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Firms' expectations and price-setting: evidence from micro data

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Abstract

In many forward-looking macroeconomic models, such as the New Keynesian model, firms' expectations about the future play a key role in determining outcomes today. We examine this hypothesis using a novel panel dataset on firms actual and expected price changes collected by the Confederation of British Industry. Our microeconometric approach overcomes the identification issues faced by previous empirical studies. The results suggest that firms' expectations play a key role in their price-setting behaviour, with a coefficient on firm's expectations consistent with the discount factor typically assumed in macroeconomic models.

Key words: Pricing-setting, survey data, inflation expectations, New Keynesian Phillips Curve.

JEL classification: C23, C26, E31.

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1 Introduction

Expectations play a central role in forward-looking macroeconomic models. Beliefs about the future matter for consumption and borrowing decisions of households, and for investment and pricing decisions of firms. But despite the central role of this mechanism in dynamic macroeconomics, there is little empirical evidence about whether this is actually how households and firms make decisions in reality.

We provide new evidence on these issues by estimating the effect of firms' inflation expectations on their price setting behaviour using a panel dataset of manufacturing firms in the United Kingdom (UK). Specifically, we make use of the Industrial Trends Survey (ITS), which is conducted quarterly by the Confederation of British Industry (CBI). A novel aspect of this survey is that it collects information on a wide range of variables including the percentage change in firms' prices over the last twelve months *and* the expected change in prices over the next twelve months. This feature of the data allows us to estimate the effect of inflation expectations on pricing decisions of firms.

Much of the research on the role of expectations has come from macroeconomic estimates of pricing relationships such as the New Keynesian Phillips Curve. But there are at least three issues in this literature. First, direct measures of expectations are often unobserved, leading some papers to use actual inflation or expectations projected with vector autoregressions. Secondly, an identification problem commonly encountered is that expectations and outcomes are determined jointly. Thirdly, the literature has not yet found strong instruments for inflation expectations, leading Mavroedis et al. (2014) to argue that it is hard to draw robust conclusions from macroeconometric estimates of New Keynesian Phillips Curves.

We overcome these issues by exploiting *direct* measures of *firms'* expectations from the UK CBI's Industrial Trends Survey. Furthermore, we tackle the identification issues with a novel combination of firm-specific characteristics and forecast surprises in aggregate producer price index (PPI) inflation as instruments for inflation expectations of individual firms. Using macroeconomic variables as instruments has the advantage that reverse causality from firm level shocks is unlikely. That said, there could be omitted variables common to the aggregate variables and firms' inflation expectations, which motivates our use of aggregate PPI forecast surprises (constructed as the difference between aggregate PPI inflation forecasts and aggregate outturns). So long as our PPI forecasts and outturns are affected by the omitted common macroeconomic factor to the same degree, this instrument should be free from reverse causality and omitted variable bias issues. Furthermore, unlike in all previous work, we show that our proposed instruments are strong, allowing us to identify robustly the effect of inflation expectations on current pricing decisions.

Using this novel approach, we provide clear evidence that firms' expectations matter for price setting behaviour as predicted by forward-looking macroeconomic models such as the New Keynesian model.[1] We show that price increases depend on expected future price increases with a coefficient which, while slightly above one, is consistent with a quarterly discount factor of just below, but not materially different from, one. Prices are also found to be affected by costs, with a Phillips Curve slope comparable to conventional calibrations in the New Keynesian literature.

Our empirical work is based on the firm level pricing relationship implied by the New Keynesian framework with Rotemberg (1982) adjustment costs. This allows us to estimate a firm level relationship that resembles the aggregate New Keynesian Phillips Curve, but without imposing a symmetric equilibrium or rational expectations. This is an important distinction: we are exploring the role of expectations in price setting behaviour but, since we observe firms' expectations directly, these expectations need not be rational.

The way in which expectations are formed has recently attracted much attention and related work has uncovered new stylised facts are difficult to reconcile immediately with the assumptions of full information and rational expectations that are used throughout macroeconomics. For example, Coibion and Gorodnichenko (2014) document that survey expectations of professional forecasters, firms, households and FOMC members are heterogeneous and react sluggishly to news, like predictions made by noisy information models. Coibion et al. (2015) collect survey data on firms' inflation expectations in New Zealand. Besides providing more evidence against full information and rationality, they find that firms pay particular attention to news in variables that matter, while discounting other news. Our instrumentation strategy, based on PPI, as opposed to CPI or real GDP growth surprises, is consistent with this result. Pesaran and Weale (2006) survey alternative models of expectation formation and discuss their testable implications.

Our work is also related to microeconometric studies that examine the frequency and determinants of price changes. Recent evidence such as Alvarez et al. (2006) suggests that nearly half of firms use both time-dependent and state-dependent price setting rules. About half of the firms were found to set prices with reference to expected future developments, consistent with the New Keynesian Phillips curve. Loupias and Sevestre (2013), looking at France, found that firms responded more readily to costs than to demand, but since demand, if met, affects marginal cost, it is not clear how far they should be distinguished in empirical work.

So far, there are only few studies that link expectations to decision making and most of these studies only examine household behaviour. 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) document that during the zero lower bound episode in Japan, households that expected higher inflation in the future reported that their household has increased consumption compared with

[1] In fact, Woodford (2005) argues that monetary policy's role in shaping expectations about the future is, in certain circumstances, the key way monetary policy works, stating: "not only do expectations about policy matter, but, at least under current conditions, very little else matters".

one year ago but intended to decrease it in the future. Bachmann et al. (2013) conduct a similar study using US data but do not find any significant relationship between inflation expectations and consumer spending.

One exception is Bryan et al. (2014) who use the FRB Atlanta's Business Inflation Expectations (BIE) survey to estimate the effect of firms' inflation expectations and costs on current prices as predicted by the New Keynesian Phillips curve. However, our work differs from theirs in several important aspects: the ITS survey provides a more granular picture of inflation expectations because responses are recorded in eleven buckets compared to five buckets in the BIE survey. Also, our data already start in 2008, while theirs are available only from 2011. Most importantly, their work assumes that firms' price expectations and marginal costs are exogenous; thus they do not address the weak instrument problem which is a major issue in macroeconomic work. Finally, their analysis uses pooled data; they do not control for firm-specific heterogeneity which can be important in a panel data context.

