The Effect of Unconventional Monetary Policy on Inflation Expectations: Evidence from Firms in the United Kingdom*

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This paper investigates the effect of quantitative easing (QE) and other unconventional monetary policies on price and wage growth expectations of UK manufacturing firms. To identify the effect of QE on firms' expectations, we use a novel approach of combining microeconometric data with macroeconomic shocks: QE is exogenous to inflation expectations of individual firms, and so are other macroeconomic developments like aggregate inflation or GDP growth. We find that firms' price and wage inflation expectations increase by 0.22 percentage points in response to £50 billion of QE, implying that inflation expectations are part of the transmission mechanism of QE. In contrast, we find a positive but small and insignificant effect of forward guidance on price and wage inflation expectations.

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1. Introduction

Following the onset of the "Great Recession" and after short-term interest rates hit the zero lower bound, several central banks adopted unconventional monetary policies to support their economies. Unconventional instruments ranged from purchases of different assets (quantitative easing, QE) to forward guidance on the future conduct of monetary policy. Some instruments, such as the Bank of England's Funding for Lending Scheme (FLS), were designed to directly stimulate domestic non-financial lending. Among these new instruments, purchases of government bonds were probably most widely used across countries: including Operation Twist the Federal Reserve System bought government bonds worth $1567 billion, and the government bond purchases by the Bank of England amounted to £375 billion.

Modern macroeconomic theory places strong emphasis on the importance of inflation expectations. Monetary stabilization policy involves anchoring long-term expectations at the inflation target and credibly ensuring a stable path for private-sector expectations back to the inflation target following any disturbance. Moreover, at the zero lower bound, preventing inflation expectations from falling is crucial to avoid a liquidity trap (Krugman 1998), and the recent unconventional monetary policy actions were aimed at avoiding such an adverse outcome.

This paper therefore investigates whether the recent unconventional policy interventions in the United Kingdom succeeded in increasing inflation expectations. Specifically, we investigate the effect of unconventional monetary policy measures on the manufacturing price and wage inflation expectations of UK manufacturing firms using a novel panel data set collected by the Confederation of the British Industry (CBI). The data cover the period 2008–14. We find that firms' expectations for annual own price inflation increase by 0.22 percentage points in response to £50 billion of QE. Similarly, their expectations for industry-wide annual price inflation increase by 0.19 percentage points. The increase in expected wage growth is somewhat higher at 0.28 percentage points.

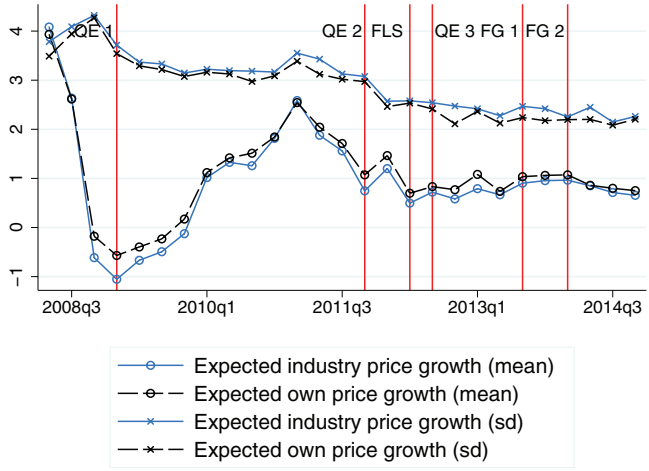
Whilst evidence of whether unconventional monetary policies affected firms' expectations is scarce, there is a growing literature on the effects of QE on asset prices and macroeconomic outcomes.

Gagnon et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), and D'Amico and King (2012) document that the first U.S. large-scale asset purchases program led to a statistically significant decline of about 30–90 basis points in Treasury yields. Following asset purchases by the Bank of England, Meier (2009) and Joyce et al. (2011) find a decline of UK gilt yields of about 40–100 basis points. But to gauge the effect these policies have on financial markets, existing studies have used time-series regressions or event-study techniques focused on dates around the announcement. Despite being an important contribution to understanding whether QE worked, these papers have typically not assessed how financial market movements translated into effects on the wider economy.

Studies that do examine the wider impact of unconventional monetary policy typically adopt vector autoregression methods or structural macroeconomic models. In terms of structural models, Chung et al. (2011) use the Federal Reserve Board's U.S. macroeconomic model to examine the possible impact of U.S. large-scale asset purchases and find that real GDP and inflation were, respectively, 3 percent and 1 percent higher as a result of the Federal Reserve's asset purchase policy. Del Negro et al. (2011) study the Federal Reserve's liquidity facilities through the lens of a DSGE model with financial frictions and find that these policies were highly effective at preventing an even deeper recession. But these economic models are typically based on strong assumptions about the precise transmission mechanism of asset purchases.

Kapetanios et al. (2012) estimate a range of time-varying structural vector autoregression (SVAR) models on UK data and conclude that £200 billion in asset purchases increased inflation by $1\frac{1}{4}$ percent and real GDP by $1\frac{1}{2}$ percent. In a related study, Weale and Wieladek (2016) find, using a wide range of alternative identification schemes that do not impose restrictions on the response of output and inflation, a similar impact on real GDP, but an effect on inflation that is three times as large. Baumeister and Benati (2013) produce related estimates for the United States. Studies that investigate the effect of QE using time-series data are, however, subject to two major econometric challenges. First, QE is observed only for a short period of time, which makes the application of many time-series estimators difficult. Secondly, identifying the effect of QE on the macroeconomy

Figure 1. Monetary Policy Announcements and Inflation Expectations (means and standard deviations)



faces a serious endogeneity problem because QE both affects and responds to macroeconomic developments.

To illustrate the endogeneity problem in macroeconomic data, figure 1 reports the cross-sectional averages of manufacturing price and wage inflation expectations in our data set together with announcements of unconventional monetary policies in the United Kingdom. The series clearly move together and policy actions, naturally, appear highly correlated with the state of the economy. At the aggregate level, it is therefore difficult to identify whether the policy decision is caused by or drives macroeconomic developments such as expected or realized price growth. We exploit the fact that QE and other unconventional policy actions are exogenous with respect to expectations of individual firms. Of course, while this tackles the reverse causality issue, there could be common factors shifting both monetary policy and firm-level expectations jointly. We address this omitted-variable problem by including a wide range of macroeconomic variables that are likely to have influenced the policymakers' decisions as proxies for the components of the monetary policy rule. Since these variables are also aggregate variables, there is no reverse causality problem from including them.

