' new orders, employment and unit costs expectations controlling for firms fixed effects (equations (2)-(3)). Standard errors are robust.

4 Do Expectations Affect Price and Wage Setting Behaviour?

So far, we have explored which factors seem to predict firms' expectations for a range of variables. But, do these expectations actually matter for outcomes? In most modern macroeconomic models expectations of firms are crucial for determining pricing behaviour and aggregate inflation dynamics. In the New Keynesian model, for example, aggregate inflation today is related expected future inflation and real marginal cost. The central bank's ability to control expectations about the future can then dramatically improve inflation outcomes today. In this section we therefore ask: Is there evidence that firms' expectations matter for price setting behaviour?

Much empirical work has been devoted to exploring this question using macro data. And, as mentioned earlier, a large body of literature has focused on estimating the New Keynesian Phillips Curve directly. But this literature has faced a number of challenges. It is unclear how to measure expectations and the literature has often used proxies (such as using realized outcomes or measures or forecasts from a statistical model) or expectations from aggregate survey data.

Two key strengths of our data are that the ITS has direct measures of firms' expectations and they are panel data. We therefore observe firms' expectations directly and through a range of fixed effects and variables, we are able to control for a range of possible confounders. We control for macro shocks with time fixed effects, industry shocks with industry-time fixed effects, and individual level characteristics with firm fixed effects. The remaining concern is that firm specific, time varying shocks, might be driving both expectations and actual pricing behaviour. Here again, the richness of the survey helps and we can include the full range of firm specific controls considered in Section 3. To explore if this robustness problem persists with the observed firm level expectations variables in our survey, we apply Bayesian Model Averaging to explore how robust our results are to regression specification.

4.1 Econometric specification

Our objective is to examine whether firms' expectations matter for pricing behaviour today. To do this, a natural regression specification to consider is the following:

$$\pi_{i,t} = \alpha^{\pi} E_{i,t}\pi_{i,t+1} + \gamma_x^{\pi} x_{i,t} + v_{i,t} \tag{4}$$

where $\pi_{i,t}$ is firm i's growth in prices and $E_{i,t}\pi_{i,t+1}$ are their expectations for the growth in their price for the coming period. Our main coefficient of interest is then α^{π}, where we would like to establish whether this is positive and significant. $x_{i,t}$ are other controls, including any fixed effects. While our

goal is not to estimate the structural parameters of a Phillips Curve, a number of models would be consistent with a pricing relationship like equation 4. For example, in the Appendix we show that a firm-level pricing relationship like this — where price changes depend on a firm's expected own price changes and marginal cost — can be derived from the common Rotemberg (1982) pricing model.[21] In this specific model, the variable $x_{i,t}$ reflects the time varying price markup (the inverse of real marginal cost). We do not have any clear choice for such a variable in our dataset, but if we regard the x variables in a less structural manner, we can think of this as a vector $\mathbf{X}_i$ with a range of firm-specific controls and fixed effects that help deal control for common firm-specific factors.

In estimating equation 4 the first practical challenge is that the survey asks for growth rates over the past twelve months and expected future growth rates over the coming twelve months. It would be incorrect to treat these variables as though they described quarterly expected and actual price movements, raising a question of how to handle the temporal aggregation in the data. We address the issue by assuming that decisions are made on a quarterly basis. We therefore aggregate equation 4 by summing four successive equations. This leads to the following expression:

$$\pi^4_{i,t} = \alpha^\pi E_{t-3}\pi^4_{i,t+1} + \gamma^\pi_{x,k}\sum_{k=0}^{3}\mathbf{X}_{i,t-k} + u_{i,t} \tag{5}$$

where the superscript 4 indicates that the variable relates to the growth rate over the preceding four quarters. The expectations term on the right-hand side of this equation has to be based on variables which are observed at period $t-3$. Strictly the $\mathbf{X}$ terms would become the sum over the previous 4 quarters but, for generality, we allow each quarter to have a different coefficient in equation 5. Our interest is in whether the coefficient α^π is positive and significant, which would be evidence of a role for expectations in current pricing decisions.[22]

To be as flexible as possible, and exploit the panel nature of our data, $\mathbf{X}_{i,t}$ includes a combination of continuous controls and firm, sector and date fixed effects. For the continuous variables we include past wage growth, the current rate of operation and the number of employees. The firm-specific controls we use are output is below capacity, and whether there has been growth in new orders, unit costs and employment. Because the last three variables are discrete, it is necessary, as before, to define two dummies for each, the first indicating a rise and the second indicating no change. For each of these we include the contemporanoues value and three lags.

[21] After imposing symmetry this equation then becomes the New Keynesian Phillips Curve for aggregate inflation, as discussed in Roberts (1995), although we do not make this final step given that we already observe firm-level expectations. Rotemberg pricing has the advantage that all firms can, in principle, make adjustments each period.

[22] The residual term, will now include a range of forecast errors, in addition to including $v_{i,t}$, specifically: $u_{i,t} = \alpha^\pi\left(E_{i,t}\pi_{i,t+1} + E_{i,t-1}\pi_{i,t} + E_{i,t-2}\pi_{i,t-1}\right) - \alpha^\pi\left(E_{i,t-3}\pi_{i,t+1} + E_{i,t-3}\pi_t + E_{i,t-3}\pi_{i,t-1}\right) + \sum_{k=0}^{3} v_{i,t-k}$

We also use the same specification to explore a possible connection between wage growth over four periods, $w^4_{i,t}$ and the wage growth which had been expected three quarters earlier, $E_{t-3}w^4_{i,t+1}$, evaluating the analogous coefficient, α^w.

4.2 Results

Table 9 shows the results of estimating equation 5. The columns refer to different specifications which include different fixed effects and firm-level controls. There is a strong stability in the coefficient estimate. It is always around 0.2-0.35 and significant at the 5% level. Columns 1 and 2 show the results only including different fixed effects and no other controls. This maximizes the sample size, although one may still be concerned about other time-varying firm-specific factors. Column 3 includes firm and time-sector fixed effects (at the 2 digit SIC level), which would deal with any sector specific trends. Columns 4-8 include firm specific controls. Specifically we include, for these models:

1. Past Wage Growth
2. Rate of Operation
3. Volume of New Orders (Dummies for Rise and No Change)
4. Employment (Dummies for Rise and No Change)
5. Unit Costs (Dummies for Rise and No Change)

with one to four lags of each variable.