In contrast to microeconometric studies, there is a large body of research that estimates the New Keynesian Phillips curve using aggregate data. Many papers have attempted to estimate the parameters of this equation from macroeconomic data with either a GIVE/GMM or VAR approach. For example, Gali and Gertler (1999) estimates that the coefficient on the forward looking inflation term is close 0.99, similar to the value implied by economic theory. An alternative approach is to use VAR models to extract inflation expectations from the data and estimate the parameters by minimizing the distance between the model predicted and actual inflation outturns. Sbordone (2002) and Sbordone (2005) use this technique to estimate the Phillips Curve on US data and broadly confirm the findings of Gali and Gertler (1999).

In an exhaustive survey of this literature covering more than 100 papers, Mavroedis et al. (2014) argue that all of this work is subject to a serious weak instrument problem.[2] They conclude that economists have learned all they can from macroeconomic data and an important contribution of this paper is to document how panel data can be used to overcome the identification problems faced by macroeconomic studies.

The remainder of the paper proceeds in the following way: In the next section we describe the survey in more detail. Section 3 then sets out the theoretical framework and the empirical specification. We also discuss identification and our instrumentation strategy in section 4. We present our baseline results in section 5 and then, in section 6, we conduct a range of sensitivity exercises. Section 7 concludes.

[2] A good instrument needs to be both exogenous and strong (highly correlated with the inflation expectations term). But, because changes in inflation are typically hard to forecast in practice (Stock and Watson (2007)), it is particularly difficult to obtain plausible instruments which satisfy the second condition. In practice this means that the results will be dependent both upon the exact econometric specification and choice of instruments.

2 Firm level survey data

Studying the role of firms' expectations on their pricing behaviour requires high quality microeconomic data. Specifically, we require panel data providing information on price changes and expected future prices changes. The Confederation of British Industry (CBI) has collected data on prices since 2008Q1 although it has a much longer history in collecting other data on business experience and business expectations. In fact very few responses were collected in 2008Q1 and 2008Q2 so, for practical purposes, the data begin in 2008Q3 and our data end in 2014Q4. This, in principle, provides us six years of quarterly data, a time dimension of up to 26 quarters.

2.1 The Industrial Trends Survey and its properties

The CBI runs a number of surveys but only the *Industrial Trends Survey*, which covers manufacturing firms, provides the information that is required. In principle, the ITS provides a large sample of around four to five hundred firms, which are sampled each quarter. Unfortunately, however, as shown in Figure 1, there is a sizable number of firms for which we observe only a few consecutive quarters. In other words, the panel is unbalanced and 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 1 or 2 days.

Over the 26 quarters between 2008 and 2014, the average number of quarterly returns from each respondent is 6.3 but the median is only 3. Out of the 1717 firms which reply to the survey over this period only five firms provide complete records for the full sample period. This aspect of the data obviously places some limitations on how we conduct our analysis. In discussing the empirical specification below, we explain that, since the variables we are interested in are reported as the change on the previous year, we consider only observations which do not overlap.

2.2 Price and expectations data

The ITS has a rich set of questions on inflation expectations. Importantly, while the responses are in buckets, there is a wide range of options and firms can report expectations for inflation as well as deflation. They can also enter a precise number if they wish. In order to explore the relationship between firms' current pricing behaviour and their expectations, we are primarily interested in the following two questions from the ITS:

- 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?

Firms can answer these questions by choosing one of 11 buckets or by entering their own answer manually. The midpoints of the buckets range from -9% to +9% giving a good degree of granularity.[3] Manual answers largely still fall within this range and to harmonize the reporting, we assign the manual answers to the corresponding buckets. If the manual answers lie outside the bucket ranges, they are allocated to the largest bucket on either side.[4]

Figure 2 reports expected and perceived price changes together with output price inflation in the manufacturing sector and consumer price inflation. The ITS survey data provides a similar picture for aggregate inflation over time when compared to output price inflation. 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 output price inflation in the manufacturing sector at this time. The congruence between the aggregate properties of the survey and the official data reassures us of the survey's reliability 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 Office for National Statistics.

Compared to output price inflation, the co-movement between expected and perceived price changes and consumer price inflation is weaker. Most importantly, firms' expected own price changes average around 1% which is below realized consumer price inflation rates during the period in question. In terms of this level gap, which is evident in Figure 2, 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. Output prices are also net of Value Added Tax.

The aggregate properties of the ITS therefore give us confidence in the quality of the survey responses. Another way to examine the quality of the survey is to count the number of firms that always provide the same answer.[5] 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, 21 provide the same answer to the question each time. 44 of the 63 respondents in the first case and 19 in the second case reported zero on each occasion. This summary of the pattern of answers suggests that, while there is evidence for clustering of responses about price changes around popular values, there is little evidence that the survey is contaminated by firms

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

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

[5] A study of the qualitative survey of 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.

providing formulaic responses.[6]

Of course, an interesting feature of microeconomic data is not simply the averages but also the heterogeneity across firms. And there is significant dispersion in the inflation expectations and perceptions of firms, as shown in Figure 3. This certainly does not mean that dispersion is noise or error, but instead that there are likely to be genuine reasons for why firms inflation expectations differ.

2.3 Costs

The other key variable we need to estimate the model is a measure of marginal cost. Costs are difficult to measure, especially at the firm level. The ITS contains some measures of costs and rate of operation. For example, one question asks *What is your current rate of operation as a percentage of full capacity?* but it is not clear what firms regard as full capacity and whether this maps well into the theoretical definition of marginal cost.

Another question asks *Is your present level of output below capacity (i.e. are you working below a satisfactory full rate of operation)?* Unfortunately this is only a binary indicator. In addition, the respondents are asked *Excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months, with regard to average costs per unit of output?* But this variable can only take three different values and therefore does not offer much variation.