Recently, the formation of expectations has attracted much attention.[1] The closest papers to ours are by Bryan, Meyer, and Parker (2014), Coibion and Gorodnichenko (2015), Coibion, Gorodnichenko, and Kumar (2015), and Cloyne et al. (2016). Coibion and Gorodnichenko (2015) and Coibion, Gorodnichenko, and Kumar (2015) uncover new stylized facts about how various economic agents form their expectations. For example, Coibion and Gorodnichenko (2015) document that survey expectations of professional forecasters, firms, households, and Federal Open Market Committee (FOMC) members are heterogeneous and react sluggishly to news, like predictions made by noisy information models. Coibion, Gorodnichenko, and Kumar (2015) collect new survey data on firms' expectations in New Zealand. Besides providing further evidence against full information and rationality, they show that firms pay particular attention to news in variables that matter, while discounting other news. Bryan, Meyer, and Parker (2014), who use the Federal Reserve Bank of Atlanta's Business Inflation Expectations (BIE) survey, compare firms' expectations with those of professional forecasters and households. They also explore how well firms' expectations forecast their perceived inflation and relate the accuracy of expectations to uncertainty about future inflation. In Cloyne et al. (2016), we explore the issue of whether firms' expectations matter for their pricing decisions today.[2] Compared with these papers, the contribution of our work is to estimate the effects of monetary policy on firms' expectations of growth in (i) the prices of their output, (ii) the prices of the output of their industry, and (iii) the wage rates that they pay. We summarize these as firms' expectations of price and wage inflation.

[1] There is a large theoretical literature on the formation of inflation expectations—as, e.g., Carroll (2003)—that we do not survey here.

[2] Other related work includes Hori and Shimizutani's (2005) study of the determinants of households' inflation expectations in Japan using a quarterly panel data set. They find that inflation expectations are affected by current inflation and past inflation expectations. The majority of Japanese households do not revise their inflation expectations following policy announcements by the Bank of Japan. Finally, Pesaran and Weale (2006) survey alternative models of expectation formation and discuss their testable implications.

It is possible that unconventional policy interventions also reduced uncertainty.[3] Unfortunately, our data set does not include direct information on firms' uncertainty about expected price and wage inflation, although we can still compute the dispersion across firms over time. Figure 1 reports the standard deviation of firms' inflation expectations. In general, dispersion declines over this period, consistent with reduced uncertainty since the early part of the crisis. But examining the role of monetary policy in driving this faces a similar identification problem to the one discussed earlier. Moreover, in studying dispersion, we would lose the cross-sectional dimension that we exploit for identification. The effect of unconventional monetary policies on uncertainty is an important topic, although outside the scope of this paper.

The rest of the paper proceeds as follows: Section 2 describes the CBI's Industrial Trends Survey (ITS) we use in this paper. Section 3 discusses our empirical approach. Our main results and a series of robustness exercises are reported in sections 4 and 5. Section 6 concludes.

2. Data

To investigate the effect of QE on price and wage inflation expectations of individual firms, we ideally need panel data on firms' expectations and with a range of firm-specific characteristics. In the United Kingdom the Confederation of British Industry (CBI) has collected quarterly data on firms' expected price and wage growth since 2008. While the broader CBI survey has a much longer history, we focus only on the sample for which information on price and wage inflation expectations is available. The CBI survey is conducted for several different sectors of the economy, but we use only the Industrial Trends Survey (ITS), which surveys firms in the manufacturing sector. We do this for two reasons. First, the ITS has the advantage that there is a large sample of firms (about 400 in each quarter) and these firms are relatively homogeneous (being all in manufacturing).

[3]For example, Weale (2013) presented evidence that the variance of option prices of future LIBOR rates decreased significantly after both the Funding for Lending Scheme and forward guidance announcements in the United Kingdom.

Second, the number of firms in the other sectors is not large enough to conduct separate analyses. Pooling the surveys would also group together very different types of firms, making it hard to interpret the results. The remainder of this section provides more information on the ITS survey and discusses how we measure the unconventional policy interventions of the Bank of England.

2.1 Overview of the Industrial Trends Survey

The ITS asks UK firms about their estimates of expected future trends in prices and wages, among other questions. Lui, Mitchell, and Weale (2011) document that the ITS data contain valuable information about developments in the manufacturing sector, and Mitchell, Smith, and Weale (2013) find that an aggregate indicator of output growth constructed from individual CBI survey responses can provide a useful early indicator of realized output growth. The survey is carried out on a quarterly basis, and our data set starts in 2008:Q2 and ends in 2014:Q4. The questions that provide us with our main dependent variables of interest are as follows:

- "What has been the percentage change over the past twelve months in the general level of output prices in the UK markets that your firm competes in, and what is expected to occur over the next twelve months?"
- "What has been the percentage change over the past twelve months in your firm's own average output price for goods sold into UK markets and what is expected to occur over the next twelve months?"
- "What has been the percentage change over the past twelve months in your firm's wage/salary cost per person employed (including overtime and bonuses) and what is expected to occur over the next twelve months?"

Firms can answer these questions by choosing one of eleven buckets or by entering their own answer manually. The midpoints of the buckets range from −9 percent to +9 percent in the case of inflation

and from −1.5 percent to +7.5 percent for wages.[4] We put the manual answers into the corresponding buckets. If the manual answers lie outside the bucket ranges, they are allocated to the largest bucket on either side.[5]

2.2 Descriptive Statistics

We start by documenting the key aggregate characteristics of our data. It is worth noting that our sample period coincides with a deep UK recession. So it is not surprising that in the survey we observe a sharp decline in inflation expectations in 2008/9 (figure 2A). The observed decline in firms' expected price growth was of much the same magnitude as the fall in output price inflation in the manufacturing sector. Overall, firms' price and wage inflation expectations lead output price growth in the manufacturing sector over the sample period. This is reassuring because it can be interpreted as an indication that the ITS is representative of the manufacturing sector. Expected own and industry-wide price growth was, however, only around 1 percent on average, and this is significantly below realized aggregate CPI inflation rates.[6] Bryan, Meyer, and Parker (2014), for the United States, also find that firms' expectations are, on average, informative about aggregate price measures. For example, they find that unit-cost inflation expectations correlate with firms' expectations of core CPI inflation. Expected price and wage growth leads perceived outcomes, too (figures 2B–2C).