Column 4 has these firm specific controls and firm fixed effects. Column 5 adds time and sector fixed effects. Column 6 has firm and time-sector fixed effects. Column 6 is the most flexible specification and it is favoured by the BIC. We therefore regard this as our baseline specification. Here, the coefficient on expectations is still 0.2 and significant at the 5% level: expectations of future price increases by the firm influence the decision to change prices today.

To examine further the robustness of our results, columns 7 and 8 estimate the baseline model of column 6 including only firms with at least ten observations (to help address the lack of balance in the panel) and removing firms who experience large changes in their expectations between quarters (to help address any bias introduced by changing circumstances for the firm, e.g. if the person responding to the survey changes). Both these sample restrictions were discussed earlier and, in table 9, make very little difference to the parameters estimates (which remain around 0.2-0.3) but lead to a lower sample size.

Finally, we also report, in column (9) the results from our Bayesian Model Averaging exercise. This explores models which include firm and time fixed effects. For the estimation to be manageable we have to use a reduced set of firm-level controls, omitting the four lags of past wage growth and the dummies for no change of the three qualitative variables. It shows that price expectations enter as an important predictor in 99 percent of 131,072 price change equation models that we estimate. In other words, unlike with the macroeconomic estimates presented in the time-series literature, our result that past expectations are related to actual price setting is robust to many different perturbations of the underlying regression model.

There is also a literature examining wage Phillips curves and, given our survey contains rich information on wages and wage expectations, it is also interesting to examine whether wage expectations matter for current wage determination. Table 10 therefore repeats the same exercise as in Table 9 for wage expectations. Columns 1-9 refer to the same econometric specifications as with prices, although the firm level control set now includes past price changes but not past wage changes. With Bayesian Model Averaging the set of firm level controls is again reduced, excluding the past price changes and also the three no change dummies. The coefficient estimate is slightly larger than for the price growth regressions, tends to be between 0.25 and 0.4, and is always significant at the 5% level. Again, wage expectations also seem to matter for current wage determination at the firm level and Bayesian model averaging shows that this result is robust to regression specification.

To summarize, this section has looked for evidence that expectations matter for current price and wage decisions at the firm-level. Our main result is that price and wage growth expectations do seem to have a positive and significant effect on price and wage growth. This is robust to a wide range of fixed effects and firm-level controls. Without a specific structural model in mind, it is not possible to map these estimate to structural parameters but, as we have noted, the general econometric specification we estimate can be motived from a simple firm-level type pricing relationship such as Rotemberg (1982).

5 Are Expectations Rational?

In previous sections we have provided evidence that expectations are associated with fundamentals, and have shown evidence that they influence current pricing decisions. But, are expectations rational? The rationality of expectations plays an important part of modern macroeconomic models and implies that firms' use all available information and do not systematically make mistakes. A strong degree of rationality and forward-looking behaviour then produces powerful effects of policies such as those associated with forward guidance in modern macro models (Woodford (2012)). Coibion et al. (2017)

Table 9: The Relationship between Expected and Actual Price Growth

The dependent variable is past price growth.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exp. Price Growth (lag 3)	0.355**	0.356**	0.317**	0.271**	0.221*	0.218*	0.217*	0.267*	0.290**
	(8.05)	(7.86)	(6.53)	(2.97)	(2.28)	(2.16)	(2.12)	(2.42)	(4.00)
Observations	1968	1968	1960	670	670	670	632	574	688
Adjusted R^2	0.09	0.15	0.35	0.18	0.24	0.68	0.67	0.67	–
BIC	8762.6	8807.1	9413.9	2598.8	2650.7	2147.6	2091.0	1670.1	–

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$

Source: CBI and ONS data

Notes: The table reports the coefficient on expected price growth in equation (5) for various combinations of control variables. Except for model (9) standard errors are robust. The models are as follows:

1. Firm fixed effects.
2. Firm and time fixed effects.
3. Firm and interactive time/SIC 2-digit sector fixed effects.
4. Firm fixed effects. Firm level controls
5. Firm and time fixed effects. Firm-level controls.
6. Firm and interactive time/sector fixed effects. Firm level controls.
7. Firm and interactive time/sector fixed effects. Firm level controls. Only firms with 10+ responses.
8. Firm and interactive time/sector fixed effects. Firm level controls. Outliers removed (see figures 6a and 6b and related discussion).
9. Firm and time fixed effects. Firm-level controls. Estimated by Bayesian model averaging

Table 10: The Relationship between Expectations and Actual Wage Growth

The dependent variable is past wage growth.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exp. Wage Growth (lag 3)	0.380**	0.353**	0.325**	0.305**	0.305**	0.282*	0.283*	0.229	0.316**
	(8.41)	(7.30)	(5.41)	(3.37)	(3.37)	(2.33)	(2.32)	(1.80)	(4.87)
Observations	1975	1975	1967	664	664	664	626	491	686
Adjusted R^2	0.12	0.16	0.28	0.13	0.13	0.54	0.53	0.71	–
BIC	5739.1	5836.5	6705.1	1837.8	1837.8	1490.6	1467.0	603.7	–

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$

Source: CBI and ONS data

Notes: The table reports the coefficient on expected price growth in equation (5) for various combinations of control variables. Except for model (9) the standard errors are robust. The models are as follows:

1. Firm fixed effects.
2. Firm and time fixed effects.
3. Firm and interactive time/SIC 2-digit sector fixed effects.
4. Firm fixed effects. Firm level controls
5. Firm and time fixed effects. Firm-level controls.
6. Firm and interactive time/sector fixed effects. Firm level controls.
7. Firm and interactive time/sector fixed effects. Firm level controls. Only firms with 10+ responses.
8. Firm and interactive time/sector fixed effects. Firm level controls. Outliers removed (see figures 6a and 6b and related discussion).
9. Firm and time fixed effects. Firm-level controls. Estimated by Bayesian model averaging

show, however, that growing micro evidence suggests departures from rationality. This is an issue we can now study with our micro data. In the remainder of this section, we explore this issue by first exploring the properties of forecast errors before proceeding to more formal rationality tests. For our continuous price and wage forecast errors, we are particularly interested in their relationship to aggregate shocks, which we proxy using official Bank of England's forecast errors.