Finally the survey asks about changes in wage costs (*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) and what is expected to occur over the next 12 months?*), yet without an equivalent measure of the change in output we cannot easily map this into a unit cost measure.

Lacking a satisfactory measure of marginal costs at the firm level, we are forced to make a compromise and construct a measure based on an aggregate series to control for movements in costs. For these data we use the Office for National Statistics nominal unit wage cost measure in manufacturing.[7] This is published quarterly in the ONS's labour productivity data release.

A further issue is that our measure is a measure of average, as opposed to, marginal costs. If firms produce with constant returns to scale the two are, of course, equivalent. But strictly speaking the New Keynesian model that we derive below is specified in terms of marginal costs, and this issue has faced various papers that study the empirical performance of the model and its implications.

For example, Gali and Gertler (1999) consider the performance of the New Keynesian

[6] A different concern is that 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 that this is not the case.

[7] As opposed to a broader measure of unit labour costs which includes employer social security and pension contributions. This broader measure is not available for the manufacturing sector. The ONS series identifier is DIX4.

Phillips Curve using the labour income share in the non-farm business sector for real marginal cost, relying on the Cobb-Douglas production function with constant returns to scale in capital and labour. Gali et al. (2007) examine the welfare costs of business cycles by examining markup dynamics where price markups (and real marginal cost) are derived from a model with constant returns to scale. [8] Here, we therefore follow Gali et al. (2007) in using an average cost measure.

3 A firm level New Keynesian Phillips Curve

3.1 Economic model

In this section we derive a variant of the New Keynesian Phillips Curve that can be estimated at the firm level. To achieve this, we introduce nominal rigidities using price adjustment costs as in Rotemberg (1982).[9] In contrast to the derivation of the aggregate New Keynesian Phillips Curve as in e.g. Gali (2008), our model does not assume symmetry or rational expectations. But we do impose a symmetric steady state during linearisation.

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

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

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

$$y_t^f(d) = \left(\frac{p_t^f}{P_t} \right)^{-\theta} y_t, \tag{2}$$

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

$$0 = y_t^f(1-\theta) + \psi_t^f \theta y_t^f \tilde{p}_t^f - \gamma \left[\Pi_t^f - 1 \right] \tilde{p}_{t|t-1}^f y_t + \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \gamma \left[\Pi_{t+1}^f - 1 \right] \Pi_{t+1}^f \tilde{p}_{t+1|t}^f y_{t+1} \right) \tag{3}$$

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 $\Pi_t^f = \frac{p_t^f}{p_{t-1}^f}$.

[8] However, Gali et al. (2007) also consider generalisations, following Rotemberg and Woodford (1999), where average and marginal cost can diverge (for example in models with overhead labour costs).

[9] Rotemberg pricing allows us to derive a Phillips Curve 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.

To arrive at a linear Phillips Curve relationship in inflation 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 be the aggregate Phillips Curve. A key advantage of following the approach above is that we end up with a firm level New Keynesian Phillips Curve that can be used in estimation. The linearised first-order condition is[10]

$$\hat{\pi}_t^f = \beta E_t \hat{\pi}_{t+1}^f + \frac{\theta\psi}{\gamma}\widetilde{\psi}_t^f \tag{4}$$

where $\widetilde{\psi}_t^f$ denotes firm-specific real marginal costs (nominal marginal cost relative to their firm's own price).

One notable feature of this pricing relationship is the lack of a lagged term. The empirical macroeconomic literature has tended to include lagged inflation when estimating Phillips Curves using macroeconomic data to capture sluggish price dynamics (such as Fuhrer and Moore (1995) and Gali and Gertler (1999)). The micro-foundations for the lag term, however, tend to be somewhat *ad hoc* and we see at least three arguments against attempting to include a lag in our framework.

First, the micro-foundations typically employed in the New Keynesian literature features an inflation index in the objective function of the firm. This leads firms to index to the aggregate inflation rate but if we follow this formulation it would produce both individual and aggregate inflation expectations terms in equation (4). In the macroeconomic literature, symmetry in equilibrium means all firms make the same pricing decisions. As such, this distinction between aggregate and firm level variables disappears and the Phillips Curve can be written in the common hybrid form with a forward and backward looking term. Since we do not want to impose symmetry of this kind, equation (4) derived with indexation, does not look like the typical hybrid Phillips Curve in the literature.

Secondly, this problem becomes even more acute when we write equation (4) to match our annualised survey data. We discuss the consequences of this in the next section.

Perhaps most importantly, it is conceptually unclear whether the inclusion of a lag term to proxy sluggish adjustment of expectations is necessary. The macroeconomic literature tends to estimate the aggregate Phillips Curve using ex-post inflation data. However, we observe inflation expectations directly. Our derivation above assumes that firms are forward-looking, but not that their expectations for future inflation are rational (an issue we explore later). As such, the observed expectations variables may still embed some degree of adaptive behaviour and lags would then be highly correlated with expectations measures. For all these reasons we prefer to estimate equation (4) directly, and analyse the issue of rationality separately in Section 5.2.

[10]The linearisation is set out in appendix A.

3.2 Temporal aggregation

A challenge that we face is that the survey asks for growth rates over the past twelve months and expected future growth rates over the coming twelve months. To treat these data as though they are related to quarterly growth rates may introduce serial correlation and hence seriously bias the estimates. We can, however, address the problem of temporal aggregation by adding up four successive New Keynesian Phillips Curve equations for the change in the price level. More detail is given in Appendix B but, in summary, we arrive at the following expression for the current four-quarter growth in prices, explained by the expected four-quarter growth in prices

$$\hat{\pi}_t^{4f} = \beta E_{t-3}\hat{\pi}_{t+1}^{4f} + \frac{\theta\psi}{\gamma}\widetilde{\psi}_t^{4f} + u_t \tag{5}$$

where the superscript 4 indicates that the variable, if a growth rate, relates to the growth rate over the preceding four quarters, while if in levels it relates to the sum of the quarterly variables up to, and including the quarter indexed.