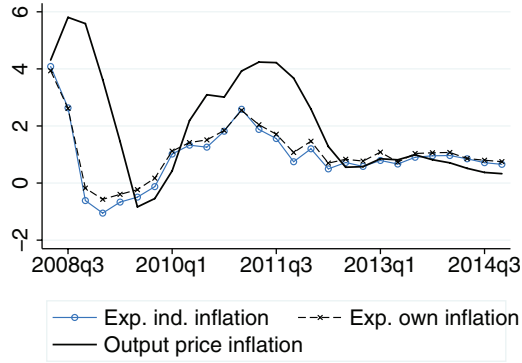
[4]Specifically, the buckets are −8.1 to −10 percent; −6.1 to −8 percent; −4.1 to −6 percent; −2.1 to −4 percent; −0.1 to −2 percent; no change; 0.1 to 2 percent; 2.1 to 4 percent; 4.1 to 6 percent; 6.1 to 8 percent; and 8.1 to 10 percent for inflation. For wages, they are −1.1 to −2 percent; −0.1 to −1 percent; no change; 0.1 to 1 percent; 1.1 to 2 percent; 2.1 to 3 percent; 3.1 to 4 percent; 4.1 to 5 percent; 5.1 to 6 percent; 6.1 to 7 percent; and 7.1 to 8 percent.

[5]This treatment does not affect our results, as fewer than 1 percent of all answers are entered manually.

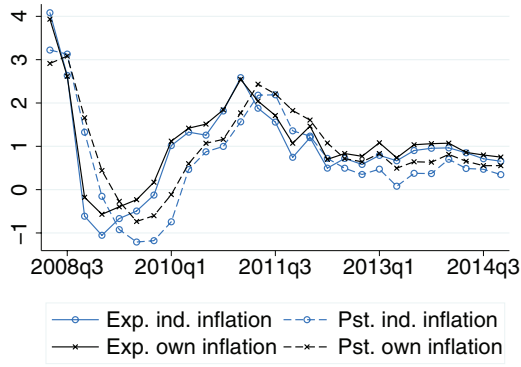
[6]One possible reason for this difference in levels is that firms exclude the effects of taxes such as value-added tax (VAT) from their responses. A further possible explanation for the level difference between the survey data and the official data is that some respondents may misinterpret the questions by answering "no change" when they mean that the rate of growth rather than the price level has not changed. But a recent answering practices survey conducted by the CBI suggests that this is not the case.

Figure 2. Cross-Sectional Averages of Price and Wage Growth Expectations and Perceptions

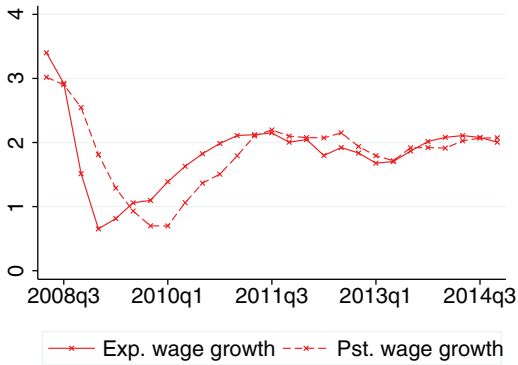
A. Price Growth Expectations and Realized Inflation



B. Price Growth Perceptions and Expectations



C. Wage Growth Perceptions and Expectations



Turning to the cross-sectional dispersion, figure 3 shows histograms for expected price and wage inflation. For own and industry-wide expectations, the distributions are centered around zero, but there is a second mode around 3 percent (figures 3A and 3B). The histogram for wage growth expectations is bimodal, too, with one mode at 2.5 percent and another at zero (figure 3C). Compared with price growth expectations, the histogram for expected wage growth is less dispersed, although this probably reflects the smaller range of the bins on the survey for reporting wage expectations. The survey also has information on firms' current perceptions of price and wage growth. Using this, there is also a distribution of forecast errors across firms, and we discuss this further in appendix 1. Importantly, however, the strong co-movement between the survey averages and the aggregate official data suggests that the cross-sectional heterogeneity averages out at the aggregate level.

2.3 Choice of Sample

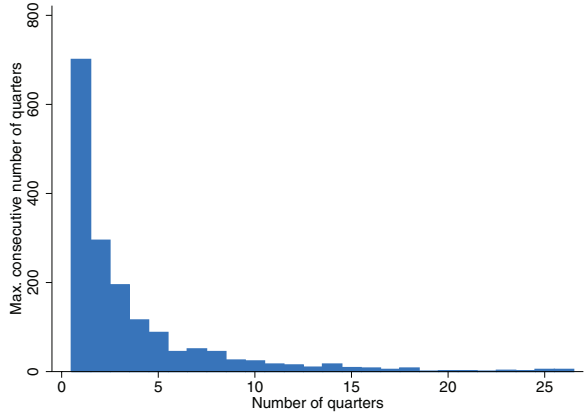
In principle the survey is a panel with firms approached repeatedly. Unfortunately, however, as shown in figure 4, there is a sizable number of firms for which we observe only a few consecutive quarters. In other words, the panel is unbalanced and the number of exits and re-entrants is large relative to the sample size (there are periods of substantial, although sometimes temporary, non-response by firms). In large part, the reason for this is that the ITS is intended to provide a rapid snapshot 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.

Over the twenty-six 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 1,717 firms which reply to the survey over this period, only 5 firms provide complete records for the full sample period.

This characteristic of our data poses some challenges on how to select a reliable and representative sample. On the one hand, firms that remain in the survey for a longer period may be more reliable, but, on the other hand, using more observations increases statistical

Figure 3. The Distribution of Expected Price and Wage Growth

Figure 4. Maximum Number of Consecutive Quarters



Note: The maximal number of subsequent observations for each firm is reported.

significance and reduces the risk of selection effects. As a compromise, we decided to include only firms that remained in the survey for at least four consecutive quarters. In appendix 3 we discuss sample selection in more detail. Specifically, we formally test whether the distribution of the dependent variables changes as we use alternative criteria to select our sample. Reassuringly, we fail to reject the equality of distributions as we limit the sample to firms observed for at least four quarters compared with other sample choices.

2.4 Unconventional Monetary Policy Measures

Between 2009 and 2014, the Bank of England deployed three main unconventional policy measures to stabilize output and prices following the onset of the Great Recession: (i) QE, which largely involved the purchase of government securities from the private sector using newly created central bank reserves[7]; (ii) the Funding for Lending Scheme, which offered banks discounted access to funding conditional on increasing lending; and (iii) the Bank provided forward guidance on when it would consider raising the Bank Rate from 1/2

[7]The Bank of England also purchased a small amount of corporate bonds and commercial paper. However, these purchases only amount to £3 billion compared with £375 billion of gilt purchases.

percent, regarded at the time as the effective lower bound. The key announcement dates can be seen in figure 1.[8]

As can be seen, the most-used tool over this period was quantitative easing (QE), and we will therefore focus more heavily on this instrument. Unlike monetary policy through the short-term interest rate, where the announcement of the policy coincides with implementation, asset purchases were first announced and then implemented. If the announcement of asset purchases is a signal that monetary conditions are going to be looser in the future or that the central bank will do "whatever it takes" to save the economy, then announcements are the more relevant variable of interest. On the other hand, e.g., in the presence of preferred-habitat investors, the implementation of QE (actual purchases) will affect the long end of the yield curve and hence financial conditions in the wider economy.