5.1 Properties of forecast errors

We first use the ITS survey to construct forecast errors. Before proceeding with any formal tests of rationality it is interesting to examine these forecast errors more closely and see how they correlate with each other, and with aggregate shocks.

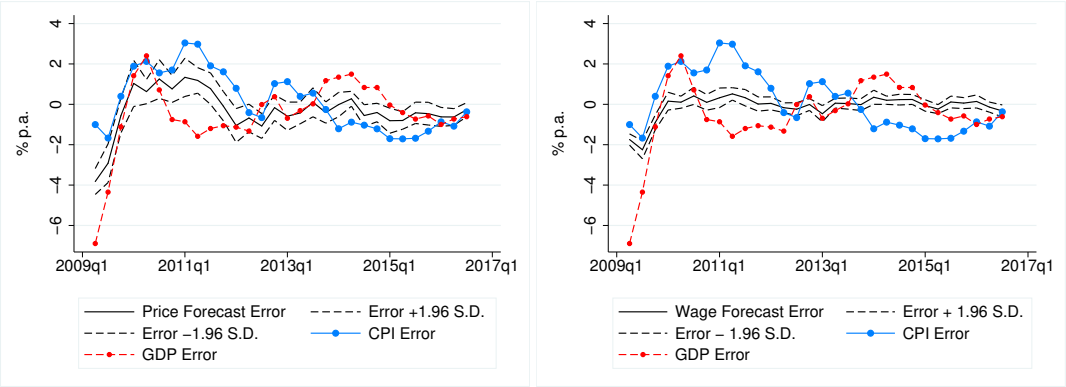
For prices we define the 1-year ahead forecast error at time t as $\pi^{4f}_{t+4} - \widehat{e}^{\pi}_{t+4} \equiv \hat{\pi}^{e4}_{t+4f}$, the difference between the reported price increases over the last year, π^{4f}_{t+4}, and the forecast made a year earlier, $\hat{\pi}^{e4}_{t+4f}$, with w^{4f}_{t+4} and $\hat{w}^{e4}_{t+4f}$ the corresponding variables for wage growth. These variables are denoted *Price Error* and *Wage Error* respectively. The remainder of this subsection uses descriptive methods to relate these forecast errors to macro-economic forecasting errors, focusing on the four quarter forecasts for inflation and GDP growth made by the Bank of England's Monetary Policy Committee. Given the time and effort devoted to these macro forecasts these are a particularly useful benchmark.

Figure 7a shows the average forecast errors in price growth for the sample period. The chart also shows bounds calculated as $\pm$ 1.96 standard error of the mean on each side of the mean, and the comparable forecast errors for CPI inflation (*CPI Error)* and GDP growth (*GDP Error)* in the Monetary Policy Committee's Inflation Forecast four quarters ahead. The chart suggests a strong correlation between firms' errors in price expectations and the forecasting errors made by the Monetary Policy Committee. Figure 7b shows the corresponding forecast errors for wage growth. The correlations in figure 7b are somewhat less obvious, although these errors are not necessarily so closely related to GDP and inflation.

Next we present summary statistics for the forecast errors in Table 11. The mean error for price growth is -0.4 percentage points. This may not seem all that large, but it is several times larger than the Bank of England's error for CPI inflation (0.07pp). It is also clear that the dispersion of forecast errors is more than twice that of the MPC's forecast errors. This is not that surprising given the dispersion in expectations shown earlier, but certainly motivates our more detailed analysis below.

We are also interested in the forecast errors in the qualitative variables. We summarise these in the following way. Since the variables are trichotomous, we can identify those observations for which the outturn is in a higher category than the expectation, those for which it is in the same category and

Figure 7: Forecast Errors in continuous survey variables compared to the Bank of England's Monetary Policy Committee forecasts



(a) Mean Price Forecast Errors

(b) Mean Wage Forecast Errors

Source: CBI and ONS data and *Inflation Report Notes: The Figure reports forecast errors in price and wage survey forecasts compared to the Bank of England's Monetary Policy Committee CPI and GDP forecasts*

those for which it is lower. We show the proportion of observations with each of these outcomes in Table 12 and use the variables to evaluate the polychoric and polyserial correlations show in Table 13. This classification is less than ideal; a firm which expected new orders to fall and in fact experienced a much sharper fall in new orders would be shown here in the middle category, while a firm whose outturn was just below its expectation, but enough to move it down a category would be classified in the first category. While this classification therefore, does not form the basis for the formal rationality tests presented below, it does give an indication of the degree to which outturns are different from expectations. It should be noted that these errors relate to forecasts made one period ago, while the wage, price and macroeconomic forecast errors relate to a forecast interval of four quarters. We denote these variables *Unit Cost Error, New Orders Error* and *Employment Error*.

Summary statistics for the forecast errors of the ordinal data are shown in Table 12. The proportion of firms for whom employment, new orders and unit costs were " as expected" is larger than the proportion experiencing lower or higher forecast errors, although for all three variables a sizable proportion of firms experience forecast errors. These were also relatively symmetric with similar proportions on the upside and the downside altuough there is a suggestion that orders were more likely to come in below rather than above expectations.

Finally, we explore the correlations between the firm-level forecast errors. It is an interesting question whether errors on one variable might be associated with errors on another variable. For example, if

Table 11: Summary Statistics for Forecast Errors

	Mean	Std. Dev.
Price Error	-0.44	3.6
Wage Error	-0.15	1.7
CPI Error	0.07	1.45
GDP Error	-0.71	2.10

Source: Bank of England, CBI and ONS data
Notes: The table reports mean and standard deviation of price and wage survey forecast errors together with the corresponding forecast errors of the Bank of England's Monetary Policy Committee.

Table 12: Categorical Forecast Errors

	Employment	New Orders	Unit Costs
Lower than Expected	16.9%	30.7%	18.1%
As Expected	64.1%	46.4%	64.8%
Higher than Expected	19%	22.9%	17.1%
Observations	1412	1402	1389

Source: CBI data
Notes: The table reports the proportions of different outcomes for the forecast errors in the categorical survey variables. The different outcomes are: (i) *lower than expected*: the out-turn is in a lower category than expected, (ii) *as expected*: the out-turn is in the same category than expected, (iii) *higher than expected*: the out-turn is in a higher category than expected.

costs end up higher than expected, perhaps prices are raised more than anticipated. It is worth stressing that the correlations in Table 13 are in no way causal — and we think it would be difficult to make such causal statements — but these statistics seem a useful way of examining the possible relationships between the variables.