The residual term will include the effects of idiosyncratic (ϵ_t^f) and aggregate shocks ($\bar{\epsilon}_t$) both directly and via the implied forecast errors as a result of temporal aggregation. Specifically:

$$\begin{aligned} u_t &= \beta\left(E_t\hat{\pi}_{t+1}^f + E_{t-1}\hat{\pi}_t^f + E_{t-2}\hat{\pi}_{t-1}^f\right) - \beta\left(E_{t-3}\hat{\pi}_{t+1}^f + E_{t-3}\hat{\pi}_t^f + E_{t-3}\hat{\pi}_{t-1}^f\right) \\ &\quad + \epsilon_t^{4,f} + \bar{\epsilon}_t^4 \end{aligned} \tag{6}$$

u_t is then partly driven by the error introduced in the equation because four-quarter expectations are formed at quarter $t-3$ instead of being the sum of the quarterly expectations formed one quarter earlier.

4 Econometric method and identification

4.1 Econometric model

We estimate a more general specification of the theoretical model that also controls for unobserved heterogeneity which is important in panel data settings (Hsiao (2003)). This is achieved by introducing individual-specific fixed effects α_f,

$$\hat{\pi}_{tf}^4 = \alpha_f + \beta\hat{\pi}_{t+1f}^{e4} + \kappa\widetilde{\psi}_{tf}^4 + u_{tf} \tag{7}$$

where we define $\hat{\pi}_{t+1f}^{e4} \equiv E_{t-3}\hat{\pi}_{t+1}^{4f}$. Both past and expected price changes are taken from the ITS survey. Firm-specific real marginal costs $\widetilde{\psi}_{tf}^4$ are constructed in the following way.[11] As shown in Appendix A, firm-specific real marginal costs can be expressed as

[11] See also Table 1 for on overview of the variables used and their definitions

$\widetilde{\psi}_t^f = \hat{\psi}_t^f + \hat{p}_t - \hat{p}_t^f$. For lack of a better measure for costs, the first two terms are measured by nominal unit wage costs in manufacturing (see also Section 2.3). The term $\hat{p}_t^f$ is the firm-specific price level in deviation from its trend. To construct this variable from the ITS data we cumulate the inflation perceptions series for each firm.[12]

As in all studies of the New Keynesian Phillips Curve, the regressors in equation (7) are likely to be endogenous since a variety of firm-specific and aggregate shocks can affect inflation, inflation expectations and marginal costs contemporaneously, as can be seen from equation (6). In addition, our use of an industry level cost measures implies that an idiosyncratic component, that may be correlated with expectations, is present in the error term. We therefore require instruments for firm level inflation expectations and the remainder of the section discusses how we address this identification problem.

4.2 Instruments

The majority of attempts to estimate the effect of inflation expectations on current pricing behaviour rely on aggregate data. As a result all of these previous studies are subject to a number of identification challenges, particularly with respect to the inflation expectations term. As noted above, expectations will be endogenous. A good instrument needs to be both exogenous and strong (highly correlated with the inflation expectations term).

In macroeconomic data valid instruments are hard to come by and, because changes in inflation are typically hard to forecast in practice (Stock and Watson (2007)), it is often difficult to obtain plausible instruments that are not weak. In practice this means that the results will be dependent both upon the exact econometric specification and choice of instruments. For example, Rudd and Whelan (2007) argue that the approach of Gali and Gertler (1999) yields spurious results. In particular, they argue that the use of particular instruments (commodity price and wage inflation) pushes the coefficient closer to 0.99 and that alternative econometric approaches yield smaller estimates. Gali et al. (2005) show that, so long their original specification and choice of instruments is used, their finding is robust to alternative econometric estimators. With respect to the VAR approach, Mavroedis et al. (2014) show that the use of weak instruments tends to push the coefficient spuriously closer to unity. Based on their survey of over one hundred papers, which attempt to estimate the NKPC, they conclude that economists have learned all that they can from macroeconomic time series.

We tackle the identification problem that has faced macroeconometric studies by using

[12]There are two practical problems when constructing a measure for $\hat{p}_t^f$. First, the responses relate to growth rates over four quarters. This means that we cannot cumulate reported price changes forward from the start of the data set in 2008Q3. Instead, we need four initial conditions for the price level at the start of the sample. Since each firm is located in its 2-digit sector we assume that the initial conditions in 2007Q4-2008Q2 are given by the price index for the output of the relevant 2-digit industry. Allowing for the presence of firm fixed effects means that any deviation of the actual starting price of each firm from that given by the output price index is absorbed into the fixed effect. In quarters with missing observations we replace the missing inflation rate with the 2-digit industry average from the ITS and then cumulate across the sample as if we observed the full span of inflation observations.

a combination of firm-specific and aggregate variables as instruments for inflation expectations and costs. In particular, the use of aggregate expectations becomes an attractive option since reverse causality from firms' to aggregate forecasts is unlikely.

This approach, however, does not necessarily address omitted variable bias if common shocks drive firm-level expectations and aggregate variables at the same time. Lagging aggregate variables will not address this issue, since common shocks could be serially correlated (a key issue with using lags in macroeconomic studies). To address this problem we instead instrument firms' inflation expectations using forecast surprises in aggregate PPI inflation in the UK and the Euro Area. Surprises are computed as the difference between the average short-run forecast (the latest available forecast before the actual outturn) of professional forecasters and the actual outturn. So long as the mean short-run forecast and actual outturn are affected by common factors to the same degree, these surprise series will not be contaminated by common shocks and hence constitute valid instruments.[13]

Two further features of our strategy are important. First, unlike in the macroeconomic literature, we can show that our proposed instruments are strong. Secondly, our instruments are also intuitively appealing: we are instrumenting firm level producer prices with aggregate PPI surprises. This instrumentation strategy is consistent with the finding of Coibion et al. (2015) that firms pay particular attention to news in variables which are most relevant for them. This implies that surprises in CPI inflation or real activity indicators, such as employment, unemployment or real GDP growth should also have an impact on prices, although one might expect the relationship to not be as direct, leading these wider indicators to be weaker instruments. This is precisely what we find in Section 6.2.