In the United Kingdom, QE was also typically implemented shortly after it was announced, with purchases of £25 billion per month. This is different from the United States, where purchases were implemented over a longer period following QE announcements. At a quarterly frequency, as in this paper, announcements and implementation will therefore be very highly correlated. For all these reasons, we therefore measure QE as the *announcement of additional asset purchases* in a given quarter scaled by nominal GDP in 2009:Q1.[9] This measure of QE is reported in figure 5. The episodes corresponding to QE1, QE2, and QE3 can be clearly identified. In section 5, we assess the robustness of our results to alternative measures of QE that are based on either a binary indicator for the QE announcement dates or the difference in the outstanding QE amounts.

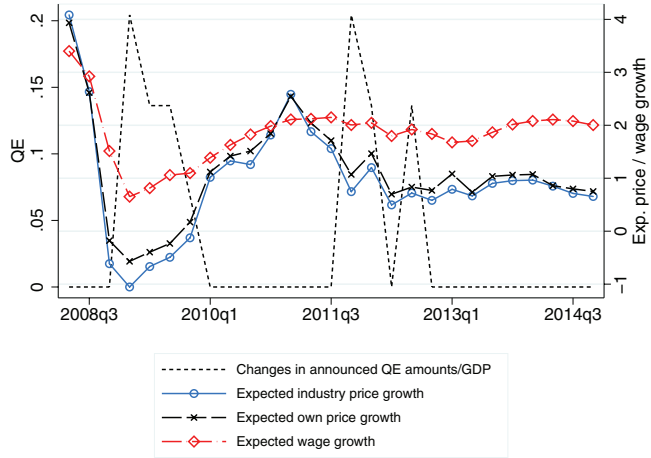
In the baseline regressions, we will also include a binary variable for announcements of forward guidance in 2013:Q3 and 2014:Q1.[10]

[8] Appendix 2 discusses how the timing of the survey fieldwork relates to the timing of the unconventional policy actions in the United Kingdom.

[9] This is equivalent to the change in the intended stock of assets purchased.

[10] In addition, we add a binary variable for the quarter when the Bank of England's Funding for Lending Scheme was implemented. Because this coincided with the European Central Bank President's "whatever it takes" speech (which was widely reported as having helped stabilize economic conditions in the euro zone), we do not place much emphasis on the results for this.

Figure 5. Inflation Expectations and Additional Announcements of Asset Purchases



As noted by Dale and Talbot (2013), "the primary aim of the MPC's forward guidance is to clarify its reaction function and thus make its current policy setting more effective. It is not an attempt to inject additional stimulus by pre-committing to a 'lower for longer' policy with the aim of pushing inflation above target for a period, raising inflation expectations and reducing real interest rates, such as that described by Woodford (2012)." That said, it is nonetheless interesting to see whether, in addition to QE, this intervention affected expectations of firms, as we explore in section 4.

3. Econometric Methodology

To investigate the effects of QE on firms' price and wage inflation expectations, we estimate the following linear panel data model:

$$Y_{it} = \alpha_i + \beta P_t + \delta M_t + \phi X_{it} + e_{it}, \tag{1}$$

where Y_{it} is the expectation of own price, industry-wide price, or own wages inflation over the next twelve months of firm i and quarter t. α_i are individual fixed effects to control for unobserved heterogeneity, which is important when estimating panel data models (Hsiao

2003). P_t are the monetary policy announcements, M_t are macroeconomic and financial variables, and X_{it} are firm-specific variables.[11] Some of the robustness checks reported in section 5 also control for a set of industry-specific variables.

Consistency of the OLS estimates requires that there is no reverse causality and that there are no common factors that influence both the independent and the dependent variables. Formally, we require strict exogeneity of the form

$$E(e_{it}|P_1, \ldots, P_T, M_1, \ldots, M_T, X_{i1}, \ldots, X_{iT}, \alpha_i) = 0. \qquad (2)$$

Because monetary policy is exogenous from the point of view of the individual firm, using macroeconomic data helps us to overcome the reverse causality issue that is a major concern for time-series studies. That is, QE and other unconventional monetary policy measures are not directly caused by individual firms' expectations. This will also be true for other macroeconomic, financial, or industry-specific factors.

To tackle the omitted-variable issue and ensure that there are no common factors affecting both firms' expectations and the policy variables, we control for many macroeconomic and financial factors. Specifically, we use GDP growth, aggregate wage growth, CPI inflation, the growth in the effective exchange rate, oil price growth, the VIX, a measure of UK credit spreads, and a measure of news in UK data releases as control variables. Among these, CPI inflation and GDP growth are arguably the most important, as these are likely to be key variables in the reaction function of the central bank. In section 5 we show that our results are not sensitive to considering a more parsimonious list of macro controls or to including additional industry-specific variables.

In our baseline specification we also include some firm-level variables. Since firm-level variables could be endogenous, we only include those likely to be fixed characteristics or to only change slowly over

[11] In view of the categorical nature of our dependent variables, the regression model (1) can be interpreted as an approximation of an ordered probit model. The responses are categorical even though the number of categories is large. In the robustness section, we document that an ordered probit gives similar results when compared to OLS.

time. Specifically, we use whether the firm is an exporter and the discrete bin the firm reported for the number of employees. For this latter variable, the bin sizes are large and so changes between quarters in this variable are likely to be slow moving. That said, in the robustness section we also show that our results are unaffected by excluding these.

4. The Effects of Unconventional Policies on Firms' Price and Wage Inflation Expectations

Table 1 reports our main results. First we discuss the effects of quantitative easing. We find that QE has a positive and significant effect on price and wage inflation expectations. QE is measured as the announced increase in asset purchases scaled by nominal quarterly GDP in 2009:Q1. This implies that for £50 billion of QE, firms' own price inflation expectations (for inflation over the next year) increase by 0.22 percentage points.[12] For industry-wide inflation expectations, the increase is similar at 0.19 percentage points. The effect on wage expectations is 0.28 percentage points.