Table 13 does not point to any strong correlations[23] . Even the largest, between errors in new orders and errors in employment, is only 0.37. Nevertheless, it is of some note that the errors firms make in forecasting wage and price changes are much more strongly correlated with aggregate shocks than they are with firms' own errors in forecasting unit costs, employment or new orders. On top of this the correlation with GDP forecast errors is larger than that with inflation forecast errors. That offers some, albeit weak, evidence that pricing is influenced by macroeconomic influences. We note the contrast between the pattern of shocks shown here and the results of table 3 which shows a clear correlation between past unit cost and past price movements. It is, of course, possible that the correlation arises entirely through the expected components of past price and unit costs but that conclusion would probably strain the data more than is sensible given the nature of the qualitative forecast errors.

[23] The correlations are calculated using only observations at least four quarters apart so as to avoid the problem of spurious correlation, while figure 7a shows the quarterly means of all the data and thus suggests a stronger correlation.

Table 13: Correlations between Forecast Errors: 2009Q2-2016Q3

	Price Error	Wage Error	CPI Error	GDP Error	Unit Cost Error	New Orders Error
Wage Error	0.22					
CPI Error	0.21	0.14				
GDP Error	0.26	0.28	0.21			
Unit Cost Error	0.01	0.04	0.07	-0.09		
New Ord. Error	0.01	0.08	0.03	-0.01	0.00	
Employment Error	0.02	0.11	0.04	-0.02	0.07	0.37

Source: Bank of England, CBI and ONS data
*N*otes: The table shows polychoric correlations between categorical variables and polyserial correlations when one variable is categorical and the other is cardinal.

5.2 Are Survey Forecasts Rational?

Given the dispersion in expectations documented in Section 2 and the forecast errors constructed above, we will now formally assess the rationality of the expectations in the ITS.

5.2.1 Prices and Wages

We first examine the rationality of the price and wage growth expectations. We are interested in both the role of macroeconomic shocks and evidence of rationality conditional on these. To do this, we use the following regression equation for price forecast errors.

$$\widehat{e}^{\pi}_{f,t+4} = \alpha^{\pi}_{f} + \theta^{\pi\pi}\hat{\pi}^{e4}_{t+4f} + \theta^{\pi w}\hat{w}^{e4}_{t+4f} + \beta^{\pi}X_{i,t} + \gamma^{\pi}Z_{t+4} + \epsilon^{\pi}_{f,t+4} \tag{6}$$

$X_{i,t}$ is a vector of variables observed at time t for firm i; we consider the dummy variables which take values of 1 if costs, employment and the volume of new sales are expected to rise in the quarter when the forecast was produced. We also use the rate of operation and the observed past increases in wages and prices at the time the forecast was produced. Z_{t+4} are the macroeconomic forecast errors plotted in Figures 7a and 7b. In an alternative specification, we replace macroeconomic forecast errors with time fixed effects. It is not possible to estimate both γ and δ since individual date dummies are collinear with aggregate variables, but the values of γ^{π} may themselves be informative.

For time series data, expectations are rational if both the constant and the coefficient on the forecast value are equal to zero. For panel data, rationality thus requires that there should be no fixed effects so that for each individual firm, forecast errors are zero in expectation conditional on the information that was available to the forecaster (Rossi and Sekhposyan (2015)).[24] We adopt a weaker formulation

[24] This is true only under covariance stationarity and a quadratic loss function.

of the null hypothesis of forecast rationality,

$$H_0 = \widehat{\theta}^{\pi\pi} = \widehat{\theta}^{\pi w} = \widehat{\beta}^{\pi} = 0. \tag{7}$$

So if H_0 is rejected, then we can safely reject the hypothesis of rationality.

The rationality of forecasts for wage growth can similarly be tested by estimating the regression equation

$$\widehat{e}^{w}_{f,t+4} = \alpha^{w}_{f} + \theta^{w\pi}\hat{\pi}^{e4}_{t+4f} + \theta^{ww}\hat{w}^{e4}_{t+4f} + \beta^{w}X_{i,t} + \gamma^{w}Z_{t+4} + \delta^{w}D_{t+4} + \epsilon^{w}_{f,t+4}. \tag{8}$$

Earlier, we showed that there might be persistence in expectations which may lead to forecast errors that are correlated over time. As a result, the panel data model in equations (6) and (8) are estimated using standard errors that are robust to heteroskedasticity and autocorrelation[25], except where Bayesian Model Averaging is used.

Table 14 reports the results from estimating the model in equations 6 and 8. The models with firm-specific controls can be estimated only for the period 2012q1-2016q3. For reasons of comparability we therefore also show the first two models estimated for this period; the conclusions over rationality remain, however broadly unchanged when these models are estimated for the whole period.

In table 14 we show the results of the test for four different specifications. The first two columns show, for prices and wages, that forecast errors are strongly negatively related to the expectations themselves. A high expected value tends to be associated with an out-turn well below forecast, even after we include firm fixed effects. We can also see, in column (1) that, for prices, macro forecast shocks for both inflation and economic growth are positively associated with out-turns higher than expected, but there is no evidence of such effects with wages (column 2). Finally we can see that firms which had experienced sharp price or wage increases in the four quarters leading up to the forecasts tended to have out-turns lower than forecast. Since the coefficients on past values are significant even though we have also included the forecasts, this effect is in addition to the average influence of past out-turns on forecasts. In the subsequent columns we include time dummies as well as firm fixed effects, but the relationship with the forecast and with the past out-turn is very similar to that shown in columns (1) and (2).

Finally in columns (5) and (6) we show the results of the models of columns (3) and (4) estimated by Bayesian Model Averaging. This shows high probabilities of inclusion for the variables which are statistically significant and low probabilities otherwise. Searching over two hundred and fifty-six models

[25]This setting implies that the estimation error is captured under the null hypothesis which means that we adopt the asymptotic framework of Giacomini and White (2006) to conduct inference. As a result we test for rationality using χ^2 rather than F statistics

leads to conclusions very similar to those shown in columns (3) and (4) with rationality firmly rejected. Thus we can be comfortable that our conclusions about rationality are not an artifact of the model specified.