We augment this set of instruments with firm-specific variables. In the baseline specification we use lags of the firm's exporter status (a binary indicator which we take as a fixed characteristic) and the firm's price level. One potential objection to this approach is that some of our proposed firm-level instruments might be determined by factors that are also present in the firm-specific inflation expectations term, in other words that they may not be genuinely exogenous and generated by firm specific shocks. Lagging the instrument will not resolve this issue if these idiosyncratic common factors are serially correlated. However, since the model already includes fixed effects, this objection would require the presence of some time-varying firm-specific effects that affected both firms' inflation expectations and the instruments. For carefully selected instruments, these issues are much less of a concern than for the corresponding macroeconomic aggregates. For example, firms' exporter status is unlikely to change that rapidly in response to shocks.

[13] An alternative approach to account for unobserved factors that are common to the dependent variable and individual-specific regressors is the method developed in Harding and Lamarche (2011) who propose a common correlated effects estimator that is applicable if some regressors are endogenous. We have applied this approach and find that the point estimates are very similar to our baseline findings. That said, in relatively small samples such as ours, the standard errors using this approach tend to be wide. The results are available on request.

Table 1 provides more detail on the aggregate and firm-specific instruments used in our baseline specification. The forecast surprise series can be used contemporaneously for the reasons discussed above. To be cautious, for the firm level instruments, we use lagged values.[14]

5 Results

5.1 Baseline results

The results of estimating equation (7) are shown in Table 2. The first column reports estimates where both EA and UK PPI forecast surprises are used as instruments, and column (2) reports results where the sum of UK and EA forecast surprises is used instead. In both specifications, we find that expected future price increases are important in explaining current price increases: each firm's price increase over the past year is related to its expectations of price increases with a coefficient statistically indistinguishable from one.[15] The influence of real marginal costs is also apparent with a coefficient of around 0.06. But most importantly, the Kleinbergen-Paap statistic is 13 and 17.9 for the specifications reported in columns (1) and (2), respectively. These figures exceed the Stock and Yogo relative bias statistics at the 5 per cent level.

The coefficient on expected price increases is consistent with (statistically indistinguishable from) the quarterly discount factor of just below one, which is the most commonly used parameter calibration in the literature. This suggests that firms' expectations do indeed play a role in their current pricing behaviour, and in a way that is consistent with New Keynesian theory.

The magnitude of the coefficient on the cost variable is a bit larger than that adopted by Gali (2008) who uses a value of 0.043, although our value of 0.06 corresponds to a Calvo probability of having a fixed price of around 0.77, which is of the order of magnitude commonly used in the New Keynesian literature. In summary, both coefficients are remarkably close to with what would be predicted by theory.

While our results suggest forward-looking pricing behaviour that is consistent with the standard New Keynesian Phillips Curve, importantly, however, we are not "testing" the full New Keynesian model. This would require full estimation of the model's other equations and, almost surely, an assumption of rational expectations. Our goal in this paper is more modest: to assess whether expectations matter for current behaviour, and in a way that is consistent with the pricing relationship that is one of the fundamental building blocks of modern macroeconomic theory. That said, in the next section we examine the degree of which pricing behaviour is consistent with rational expectations.

[14] Given the temporal aggregation, these assumptions imply using the three quarter lag of the forecast surprises and the four quarter lag of the firm level instruments.

[15] The p-value for testing this restriction is 0.42 and 0.37 in column (1) and (2), respectively.

5.2 Are expectations rational?

An important implication of rational expectations is that forecast errors are zero in expectation conditional on the information that was available to the forecaster (Rossi and Sekhposyan (2015)).[16] This section tests whether the forecasts made by the respondents of the CBI survey are rational. In a panel data setting, forecast rationality can be tested by estimating the model

$$\widehat{e}_{f,t+4} = \alpha_f + \theta \hat{\pi}^{e4}_{t+4f} + \epsilon_{f,t+4} \tag{8}$$

where $\widehat{e}_{t+4} \equiv \pi^{4f}_{t+4} - \hat{\pi}^{e4}_{t+4f}$ is the 1-year ahead forecast error at time t defined as the difference between the outturn and the 1-year ahead forecast. The panel data model in equation (8) is estimated using standard errors that are robust to heteroskedasticity and autocorrelation because forecast errors are likely to be correlated over time.[17]

If expectations are rational, we would expect that both α_f and θ in equation (8) are equal to zero. Alternatively, the rationality test can be formulated as a joint test of unbiasedness ($\alpha_f = 0$) and efficiency ($\theta = 0$). Table 3 reports the results from estimating the model in 8 for alternative samples that are defined by firm size (columns 2 and 3) or exporter status (columns 4 and 5). We find that rationality is rejected for all samples considered, possibly pointing to information frictions as discussed in e.g. Coibion and Gorodnichenko (2014). [18]

6 Robustness

In this section we provide several robustness exercises. Specifically, we document that our baseline results in Table 2 are robust to using alternative firm-level instruments. We also show that PPI inflation surprises provide the strongest instrument within a large set of alternative surprise indicators because the alternative surprises are less directly related to producer prices. All additional instruments used in this section are described in Table 4.

6.1 Sensitivity to alternative firm level instruments

Table 5 documents that our main results are robust to to using alternative sets of firm-level instruments. In specification (1), firm's exporter status is replaced by a firm-specific capacity indicator. Specification (2) uses firm's unit costs instead of firm's exporter status

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

[17] 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.

[18] There is a controversial debate among economists whether or not it is possible to test for rational expectations using survey data, see Keane and Runkle (1999) for a summary. One argument against rationality tests based on survey data is that one can test only the implications of theories, rather than the assumptions they are built upon (Prescott (1977)). Others disagree by pointing to an identification problem that arises when a theory is rejected because without testing for rational expectations, it is not possible to find out whether the equations of the model have been rejected or the assumptions about expectation formation (Keane and Runkle (1999)). Here, we adopt the later view.

and specification (3) includes firm's rate of operation. All specifications include forecast surprises and the lagged price level as instruments.