One interesting feature of these results is that all measures of expectations are affected: expectations of industry prices, own prices, and wages. The unconditional correlation between wage and price expectations is around 0.3, although it is noteworthy that QE has similar effects on both price and wage inflation expectations. One reason for this could be that these are firm-reported expectations for wage inflation over the next twelve months. To the extent a firm expects to increase prices as a result of QE, it is natural that they might also expect to have to increase wages. The causality could also work the other way: in light of stronger demand, firms expect wages to be higher than otherwise would have been the case, and expect to put up prices accordingly. In related work, Cloyne et al. (2016), we explore the link between costs, expectations, and pricing behavior of firms using the framework of the New Keynesian Phillips curve.

One caveat in interpreting these estimates is the co-incidence between the first QE episode and the final cut in Bank Rate to $\frac{1}{2}$

[12]That is the regression coefficient, 1.598 times the size of the shock $\frac{50}{367}$ where the denominator is nominal GDP in 2009:Q1.

Table 1. Fixed Effects Regressions of Price and Wage Inflation Expectations on QE

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
QE	1.598*	1.407*	2.078*
	(2.19)	(2.06)	(7.10)
FG	0.181	0.114	0.059
	(1.93)	(1.25)	(1.14)
FLS	0.588**	0.505**	0.496**
	(3.51)	(3.03)	(7.08)
GDP Growth	0.124**	0.117**	0.045**
	(3.60)	(3.55)	(3.02)
Wage Growth	0.118**	0.087**	0.072**
	(4.02)	(3.23)	(5.57)
CPI Inflation	0.395**	0.377**	0.338**
	(5.28)	(5.43)	(9.59)
Effective Exchange Rate Growth	−0.043**	−0.036**	0.001
	(−3.77)	(−3.35)	(0.30)
Oil Price Growth	0.006**	0.005*	−0.003**
	(2.88)	(2.55)	(−3.06)
VIX	−0.062**	−0.049**	−0.029**
	(−7.91)	(−6.69)	(−8.00)
Credit Spread	−0.003**	−0.003**	−0.005**
	(−3.45)	(−3.36)	(−13.31)
Macroeconomic News	−0.028**	−0.023**	−0.009**
	(−5.82)	(−5.55)	(−3.78)
Exporter	0.348	0.085	0.177*
	(1.75)	(0.43)	(1.97)
Employees/1,000	−0.156	0.053	0.053
	(−0.72)	(0.27)	(0.67)
Constant	1.542**	1.555**	2.782**
	(5.12)	(5.31)	(20.39)
Observations	7,189	7,277	7,499
Adjusted R^2	0.122	0.105	0.159

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$.

percent per annum. As such, our estimates should strictly be taken as evidence of the effects of the packages of policy measures announced on the QE dates. That said, after that first QE episode, the other announcements implemented only further amounts of QE.

As discussed earlier, we also include variables for two other unconventional policies: the Funding for Lending Scheme (FLS) and forward guidance (FG). Table 1 also shows that the effects of forward guidance on price and wage inflation expectations have the intuitive sign (positive) but are insignificant. We also include a dummy for the quarter where the Bank of England's Funding for Lending Scheme was implemented. Here we find a sizable and significant effect on wage and price expectations.

The lack of effect on average inflation expectations from FG and the positive effect from the FLS accords with evidence on the reaction of financial markets presented by Weale (2013). A number of arguments might also support the view that FG could reduce uncertainty but might not affect average expectations. For example, using the distinction of Campbell et al. (2012), *delphic* FG—which aims to communicate the central bank's view about the current state of the economy—may or may not affect the mean of inflation expectations. In contrast, *odyssean* FG—which is designed to impart extra stimulus in a "lower for longer" manner—should also affect the mean.[13]

Directly comparing our results for the effects of different policy instruments does require some caution. The FG intervention is measured by a dummy variable. Naturally this has much less variation than our QE measure, and the lack of significance may simply reflect a lack of identification. The FLS announcement also occurred in the same quarter as the ECB President's "whatever it takes" speech (which was widely reported as having helped stabilize economic conditions in the euro area). As noted above, this dummy does have a significant and positive effect on price and wage inflation expectations. But we do not believe it is possible to disentangle the effects of the two separate policies. We therefore prefer to interpret our

[13]We thank the referee for pointing out this interesting interpretation of our results. Consequently, our results do not necessarily imply that forward guidance does not affect firms' expectations in general.

results for the FLS dummy as a control for the combined effect of the unconventional policies announced in this quarter.

One advantage of using macroeconomic data as control variables is that we can also see whether these have the expected effect on the manufacturing price and wage inflation expectations of firms. We find that GDP growth has a significant and positive effect on price and wage inflation expectations. Turning to the role of prices, CPI inflation has a positive effect on firms' inflation and wage expectations. Both of these results seem intuitive.

In terms of wider macroeconomic variables, price and wage inflation expectations are positively related to wage growth and negatively to credit spreads and the VIX. The VIX is a measure of volatility that is computed from stock market options in the United Kingdom. The negative effect seems reasonable given that the VIX is a well-known measure of macroeconomic uncertainty and movements in the VIX and credit spreads were well correlated with the European sovereign debt crisis over this period. We also control for macroeconomic news, defined as the difference between the outturns of main macroeconomic indicators and their consensus forecasts. This variable acts to control for forward-looking factors in the determination of inflation expectations.

Our regressions also include firm characteristics. To avoid reverse causality, we include only firm-specific variables that describe the current state of the firm and are slow in adjusting to expectations such as the firm's exporter status and the number of employees. But these variables are not significant in determining price and wage inflation expectations.

5. Robustness and Extensions

5.1 Alternative Estimation Methods

Our OLS estimates are subject to two econometric concerns. First, we have treated all manual responses outside of the highest and lowest buckets as though they are answers at the midpoint of these buckets, with a corresponding treatment of those lower than the lowest bucket. This means that our data are censored, and failure to take this into account may distort our estimates. Secondly, there is

some evidence (Pesaran and Weale 2006) that when people respond to surveys of the type from which these data are drawn, they tend to show a preference for some numbers over others, with the implication that responses which appear to be cardinal may in fact be better seen as ordinal. In particular the central bucket, "no change" is likely to include responses slightly different from zero, with the implication that the adjacent buckets may also slightly differ from their labeling.