The results of the χ^2 test for rationality (χ^2 in table 14) indicate that the null hypothesis of the rationality of price and wage growth expectations is firmly rejected. Expectations show excess volatility, so that firms which have high values for expected growth of wages or prices tend to find out-turns below their expectations. The coefficients on expected price and wage changes are robust to the three specifications.

When macroeconomic shocks are measured only by Monetary Policy Committee forecast errors, we find that the error in the growth forecast has a significant influence on price growth errors while wage growth errors are not materially influenced by either macroeconomic forecast error. When we control for firm-specific variables known at the time the forecasts were produced, we find that past price and wage increases also contribute significantly to explaining forecast errors of prices and wages respectively.

We also investigated whether industry price growth (measured by the increase in the producer price index at a 2-digit level had a material influence on price forecast errors. The coefficients on price index growth were highly insignificant.

Overall these results cast doubt on whether the strong assumptions in many macro models hold in reality. They may point to information frictions as discussed in e.g. Coibion and Gorodnichenko (2015), but should in any case leave us uncomfortable with the widespread assumption that expectations are rational.

Table 14: Forecast Errors: Tests for Rationality

	No Time Dummies		Time Dummies		Time Dummies: BMA	
	(1)	(2)	(3)	(4)	(5)	(6)
	$\widehat{e}$ (Prices)	$\widehat{e}$ (Wages)	$\widehat{e}$ (Prices)	$\widehat{e}$ (Wages)	$\widehat{e}$ (Prices)	$\widehat{e}$ (Wages)
Price Growth Expectations (lag 4)	-0.697**	-0.033	-0.707**	-0.035	-0.699**	-0.001
	(-11.33)	(-1.70)	(-11.82)	(-1.80)	(-17.77)	(-0.19)
Wage Growth Expectations (lag 4)	0.099	-0.675**	0.118	-0.673**	0.034	-0.674**
	(1.28)	(-12.23)	(1.48)	(-12.32)	(0.46)	(-19.20)
IR Inflation Forecast Error	0.575**	-0.037				
	(2.71)	(-0.38)				
IR Growth Forecast Error	0.405**	-0.119				
	(2.79)	(-1.47)				
Expected cost rise (lag 4)	0.279	0.045	0.082	-0.001	0.002	-0.001
	(1.50)	(0.48)	(0.44)	(-0.01)	(0.07)	(-0.04)
Rate of Operation (lag 4)	-0.003	0.001	-0.001	0.002	0.000	0.000
	(-0.52)	(0.44)	(-0.20)	(0.60)	(0.03)	(0.08)
Expected employment rise (lag 4)	0.155	0.044	0.097	0.029	0.005	0.001
	(0.86)	(0.43)	(0.51)	(0.28)	(0.11)	(0.08)
Expected orders rise (lag 4)	0.140	0.071	0.144	0.070	0.007	0.002
	(0.75)	(0.81)	(0.77)	(0.79)	(0.14)	(0.12)
Past Price Increase (lag 4)	-0.121*	0.024	-0.124*	0.022	-0.116**	0.000
	(-2.08)	(1.48)	(-2.14)	(1.34)	(-3.42)	(0.12)
Past Wage Increase (lag 4)	0.122	-0.154**	0.127	-0.156**	0.049	-0.150**
	(1.56)	(-3.55)	(1.62)	(-3.60)	(0.62)	(-5.04)
Observations	1836	1829	1836	1829	1836	1829
No. restrictions	8	8	8	8	8	8
χ^2	284	300	292	304	532	494

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$

Source: CBI and ONS data

Notes: The table reports parameter estimates from estimating the determinants of firms' forecast errors controlling for firm fixed effects, with time fixed effects also included in models (3) to (6) (equation (8)). Standard errors are clustered at the firm level. *Expected Cost Increase Expected Employment Increase* and *Expected Orders Increase* are dummy variables which take a value one if the respondent expects an increase and zero otherwise.

5.2.2 New Orders, Employment and Costs

Next, we consider the rationality of the new orders, employment and cost expectations. The challenge, as discussed above, is that these are discrete choice variables. Das et al. (1999) set out methods of testing for rationality when data are categorical. They make the assumption that with three categories a firm responds "Up" if it forecasts an outcome greater than some value a_1, "No change" if the firm forecasts an outcome in the interval $[a_2, a_1]$ and "Down" if it forecasts a value below a_2. The firm reports outcomes one quarter later using the same classification method. The cut points, a_1 and a_2 are assumed not to change between the forecast and the realisation, although they can differ between firms.

Without observing numerical outcomes (see Lui et al. (2011)) it is not possible to test whether a forecast of the mean is rational or not. It is possible, however, to test rationality making the assumption that the forecast is the mode or the median and we follow this approach.[26] If the forecast is a median forecast, the necessary requirement is that the median of the realisation should lie in the same category as the forecast. Thus, with three categories

$$\sum_{j=k+1}^{3} p_{jk} \leq 0.5 \ (k = 1, 2)$$
$$\sum_{j=1}^{k-1} p_{jk} \leq 0.5 \ (k = 2, 3).$$

The results of this exercise do not point to any departure from rational behaviour for any of the three variables we consider: we do not find that more than fifty per cent of the outcomes were for lower ranges than forecast or for higher ranges than forecast. Details of these tests are also available on request.

But, we can also explore this for respondents conditional on the category of their forecast. The test results conditional on the initial forecast do point to departures from rationality. For $k = 1$ or $k = 3$ we simply need to test whether the proportion $p_{kk} \geq 0.5$ is acceptable, contingent on the observed proportion $\hat{p}_{kk}$. This is done using the normal distribution with a one-sided test

$$\sqrt{n_k}\left(\frac{\hat{p}_{kk} - 0.5}{\sqrt{p_{kk}(1 - p_{kk}}}\right) \sim N(0, 1).$$

It is only meaningful to conduct these tests if the observed $\hat{p}_{kk} < 0.5$. If the observed value is greater than 0.5 the one-sided test will never reject the hypothesis that the true probability is at least 0.5. If $k = 2$, it is not possible for both $\hat{p}_{12}$ and $\hat{p}_{32}$ to be above 0.5. If neither value is above 0.5 there is, once again, no point in testing. But if one value is below 0.5, then the normal approximation can again be used to test whether the difference is significant.

[26] Results for those based on the mode are available on request.