6.2 Sensitivity to other surprise indices

In Section 4.2, we argued that contemporaneous PPI inflation surprises are a good instrument, since they are likely to be more directly related to firm producer price expectations. Clearly, surprises about CPI inflation, real GDP growth, wages, employment and unemployment outturn can also affect firms inflation expectations in the same manner, but one might expect the effect to be weaker. Indeed, Coibion et al. (2015) find that firms pay particular attention to news in variables which are most relevant for them, while discounting others. This suggests that out of the universe of possible forecast surprises, PPI (i.e. those most closely related to firms) surprises should be the strongest instrument. Table 7 re-estimates our baseline specification, but with these different sets of instruments. Most of these variables do not pass weak instrument tests, reinforcing the relevance and validity of the instruments used in our baseline specification.

6.3 Small and large firms

Table 8 repeats our baseline regression separately for small and large firms where size is defined based on the number of employees. Compared to small firms (column (1)), large firms (column (2)) are more forward looking and change their price by more for a given change in their marginal costs. But probably due to the reduced number of observations used in each regression, the weak identification statistics are lower compared to our baseline specification.

7 Conclusions

Forward-looking macroeconomic models assume that decisions by economic agents are affected by their beliefs about the future. This insight has 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)).

Despite the theoretical importance of firms' expectations, robust empirical evidence on the effect of expectations on outcomes is scarce. In the case of the New Keynesian Phillips curve, the wide range of estimates in the literature tends to reflect a challenging weak instrument problem. This paper has tackled the issue by providing new evidence on the effect of inflation expectations on firms' pricing decisions in a panel dataset of UK manufacturing firms. As we show, it is our combination of microeconometric data and macroeconomic instruments that helps us to address the identification problem that has been so challenging in the macroeconometric literature.

We find that firms' expectations matter for price setting behaviour and price increases depend on expected future price increases with a coefficient which is consistent with a quarterly discount factor of just below one. Prices are also found to be affected by costs, with a coefficient magnitude that is consistent with theory.

Our results are hopefully of key relevance for future macroeconomic research. Using a novel empirical strategy, our findings shed new light on one of the most important building blocks of New Keynesian models, and are supportive of the view that economic outcomes today are indeed shaped by expectations of the future.

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Table 1: Description of variables in the baseline specification

a) Variables included in the second stage regression

Symbol	Name	Description
π_{tf}^{4}	Price change	Firm's reported price increase over the past year
π_{tf}^{e4}	Expected price change	Firm's expected price increase over the next year
$\widetilde{\psi}_{t}^{4}$	Real marginal costs	Log of annualized unit wage costs in manufacturing minus firm's annualized log price level

b) Instruments

Name	Description
Aggregate instruments	
UK PPI forecast surprises	Average of professional forecasts of UK PPI inflation (data source: Bloomberg) closest to the date of the actual outturn minus UK outturns. Forecast surprises are normalized to have zero mean and a standard deviation equal to 1. The daily surprise series is summed up to quarterly data.
EA PPI forecast surprises	Average of professional forecasts of German, French and Italian PPI inflation (data source: Bloomberg) closest to the date of the actual outturn minus individual country outturns. Forecast surprises are normalized to have zero mean and a standard deviation equal to 1. The daily surprise series are averaged across countries. The resulting time series is summed up to quarterly data.
Total (UK and EA) PPI forecast surprises	Sum of EA forecast surprises and UK forecast surprises
Firm-level instruments	
Lagged quarterly price level	Lag 4 of firm's price level constructed by accumulating reported inflation rates extrapolated with 2 digit industry-level inflation rates
Lagged exporter status	Lag 4 of firm's reported exporter status

Table 2: The effect of firm's inflation expectations on price setting

	(1) Price changes	(2) Price changes
Expected price changes	1.162**	1.181**
	(5.82)	(5.82)
Real marginal costs	0.061**	0.062**
	(4.00)	(4.01)
Observations	1095	1095
Kleibergen-Paap weak IV statistic	13.0	17.19

t statistics in parentheses

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

Notes: Real marginal costs and expected price changes are instrumented with: lagged quarterly price level, lagged exporter status, EA and UK PPI forecast surprises (column (1)) and total PPI forecast surprises (column (2)). According to the Stock-Yogo (2005) critical values, the Kleibergen-Paap test statistics exceed the 5 (5) percent threshold for the relative bias and the 15 (10) percent threshold for the size for column (1) (column(2)). The underidentification test is rejected with a p-value of 0 (0) and the overidentification test is accepted with a p-value of 0.50 (0.84).

Table 3: Testing for rationality of firm's inflation expectations

	(1) $\widehat{e}$	(2) $\widehat{e}$	(3) $\widehat{e}$	(4) $\widehat{e}$	(5) $\widehat{e}$
Inflation expectations	0.775**	0.924**	0.609**	0.687**	0.898**
	(18.41)	(17.85)	(10.44)	(14.07)	(13.83)
Constant	-0.576**	-0.653**	-0.498**	-0.578**	-0.463**
	(-12.63)	(-11.23)	(-8.24)	(-10.45)	(-7.37)
Observations	2232	1151	1081	1548	684

t statistics in parentheses

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

Notes: Dependent variables are forecast errors. The first column reports results for all firms. The second and third column contain results for small and large firms and the final columns report results for exporters and non-exporters, respectively.