Both of these issues can be addressed, although at the expense of making strong parametric assumptions about the nature of the underlying disturbance process. The tobit model is the classic means of estimating models using censored data; it assumes that the residuals of equation (1) are normally distributed. Given this, it is possible to estimate the underlying relationship. The second issue can be dealt with by estimating an ordered probit model, again making the assumption that the residuals of the equation which drives the latent variable (actual price and wage inflation expectations) are normally distributed. With both of these alternative specifications, we continue to find that QE has a significant effect on both wage and price expectations, while forward guidance does not. Thus our results are robust to the simplifying assumptions we have made in estimating by OLS.[14]

5.2 Sensitivity to Controls

In this section we consider the robustness of our results to different sets of control variables. First, we use a more parsimonious set of macro controls. These results are reported in table 2. In this specification we only include the binary variable for FLS and other policy announcements, GDP growth, wage growth, inflation, and the credit spread. The results for the policy coefficients are largely unchanged from the baseline regression.

Next, we consider adding an extra control for U.S. QE, an important potential omitted variable. Table 3 again shows that our findings are very similar in magnitude.[15] The effect of UK QE on firms'

[14]Tobit and ordered probit estimates are available from the authors on request.

[15]The significant effects of U.S. QE suggest international spillovers that could be the subject of interesting future work.

Table 2. Fixed Effects Regressions of Price and Wage Inflation Expectations on QE (fewer macro controls)

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
QE	1.352	1.177	2.046**
	(1.83)	(1.72)	(6.90)
FG	0.139	0.080	0.078
	(1.48)	(0.87)	(1.51)
Observations	7,189	7,277	7,499
Adjusted R^2	0.103	0.092	0.148

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$. The same set of control variables as in table 1 is included, with the exception of exchange rate growth, oil price growth, and VIX.

Table 3. Fixed Effects Regressions of Price and Wage Inflation Expectations on QE (controlling for U.S. QE)

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
QE	1.380	1.238	2.052**
	(1.90)	(1.82)	(6.90)
FG	0.353**	0.252*	0.080
	(3.31)	(2.45)	(1.51)
U.S. QE	0.001**	0.001**	0.000
	(4.25)	(3.87)	(1.18)
Observations	7,189	7,277	7,499
Adjusted R^2	0.124	0.107	0.159

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$. The same set of control variables as in table 1 is included.

expected price growth loses significance at the 5 percent level but clearly remains significant at the 10 percent level. The effect of UK QE, however, still remains highly significant for firms' expected wage growth. Interestingly, the forward guidance dummy now becomes

Table 4. Fixed Effects Regressions of Price and Wage Inflation Expectations on QE (including industry controls)

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
QE	1.699*	1.590*	2.162**
	(2.31)	(2.31)	(7.29)
FG	0.144	0.095	0.045
	(1.50)	(1.01)	(0.086)
Observations	7,062	7,151	7,373
Adjusted R^2	0.126	0.107	0.159

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$. The same set of control variables as in table 1 is included in addition to industry controls (employee growth, gross value-added growth, and output price inflation).

significant. While controlling for U.S. QE is of course important, this is also the only specification that supports an effect of forward guidance. Given that this coefficient is not significant in any other regression, we do not see this as evidence against our previous conclusion that the effects of forward guidance are too imprecisely estimated to give a clear indication of whether it affected firms' expectations.

If monetary policy were responding to the conditions in manufacturing, we would not be adequately capturing this by including UK macro aggregates. To guard against this concern, table 4 reestimates our baseline specification including industry-level employee growth, gross value-added growth, and output price inflation. Reassuringly, the policy coefficients are all very similar to our baseline results.

A further concern is that the firm-level variables are endogenous. This is particularly true for the employees variable. Table 5 therefore presents the results where these are excluded. Again, the main results are very similar.

Finally, we examine whether adding labor productivity measures affects our findings. Since productivity growth can be an important determinant of wages, it seems natural to include this as a further control. Table 6 adds two-digit industry-level labor productivity measures to the equation for wage expectations (keeping all

Table 5. Fixed Effects Regressions of Price and Wage Inflation Expectations on QE (excluding firm-specific controls)

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
QE	1.588*	1.410*	2.083**
	(2.18)	(2.07)	(7.10)
FG	0.186*	0.114	0.060
	(1.98)	(1.25)	(1.17)
Observations	7,189	7,277	7,499
Adjusted R^2	0.121	0.105	0.158

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$. The same set of control variables as in table 1 is included, with the exception of firm-specific variables.

Table 6. Fixed Effects Regressions of Wage Inflation Expectations on QE (including two-digit productivity)

	Expected Wage Growth
QE	2.101**
	(7.17)
FG	0.057
	(1.10)
FLS	0.500**
	(7.12)
Productivity	0.025**
	(3.49)
Observations	7,464
Adjusted R^2	0.100

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$.

the baseline control variables).[16] As can be seen, the effects of unconventional monetary policies are very similar. As expected, we also

[16]We do not have a measure of firm-level productivity and, in any case, this variable would be endogenous if included in the regression.

find a positive and significant effect of industry-level productivity on firm-level wage expectations.

5.3 Alternative Sample Restrictions

Our baseline specification restricts the sample to firms that are observed for at least four consecutive quarters. Tables 7 and 8 assess the sensitivity to this choice by restricting the sample to firms that answered the survey for at least two and six consecutive quarters, respectively. When estimating equation (1) using these alternative samples, we find that the effects of QE are similar to our baseline results.

We also formally test whether the size of the estimated coefficients on QE are significantly different across different choices of the sample size using a likelihood-ratio (LR) test. The null hypothesis of this test is that estimated regression coefficients in the sample with at least four consecutive quarters are equal to the coefficients in the sample with at least k consecutive quarters, where $k = 2, 3, 5, \ldots, 8$.[17] We fail to reject the hypothesis that the effects of QE vary across alternative samples.[18]

5.4 An Alternative Measure of QE

Our main results in table 1 measure QE as the increase in announced QE amounts scaled by quarterly nominal GDP in 2009:Q1. We explore the robustness of our findings to using an alternative measure of QE that is based on either a binary indicator for the QE announcement dates or the difference in the outstanding QE amounts scaled by nominal GDP in 2009:Q1. As documented in tables 9 and 10, our baseline results are robust to using these alternative QE measures.

[17]The LR test statistic is given by $LR = -2(LR_{full} - (LR_{group1} + LR_{group2}))$ and under H_0, it is asymptotically distributed as χ^2 with df = number of estimated coefficients.

[18]If we test for equality of all regression coefficients, H_0 is rejected in more than half of all cases. However, testing the equality of all coefficient estimates is likely to be too restrictive given that our focus is only on the policy coefficients.