In Figure 8a we show the proportions, p_{kk}, of those who (i) reported a fall conditional on having forecast such an outcome, and those who reported a rise conditional on having forecast such an outcome. When this proportion drops below 0.5, this is evidence of a departure from rationality. We also show upper 95% confidence interval for each proportion, calculated as

$$\hat{p}_{kk} + 1.65\sqrt{\frac{p_{kk}(1-p_{kk})}{n_k}}.$$

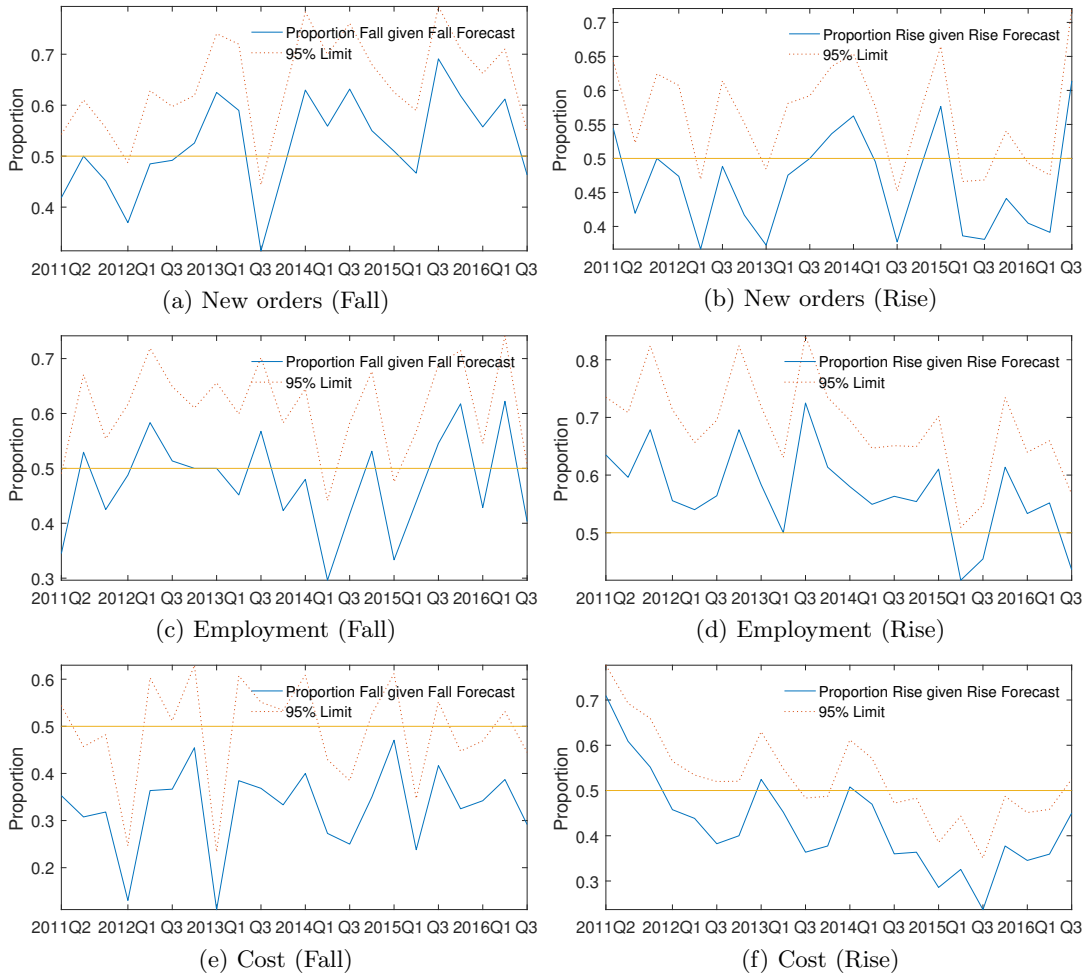
Looking first at movements in new orders, Figures 8a and 8b show there are two cases where the probability of reporting " Down" conditional on having forecast it is significantly below 0.5. There are seven cases where the probability of reporting " Up" conditional on it having been forecast is significantly below 0.5. With just over twenty observations, we should expect only one of each if firms are providing rational forecasts of their median outcomes. There is, therefore, some statistical evidence for over-optimism among firms expecting new orders to rise.

For employment, the evidence for non-rational behaviour is weaker. Figures 8c and 8d show that there are two occasions when the median test is significantly breached, in both cases by firms which had forecast falling employment (in 2014Q2 and 2015Q1). There are no breaches by the firms which forecast stable or rising employment.

On the other hand, forecasts of movements in unit costs clearly fail the tests for rationality. For the firms that forecast falls in unit costs, the median test was failed significantly on ten occasions. For those forecasting rises, the median test was also failed on ten occasions (see Figures 8e and 8f). Of these, there were four occasions (2014Q3, 2015Q2, 2015Q4 and 2016Q1) when the tests were failed both by the firms which forecast falls in costs and by those which forecast rises. This, of course, might indicate that firms tended to take views which were too extreme, both on the upside and on the downside.

We noted earlier that the test is based on the premise that firms' forecasting errors are independent of each other. If there is a single macro-economic influence that leads to out-turns higher than had been forecast, for example, then it is not obvious that this is a failure of efficient forecasting. On the other hand, repeated test failures — of the kind observed for unit cost expectations — may be indicative of forecasting failure rather than macroeconomic shocks. It is hard to see that a common macroeconomic shock could, on four occasions out of twenty-three, lead to significantly below half of the firms who forecast a fall in costs actually experiencing this while, at the same time, significantly fewer than half of the firms who forecast a rise actually experienced this.

Figure 8: Rationality tests for new orders, employment and cost expectations



(a) New orders (Fall)

(b) New orders (Rise)

(c) Employment (Fall)

(d) Employment (Rise)

(e) Cost (Fall)

(f) Cost (Rise)

Source: CBI data

Notes: The figures report results of rationality tests for categorical survey variables using the methodology described in section 5.2.2

5.3 Summary

We find clear departures from rationality for wage and price expectations, with firms that report extreme values for expectations tending to observe less extreme outcomes on average. There is also some evidence that firms which have reported large price and wage increases in the past tend to find outcomes lower than their expectations.

The tests for rationality of the qualitative responses are inevitably different in character. But, on the assumption that firms are reporting medians, we find, once we look separately at the firms forecasting increases from those reporting decreases, clear departures from rationality for new orders and unit costs. For employment the evidence is weaker- in only two quarters for firms forecasting a fall in employment and none for those forecasting an increase.