Table 4: Description of additional instruments used for robustness checks

Name	Description
Aggregate instruments	
UK CPI forecast surprises	as UK PPI forecast surprises except for CPI
EA CPI forecast surprises	as EA PPI forecast surprises except for CPI
UK real GDP growth forecast surprises	as UK PPI forecast surprises except for real GDP growth
EA real GDP growth forecast surprises	as EA PPI forecast surprises except for real GDP growth
UK industrial production forecast surprises	as UK PPI forecast surprises except for industrial production
EA industrial production forecast surprises	as EA PPI forecast surprises except for industrial production
UK unemployment forecast surprises	as UK PPI forecast surprises except for unemployment
EA unemployment forecast surprises	as EA PPI forecast surprises except for unemployment
Firm-level instruments	
Lagged unit costs	Lag 4 of firm's reported change in unit costs over the past 3 month
Lagged rate of operation	Lag 4 of firm's reported rate of operation over the past 3 month
Lagged capacity indicator	Lag 4 of firm's reported capacity indicator over the past 3 month

Table 5: The effect of firm's inflation expectations on price setting: alternative firm-specific instruments (UK and EA surprises)

	(1) Price changes	(2) Price changes	(3) Price changes
Expected price changes	1.158^{**}	1.106^{**}	1.189^{**}
	(6.19)	(5.92)	(6.20)
Real marginal costs	0.061^{**}	0.058^{**}	0.062^{**}
	(4.08)	(3.92)	(4.07)
Observations	1078	1081	1087
Kleibergen-Paap weak IV statistic	14.51	15.46	15.42

t statistics in parentheses

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

Notes: Real marginal costs and expected price changes are instrumented with: *all specifications*: lagged quarterly price level and EA and UK PPI forecast surprises. *Column (1)* also includes lagged capacity indicator, *column (2)* uses lagged unit costs and *column (3)* uses lagged rate of operation. According to the Stock-Yogo (2005) critical values, the Kleibergen-Paap test statistics exceed the 5 percent threshold for the relative bias and the 15 percent threshold for the size. The underidentification test is rejected with a p-value of 0 in all cases and the overidentification test is accepted with a p-value ≥ 0.35.

Table 6: The effect of firm's inflation expectations on price setting: alternative firm-specific instruments (total surprises)

	(1) Price changes	(2) Price changes	(3) Price changes
Expected price changes	1.169^{**}	1.108^{**}	1.202^{**}
	(6.17)	(5.90)	(6.20)
Real marginal costs	0.062^{**}	0.058^{**}	0.063^{**}
	(4.07)	(3.91)	(4.07)
Observations	1078	1081	1087
Kleibergen-Paap weak IV statistic	19.11	20.59	20.43

t statistics in parentheses

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

Notes: Real marginal costs and expected price changes are instrumented with: *all specifications*: lagged quarterly price level and total PPI forecast surprises. *Column (1)* also includes lagged capacity indicator, *column (2)* uses lagged unit costs and *column (3)* uses lagged rate of operation. According to the Stock-Yogo (2005) critical values, the Kleibergen-Paap test statistics exceed the 5 percent threshold for the relative bias and the 10 percent threshold for the size. The underidentification test is rejected with a p-value of 0 in all cases and the overidentification test is accepted with a p-value ≥ 0.2.

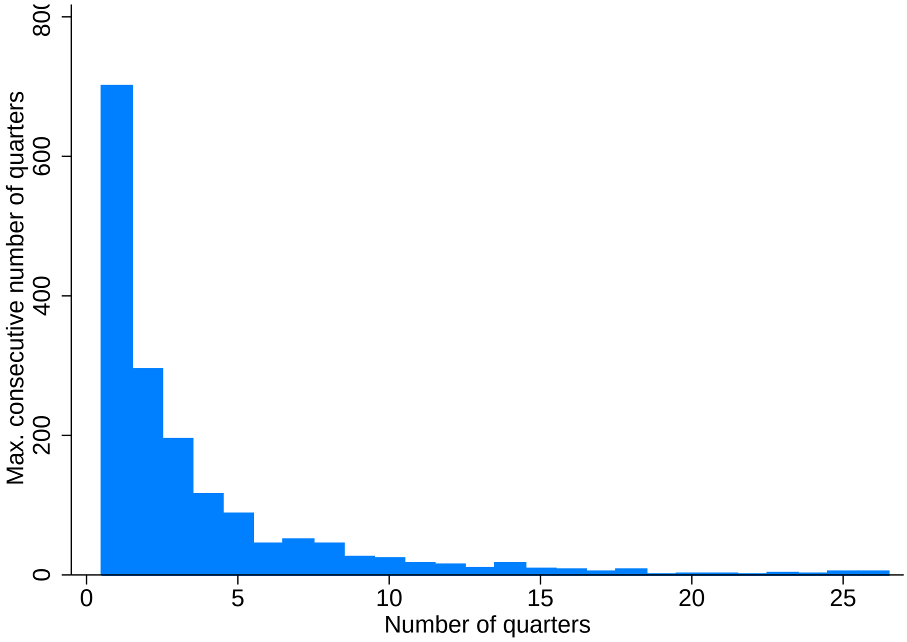
Table 7: The effect of firm's inflation expectations on price setting: alternative surprise instruments

	(1) Price changes	(2) Price changes	(3) Price changes	(4) Price changes
Expected price changes	1.363**	1.306**	0.968**	2.209
	(4.11)	(3.56)	(3.50)	(0.57)
Real marginal costs	0.061**	0.063**	0.063**	0.058*
	(3.71)	(3.89)	(4.32)	(2.52)
Observations	1095	1095	1095	1095
Kleibergen-Paap weak IV statistic	4.64	3.89	5.40	0.1

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$

Notes: Real marginal costs and expected price changes are instrumented with: *all specifications*: lagged quarterly price level and lagged unit costs. *Column (1)* also includes UK and EA industrial production forecast surprises, *column (2)* uses UK and EA CPI forecast surprises, *column (3)* uses UK and EA real GDP growth forecast surprises and *column (4)* uses UK and EA unemployment forecast surprises. According to the Stock-Yogo (2005) critical values, the Kleibergen-Paap test statistics cannot reject weak identification at conventional thresholds. The underidentification test is rejected with a p-value of 0 in all cases and the overidentification test is accepted with a p-value ≥ 0.15.

Figure 1: Maximum number of consecutive quarters



Notes: For each non-consecutive observation, the number of subsequent observations for that firm.