Table 7. Fixed Effects Regressions of Price and Wage Inflation Expectations on QE (using firms with at least two consecutive quarters)

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
QE	1.804**	1.818**	2.278**
	(2.83)	(2.99)	(8.63)
FG	0.187*	0.189*	0.058
	(2.09)	(2.20)	(1.27)
Observations	9,924	10,025	10,213
Adjusted R^2	0.120	0.107	0.162

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$. The same set of control variables as in table 1 is included.

Table 8. Fixed Effects Regressions of Price and Wage Inflation Expectations on QE (using firms with at least six consecutive quarters)

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
QE	1.452	2.069**	2.109**
	(1.72)	(2.63)	(6.24)
FG	0.221	0.229*	0.060
	(1.95)	(2.14)	(0.99)
Observations	5,072	5,159	5,365
Adjusted R^2	0.121	0.106	0.151

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$. The same set of control variables as in table 1 is included.

5.5 Heterogeneity across Firms

In previous sections we studied the average effects of unconventional monetary policy on firms' expectations. These averages, however, may mask some interesting heterogeneity across firms. While a thorough investigation of the transmission mechanism of unconventional

Table 9. Fixed Effects Regressions of Price and Wage Inflation Expectations on Outstanding Amounts of QE

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
QE (outstanding)	2.009*	1.827	3.627**
	(2.04)	(1.95)	(7.44)
FG	0.213*	0.142	0.116*
	(2.27)	(1.56)	(2.21)
Observations	7,189	7,277	7,499
Adjusted R^2	0.122	0.105	0.161

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$. The same set of control variables as in table 1 is included.

Table 10. Fixed Effects Regressions of Price and Wage Inflation Expectations on a Binary QE Measure

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
QE (binary)	0.301**	0.254*	0.388**
	(2.64)	(2.34)	(7.84)
FG	0.187*	0.119	0.067
	(1.99)	(1.30)	(1.30)
Observations	7,189	7,277	7,499
Adjusted R^2	0.122	0.105	0.160

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$. The same set of control variables as in table 1 is included.

monetary policy is outside the scope of this paper, in this section we document some interesting differences across firm types that may shed some light on which firms are most affected by monetary policy. In particular, we explore whether firm size, exporter status, and the degree of investment constraints might lead to differential effects of monetary policy on expectations. Given the discussion above, and that our QE variable has more variation over the sample, we focus on the effects of QE in this section.

Table 11. Fixed Effects Regressions of Price and Wage Inflation Expectations on QE (splitting sample by size and exporter status)

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
Small Firms			
QE	1.645 (1.94)	1.281 (1.61)	1.901** (5.65)
Large Firms			
QE	0.978 (0.67)	1.666 (1.35)	2.264** (3.74)
Exporter			
QE	1.061 (1.24)	0.804 (0.99)	1.547** (4.46)
Non-exporter			
QE	2.414 (1.76)	2.786* (2.12)	3.144** (5.95)

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$.

Interestingly, a distinction based on firm size did not produce significant heterogeneity. Table 11 shows that the point estimates for the effects of QE are similar for large and small firms. The effects lose significance, but if firm size is not the relevant dimension of heterogeneity, this is not surprising since splitting the sample lowers the number of observations but does not produce a more homogeneous group. Table 11 also reveals a similar picture when we split the sample by exporter status.

The ITS also includes some interesting questions about investment and, in particular, about which factors hold back expected capital expenditure. Along this dimension, we do find some clear heterogeneity in the effects of QE on inflation expectations. Our conjecture is that firms facing fewer investment constraints are more

Table 12. Fixed Effects Regressions of Price and Wage Inflation Expectations on QE: Firms Whose Expected Capital Expenditure Authorizations Are Limited by Alternative Factors

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
Shortage of Internal Finance and/or Inability to Raise External Funds			
QE	−1.243 (−0.71)	−2.012 (−1.33)	1.994** (3.15)
Cost of Finance			
QE	0.691 (0.20)	4.016 (1.52)	2.689* (2.15)
Inadequate Return			
QE	2.027 (1.43)	2.449 (1.96)	1.695** (3.22)
Shortage of Labor			
QE	−0.894 (−0.26)	0.456 (0.14)	3.468* (2.16)
Uncertainty about Demand			
QE	2.809** (3.12)	2.812** (3.27)	2.625** (6.38)

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$.

likely to plan ahead, as they will be more directly affected by the effect of monetary policy on, for example, capital markets and bank lending. This echoes Coibion, Gorodnichenko, and Kumar (2015), who find that firms tend to pay more attention to information that is relevant to them.

Table 12 reports the results for firms whose expected capital expenditures are limited by a number of factors. Table 12 shows that we no longer find an effect of QE on the price inflation expectations of "constrained firms." This is true across a range of constraints such

Table 13. Fixed Effects Regressions of Price and Wage Inflation Expectations on QE: Firms Whose Expected Capital Expenditure Authorizations Are Not Limited by Alternative Factors

	Expected Industry Price Inflation	Expected Own Price Inflation	Expected Wage Growth
Shortage of Internal Finance and/or Inability to Raise External Funds			
QE	3.328** (4.07)	3.155** (4.02)	2.658** (7.92)
Cost of Finance			
QE	2.479** (3.20)	2.385** (3.22)	2.638** (8.78)
Inadequate Return			
QE	2.801** (3.00)	2.885** (3.19)	3.149** (8.18)
Shortage of Labor			
QE	2.713** (3.46)	2.552** (3.43)	2.521** (8.29)
Uncertainty about Demand			
QE	2.161 (1.59)	1.707 (1.26)	2.674** (5.87)

Notes: t-statistics are in parentheses. * denotes $p < 0.05$, ** denotes $p < 0.01$.

as a shortage of funds, the cost of finance, and a shortage of labor. On the other hand, when we look at firms that report that their capital expenditure expectations have not been limited by these factors, we find the familiar positive and significant effects of QE (table 13).

6. Conclusions

An important lesson from the Great Depression is that persistent deflation can lead to undesirable economic outcomes, such as debt

deflation spirals (Fisher 1933) and enduring economic stagnation (Hansen 1939). And the beginning of the Great Recession had important parallels with the Great Depression (Almunia et al. 2009). To prevent history from repeating itself, central banks around the world implemented a number of unconventional monetary policies, including large-scale asset purchases of government and private-sector assets, forward guidance on interest rates, and policies targeted to directly stimulate lending. But the extent to which these different policies had a material impact on output and inflation is still not well understood. An important channel through which these policies can affect the latter is through their impact on inflation expectations. To our knowledge, this is the first paper to examine the impact of these policies on firm inflation expectations with a new data set from the United Kingdom.