Expectations of new orders seem more likely to be disappointed on the downside than excessively pessimistic. The most interesting departures were, however, with costs, where we found that, in four quarters, departures both from those forecasting falls and those forecasting increases. This makes it very unlikely that the apparent departures from rationality may have been the outcome of a single macroeconomic shock.

One interpretation of our results is that firms may have rational expectations of quantity variables — employment and to some extent new orders — but not of price variables — wages and unit costs. That might be the case if, at least in the short term, quantity variables are much more important to firms than price variables.[27] Of course, all these factors are still related. For example, employment decisions also affect unit costs. But, while employment expectations appear more rational, there may still be departures from rationality for unit costs: firms may not assess rationally the prospects for the other influences on costs.

6 Conclusions

Modern macroeconomic models make a number of assumptions about the common information, forward-looking behaviour and rationality of firms. These assumptions play an important role in determining the predictions of these models for aggregate outcomes. Insights for these models have also influenced central banking where the management of inflation expectations is considered to be important in order to achieve low and stable inflation rates (Bernanke (2004)).

[27] These findings are also consistent with the results for New Zealand in Coibion et al. (2018) who find that many more firms track GDP compared to inflation.

We shed new light on how firms' expectations are formed, and whether they matter, using a novel panel dataset on manufacturing firms' expectations from the UK's Confederation of British Industry. We focused our analysis around three issues: (i) the information on which firms' form expectations and the associated heterogeneity and dispersion this might produce (ii) whether firms' are forward-looking in their price setting and whether expectations affect pricing outcomes today (iii) whether firms' expectations are rational. All three of these components are central to modern macro models.

We have shown that firms' expectations of price and wage growth are influenced by a combination of aggregate and firm level indicators; price expectations seem mainly related to firm level indicators but with modest influence from past import price growth, while wage expectations are materially influenced by expected GDP growth and past CPI inflation as well as firm-specific effects. Expected growth in new orders and employment are most closely associated with past orders, while cost expectations seem to reflect past firm specific costs and aggregate import price inflation. Given the small amount of previous work on this issue, the precise regression specification we used to arrive at these results is clearly subject to a considerable degree of uncertainty. It is therefore reassuring that the application of Bayesian model averaging to our data, with the aim of uncovering the expectations formation function in an agnostic and systematic way, yields clear results. Overall, this suggests that firm-specific influences play an important role, and that firms are selective about the indicators that they use when forming expectations for particular variables. As in other recent papers, we also find evidence of considerable dispersion of firms' price and wage growth expectations.

Firms' wage and price growth expectations also seem to matter for price setting behaviour. We test the notion that firms' own pricing decisions are influenced by their expectations of what their price might be in the future. To our knowledge, we are the first to examine this relationship at the firm level and, although we do not estimate a structural relationship, our approach can be easily motivated by theories often used to derive aggregate Phillips Curves in the macro literature. We find a clear positive, and significant, effect of expectations on both current wage and price decisions. This is robust to a range of specifications. We use Bayesian model averaging to show that our results are robust to all 131,072 possible regression models. Although this is evidence that firms' expectations are important in pricing decisions, we also show that these expectations are not fully rational. Expectations channels (e.g. in the transmission of monetary policy) therefore still seem potentially important, but actual outcomes will depend on how precisely expectations are formed. The statistical evidence in section 3 speaks to this, but understanding the expectations formation process more deeply is an interesting avenue for future work.

Taken together, our results suggest heterogeneity in the use of information, rational inattention or bounded rationality and some degree of forward-looking behaviour may be important empirical regularities in firms' expectations of future outcomes. This suggests that the transmission mechanisms may be more complex than many models typically assume. Whether this changes the predictions of our models is then, ultimately, a theoretical issue, but our results provide new and important empirical insights to motivate this line of work.

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Table 15: Definition of survey variables

Variable name	Variable description
Expected price growth (C)	Expected increase in price of own output over the next year
Expected wage growth (C)	Expected increase in own wage rates over the next year
Expected unit cost growth (Q)	Are unit costs expected to rise, not change or fall over the next three months?
Expected employment growth (Q)	Is employment expected to rise, not change or fall over the next three months?
Expected new orders growth (Q)	Is the volume of new orders expected to rise, not change or fall over the next three months?
Past price growth (C)	Increase in price of own output over the past year
Past wage growth (C)	Increase in own wage rates over the past year
Past unit cost growth (Q)	Did unit costs rise, not change or fall over the last three months?
Past new orders growth (Q)	Did volume of new orders rise, not change or fall over the last three months?
Past employment growth (Q)	Did employment rise, not change or fall over the last three months?
Rate of operation (C)	Current rate of operation (%)

Notes: C indicates cardinal variable and Q indicates qualitative variable.

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A Variable definitions

Tables 15 and 16 describe the variables used.

B Reweighting

Table 5 shows that the sectoral composition of the CBI survey sample is rather different from that of the manufacturing sector as a whole. Composition effects may, unless corrected, therefore result in survey aggregates which differ from the corresponding aggregate data. In this appendix we describe the re-weighting we have used to correct for this. The first point to note is that the most natural means of weighting would be with reference to value added. That is, however, not possible because the CBI survey does not record the value added of each of its respondents. Instead we are forced to reweight with reference to employment and employment categories. The ONS' Business Structure Database (BSD) allows us to identify enterprises by employment in each enterprise. We classify the firms in the

Table 16: Definition of macroeconomic and industry-level variables

Variable name	Variable description	ONS Code
2-digit price growth	Growth over four quarters in the Output Price Index of the 2-digit SIC to which the firm belongs	Various. See note below.
IR inflation forecast	Rate of inflation over next four quarters forecast by MPC of the Bank of England	
IR GDP growth forecast	Rate of GDP growth over next four quarters forecast by MPC of the Bank of England	
CPI inflation	Rate of CPI inflation over past four quarters	D7BT
AWE growth	Rate of growth of average weekly earnings over past four quarters	KAB9
Unemployment rate	Unemployment rate (%)	MGSX
Import price growth	Rate of growth of import price deflator over past four quarters	(IKBI-BOKH+BQHQ)/(IKBL-BQKO+BQHS)

Notes: Variables are expressed in % p.a. unless stated otherwise.
For 2-digit price codes see table 4 of the data set available at https://www.ons.gov.uk/economy/inflationandpriceindices/datasets/producerpriceindexreferencetables.
The import price index is the deflator for goods and services adjusted for MTIC fraud

economy by employment category as shown in table 4 and SIC 2-digit grouping as shown in table 5. From the BSD we can then work out the share of total manufacturing employment in each employment category/SIC category cell. We use the average values for the period 2008-2016. We can similarly count the number of firms in the CBI sample in each employment category/SIC category cell. A weight for each cell is calculated as the share of employment divided by the number of firms in the cell, again for the whole of the sample period. This means that cells with a relatively high employment share are given high weights and cells with a relatively high number of firms are given low weights. There are four cells with no firms observed in the survey despite some employment being shown in the BSD. We have to give these zero weights, but add employment share to the nearest cell which does show both employment and survey respondents, thereby increasing the weight given to these nearest neighbours.