Table 8: The effect of firm's inflation expectations on price setting: Small vs. large firms

	(1) Price changes	(2) Price changes
Expected price changes	0.852**	1.384**
	(3.39)	(4.78)
Real marginal costs	0.043*	0.072**
	(2.46)	(2.80)
Observations	575	484
Kleibergen-Paap weak IV statistic	7.51	5.75

t statistics in parentheses

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

Notes: Column (1) reports results for small firms (number of employees below the median) and column (2) for large firms (number of employees at least equal to the median). Firm-specific real marginal costs and expected price changes are instrumented with: lagged quarterly price level, lagged unit costs, EA and UK PPI forecast surprises. According to the Stock-Yogo (2005) critical values, the Kleibergen-Paap test statistics exceed the 20 (20) percent threshold for the relative bias and the 25 (30) percent threshold for the size. The underidentification test is rejected with a p-value of 0 (0) and the overidentification test is accepted with a p-value of 0.23 (0.88).

Figure 2: Time Series of Official and Survey Data

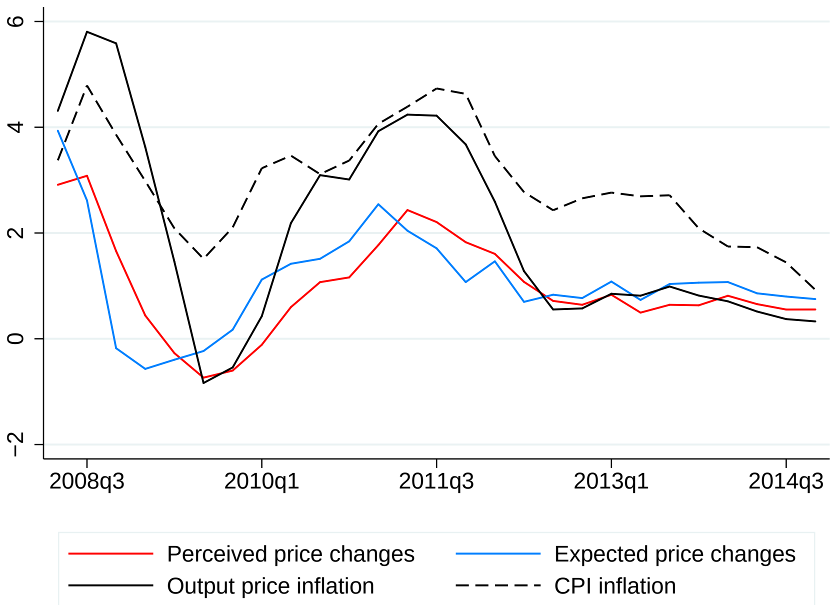
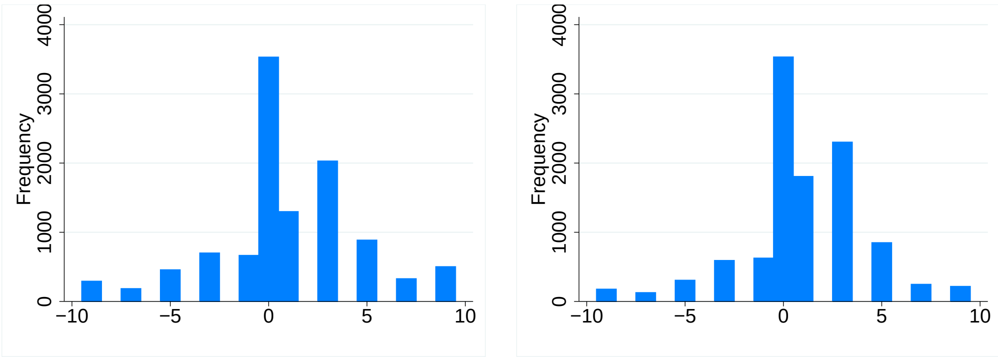


Figure 3: Distribution of past and expected price changes



(a) Perceived price change over the past 12 months

(b) Expected price change over the next 12 months

A Linearisation of the pricing relationship

This section presents the linearisation of the pricing relationship in the paper and shows how to reach the firm level Phillips Curve. The presentation here is also slightly more general in that we show what happens when firms index to aggregate inflation Π. As can be seen, addition terms show up the the Phillips Curve that could be rearranged into the usual hybrid-type Phillips Curve (assuming indexation to past inflation) after imposing symmetry. Since this is not an assumption we wish to make (as our firms in the ITS are clearly heterogeneous), we would be left with additional terms that would be hard to interpret.

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

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

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

Taking the left-hand side first:

$$-\theta \widetilde{\psi}_t^f \tag{9}$$

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:

$$-\gamma(\hat{\pi}_t^f) \tag{10}$$

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

$$\gamma\beta \left(\hat{\pi}_{t+1}^f\right) \tag{11}$$

Putting all this together:

$$\hat{\pi}_t^f = \beta E_t(\hat{\pi}_{t+1}^f) + \frac{\theta\psi}{\gamma} \widetilde{\psi}_t^f \tag{12}$$

B Temporal aggregation

Temporal aggregation starts by adding up the four Phillips Curves across four periods. Specifically, write equation (4) together with three lags as

$$
\begin{aligned}
\hat{\pi}_t^f &= \beta E_t \hat{\pi}_{t+1}^f + \frac{\theta\psi}{\gamma}\widetilde{\psi}_t^f + \epsilon_t^f + \bar{\epsilon}_t \\
\hat{\pi}_{t-1}^f &= \beta E_{t-1} \hat{\pi}_t^f + \frac{\theta\psi}{\gamma}\widetilde{\psi}_{t-1}^f + \epsilon_{t-1}^f + \bar{\epsilon}_{t-1} \\
\hat{\pi}_{t-2}^f &= \beta E_{t-2} \hat{\pi}_{t-1}^f + \frac{\theta\psi}{\gamma}\widetilde{\psi}_{t-2}^f + \epsilon_{t-2}^f + \bar{\epsilon}_{t-2} \\
\hat{\pi}_{t-3}^f &= \beta E_{t-3} \hat{\pi}_{t-2}^f + \frac{\theta\psi}{\gamma}\widetilde{\psi}_{t-3}^f + \epsilon_{t-3}^f + \bar{\epsilon}_{t-3}
\end{aligned}
$$

After adding these equations together we can collect the shock terms and forecast errors. to yield the equation reported in the main text.