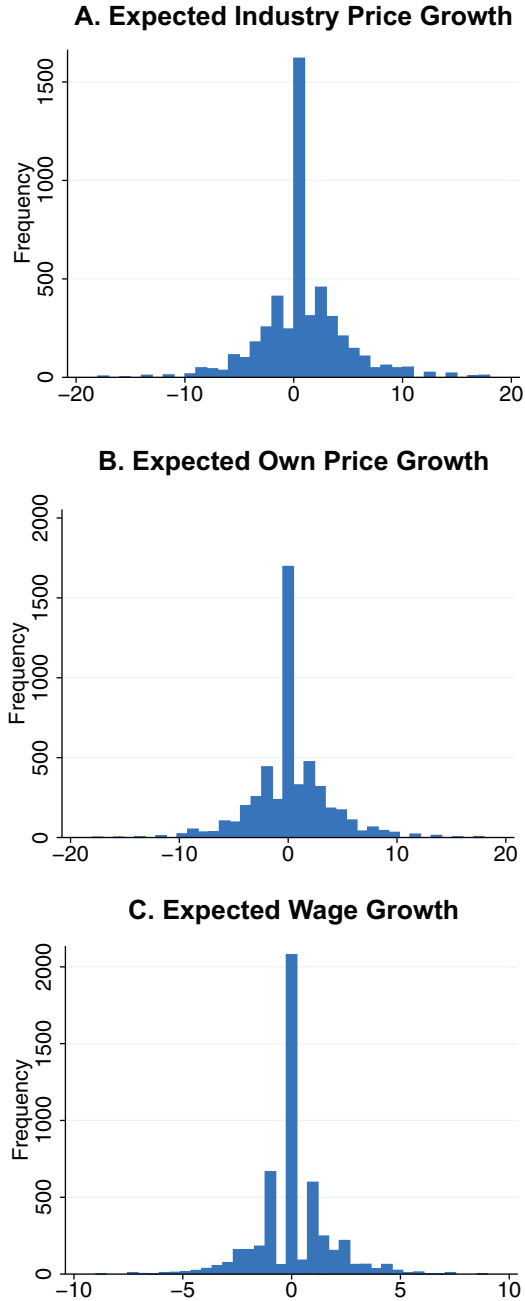
To identify the effect of QE on firms' expectations, we use a novel approach of combining microeconometric data with macroeconomic shocks: QE is exogenous to inflation expectations of individual firms. We can therefore estimate the effect of QE on firms' inflation expectations using a panel data model that also includes a wide range of aggregate and industry-wide developments. Our main result is that firms' own inflation expectations increased by 0.22 percentage points in response to £50 billion QE in the United Kingdom. Our findings suggest that inflation expectations play a role in transmission of QE to the real economy. In contrast, the effect of the Monetary Policy Committee's forward guidance is not statistically significant.

The ability of central banks to stabilize inflation expectations at the zero lower bound and ensure the economy does not slip into deflation remains a key aspect of the policy debate. Our findings suggest that QE interventions played a modest role in stabilizing inflation expectations in the United Kingdom in recent years. Our findings for Funding for Lending and forward guidance were not conclusive, but precisely estimating the effects of other unconventional policies on expectations remains an interesting avenue for future research.

Appendix 1. Forecast Errors

An interesting question is, how accurate are firms' expectations of price and wage growth? Figure 6 reports histograms of the forecast

Figure 6. Distribution of Forecast Errors



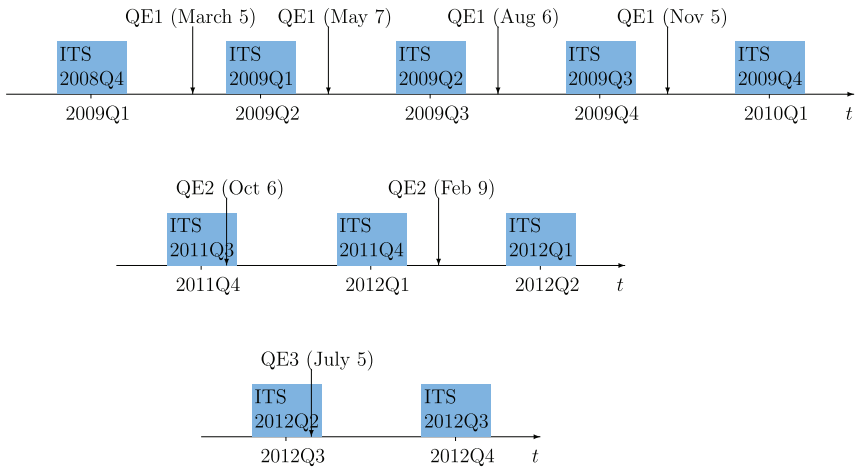
Note: Forecast errors are computed as the difference between firm's inflation or wage perception and expectations formed for the same quarter.

errors from the perspective of the individual firm, that is, the difference between perceptions of price and wage growth over the past year and expectations formed one year ago. A possible interpretation of this difference is unanticipated aggregate or idiosyncratic shocks that were realized in the interim period. The measures of forecast errors are centered around zero, but there is significant dispersion.

Appendix 2. The Timing of Policy Interventions

The timing of the survey fieldwork and the announcement of QE is shown in figure 7. In each quarter, the survey fieldwork starts approximately ten days before the end of the current quarter and ends approximately ten days after the start of the next quarter. In the case of the 2008:Q4 ITS, for example, the survey period started around December 20, 2008, and ended around January 10, 2009. The policy announcements took place outside the fieldwork periods, with the exception of QE2 and QE3, where the announcements took place

Figure 7. QE Announcements and Survey Periods



Notes: The shaded boxes denote the period where the fieldwork for the survey was completed. The fieldwork starts approximately ten days before the end of the current quarter and ends approximately ten days after the start of the next quarter.

a few days before the fieldwork for the previous quarter was completed. In these cases, we assume that the survey for the previous quarter was not much affected by the announcements.

Appendix 3. Sample Selection

In our baseline specification, we only use firms that answer the survey for at least four consecutive quarters. To investigate if this sample-selection rule induces selection effects, we formally test if the distribution of the dependent variables changes if we use an alternative criterion to select our estimation sample. We perform a Kolmogorov-Smirnov test of the null hypothesis that the distribution of the dependent variables does not change when we consider firms that remained in the survey for at least k consecutive quarters as compared with four quarters (where $k = 2, 3, 5, \ldots, 8$). We fail to reject equality of distribution in all cases considered (except for one), meaning that restricting the sample does not produce any selection effects.

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