C A micro-founded firm-level pricing relationship

In this section we illustrate one way to motivate a firm-level pricing relationship consistent with our data and similar to equation 4 in the text. As noted in the text, our goal is not to estimate a particular structural model, but this appendix provides some theoretical motivation for the firm-level analysis in the main text.

We start from the Rotemberg (1982) price setting model and introduce nominal rigidities using price

adjustment costs as in Rotemberg (1982).[28]

Specifically, we consider the following problem faced by a firm that maximises its expected profits in the presence of price adjustment costs,

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[p_t^f y^f - P_t \Psi_t^f - \frac{\gamma}{2} \left(\frac{p_t^f}{p_{t-1}^f} - 1 \right)^2 P_t y_t \right]] / P_t \tag{9}$$

and subject to a demand function that follows the Dixit Stiglitz model of imperfect competition,

$$y_t^f(d) = \left(\frac{p_t^f}{P_t} \right)^{-\theta} y_t, \tag{10}$$

where $\psi_t^f = \partial \Psi_t^f / \partial y_t^f$, is the the marginal cost of production, p_t^f is the price firm f charges for its output, and y_t^f is the quantity produced. P_t is the price of consumption goods and y_t is aggregate output. Ψ_t^f is the cost of production measured in terms of consumption goods, so that $P_t \Psi_t^f$ is the nominal cost of production.

The first order condition is

$$0 = y_t^f (1-\theta) + \psi_t^f \theta y_t^f \tilde{p}_t^f - \gamma \left[\Pi_t^f - 1 \right] \tilde{p}_{t|t-1}^f y_t + \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \gamma \left[\Pi_{t+1}^f - 1 \right] \Pi_{t+1}^f \tilde{p}_{t+1|t}^f y_{t+1} \right) \tag{11}$$

where $\tilde{p}_t^f \equiv \frac{P_t}{p_t^f}, \tilde{p}_{t|t-1}^f \equiv \frac{P_t}{p_{t-1}^f}$ and $\Pi_t^f = \frac{p_t^f}{p_{t-1}^f}$.

To arrive at a linear pricing relationship in terms of firm-level price growth, we linearise the first order condition above. Typically with Calvo pricing-based approaches a symmetric equilibrium would need to be imposed and the linearised pricing relationship would produce the aggregate New Keynesian Phillips Curve. A key advantage of following the approach above is that we end up with a firm level relationship that motives the empirical approach in the text.

For ease of derivation re-define any inflation term as the gross inflation rate, $\tilde{\pi} = 1 + \pi$ above. Also, divide through by y_t^f

$$0 = y_t^f (1-\theta) + \psi_t^f \theta y_t^f \tilde{p}_t^f - \gamma \left[\Pi_t^f - 1 \right] \tilde{p}_{t|t-1}^f y_t + \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \gamma \left[\Pi_{t+1}^f - 1 \right] \Pi_{t+1}^f \tilde{p}_{t+1|t}^f y_{t+1} \right)$$

$$\theta \left(1 - \psi_t^f \tilde{p}_t^f \right) = 1 - \gamma \left[\Pi_t^f - 1 \right] \frac{\tilde{p}_{t|t-1}^f y_t}{y_t^f} + \beta \gamma E_t \left(\frac{\lambda_{t+1}}{\lambda_t \Pi_{t+1}} \left[\Pi_{t+1}^f - 1 \right] \Pi_{t+1}^f \frac{y_{t+1}}{y_t^f} \tilde{p}_{t+1|t}^f \right)$$

[28] The New Keynesian Phillips Curve is often derived using Calvo pricing. Rotemberg pricing produces a pricing relationship relationship at the firm level that would not be possible under Calvo pricing, which assumes some firms do not change prices each period. After aggregation, Rotemberg pricing is identical to Calvo pricing to first order (see Roberts (1995) for a discussion).

Taking the left-hand side first:

$$-\theta\widetilde{\psi}_t^f \tag{12}$$

where $\widetilde{\psi}_t^f = \hat{\psi}_t^f + \hat{p}_t - \hat{p}_t^f$ are firm-specific real marginal costs and $\tilde{p}_t^f = p_t^f / P_t$. It is assumed that the steady-state inflation rate is of size similar to the linearised deviations of the other variables, so that the product of it and any other variables is second-order and can be neglected. In the steady state all inflation rates are assumed equal so that $\left[\Pi_t^f - 1\right] = 0$. This means that we need consider only the linearisation of this term; the deviations of the other terms in the product are multiplied by zero. The first term on the right-hand side simplifies to:

$$-\gamma(\hat{\pi}_t^f) \tag{13}$$

which when linearised (and imposing $\pi = 1$ and symmetry in the steady state becomes, with ˆindicating deviations, and with the deviations of both gross and net price changes equal to $\hat{\pi}_t^f$: Expanding and linearising the second term on the right-hand side gives

$$\gamma\beta\left(\hat{\pi}_{t+1}^f\right) \tag{14}$$

Putting all this together yields a firm-level pricing relationship where individual price changes today are related to future expected own-price changes.

$$\hat{\pi}_t^f = \beta E_t \hat{\pi}_{t+1}^f + \frac{\theta\psi}{\gamma}\widetilde{\psi}_t^f \tag{15}$$

where $\widetilde{\psi}_t^f$ denotes firm-specific real marginal costs (nominal marginal cost relative to their firm's own price). Imposing symmetry would convert this into an aggregate relationship, as in Roberts (1995) (the New Keynesian Phillips Curve).