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Discussion Paper No. 47

The effect of unconventional monetary policy on inflation expectations: evidence from firms in the United Kingdom

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Abstract

This paper investigates the effect of quantitative easing (QE) and other unconventional monetary policies on inflation and wage 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' 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 inflation and wage expectations.

Key words: Inflation expectations, firm survey data, unconventional monetary policy, quantitative easing.

JEL classification: D22, E52, E31.

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1 Introduction

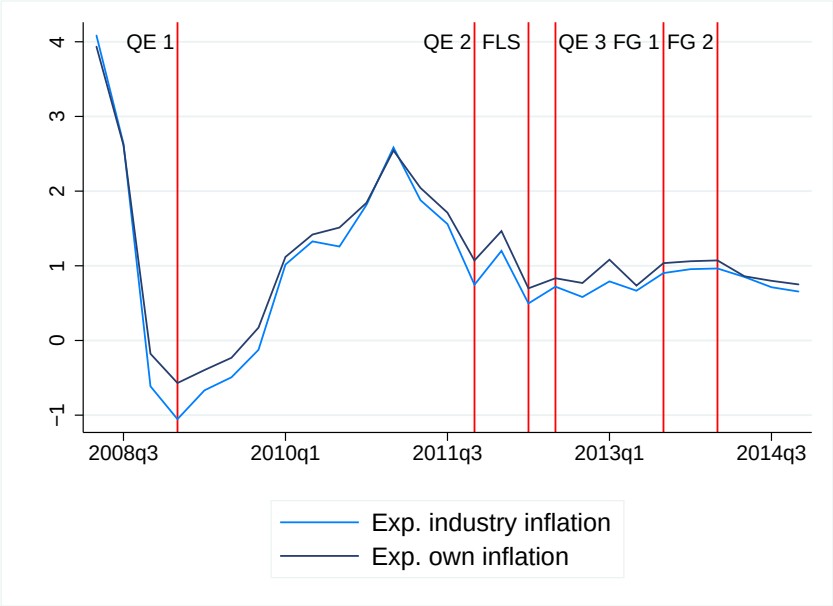
Following the onset of the 'Great Recession' and after short-term interest rates hit the zero lower bound, several central banks adopted unconventional monetary policies to support their economies. Unconventional instruments ranged from purchases of different assets (quantitative easing, QE) to forward 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 of the Bank of England amount to £375 billion.

Modern macroeconomic theory places strong emphasis on inflation expectations. Monetary stabilisation 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 succeeded in increasing inflation expectations. Specifically, we investigate the effect of unconventional monetary policy measures on inflation and wage expectations of UK manufacturing firms using a novel panel dataset of UK manufacturing firms collected by the Confederation of the British Industry (CBI). The data cover the period 2008-2014. 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 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), D'Amico and King (2012) and Krishnamurthy and Vissing-Jorgensen (2011) document that the first US large scale asset purchases programme led to a statistically significant decline of about 30-90 basis point 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.

Figure 1: Monetary policy announcements and inflation expectations



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 US macroeconomic model to examine the possible impact of US large scale asset purchases and find that real GDP and inflation were respectively 3% and 1% higher as a result of the Federal Reserve's asset purchase policy. Del Negro et al. (2011) study the Fed's liquidity facilities through the lens of a DSGE model with financial frictions and find that these policies were highly effective to prevent 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 SVAR models on UK data and conclude that £200 billion asset purchases increased inflation by $1\frac{1}{4}\%$ and real GDP by $1\frac{1}{2}\%$. In a related study, Weale and Wieladek (2014) 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 US. 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 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 inflation and wage expectations in our data set together with announcements of unconventional monetary policies in the UK. The series clearly move together and policy actions, naturally, appear highly correlated with the state of the econ-

omy. 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 inflation. 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] In a series of papers, Coibion and Gorodnichenko (2014) and Coibion et al. (2015) uncover new stylised facts about how various economic agents form their expectations. 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 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. Hori and Shimizutani (2005) study 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. Compared to these papers, the contribution of our work is to estimate the effects of monetary policy on firms' inflation and wage expectations.

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 the 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 inflation and wage expectations of individual firms, we ideally need panel data on firms' expectations which are a reliable predictor of aggregate outcomes, together with a range of firm-specific characteristics. In the UK the Confederation of British Industry (CBI) has collected quarterly data on firms' inflation and wage expectations since 2008. While the broader CBI survey has a much longer history, we focus only on the sample for which information on inflation and wage expectations is

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

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 are relatively homogeneous (being all in manufacturing). 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.

Overview of the Industrial Trends Survey. The Industrial Trends Survey (ITS) asks UK firms about their estimates of expected future trends in prices and wages, among other questions. Lui et al. (2011) document that the ITS data contain valuable information about developments in the manufacturing sector, and Mitchell et al. (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 dataset starts in 2008Q2 and ends in 2014Q4. The questions that provide us with our main dependent variables of interest are:

1. What has been the percentage change over the past 12 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 12 months?

2. 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 and what is expected to occur over the next 12 months?

3. 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?

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% in the case of inflation and from -1.5% to +7.5% for wages.[2] 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.[3]

[2]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% for inflation and −1.1 to −2%; −0.1 to −1%; no change; 0.1 to 1%; 1.1 to 2%; 2.1 to 3%; 3.1 to 4%; 4.1 to 5%; 5.1 to 6%; 6.1 to 7% and 7.1 to 8% for wages.

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

Descriptive statistics. We start by documenting the key aggregate characteristics of our data. It is worth noting that our sample period coincides with the deepest UK recession in nearly a century. So it is not surprising that in the survey we observe a sharp decline in inflation expectations in 2008/09 (Figure 2a). The observed decline in firms' inflation expectations was of much the same magnitude as the fall in output price inflation in the manufacturing sector. Overall, inflation expectations lead output price inflation 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 inflation was, however, only around 1% on average and this is significantly below realized aggregate CPI inflation rates.[4] Expected inflation and wages lead perceived outcomes, too (Figures 2b-2c).

Turning to the cross sectional dispersion, Figure 3 shows histograms for expected inflation and wages. For own and industry wide inflation expectations, the distributions are centred around zero, but there is a second mode around 3% (Figures 4a, 4b). The histogram for wage expectations is bimodal, too, with one mode at 2.5% and another at zero (Figure 4c). Compared to inflation expectations, the histogram for wage expectations 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 inflation. Using this, there is also a distribution of forecast errors across firms and we discuss this further in Appendix A.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.

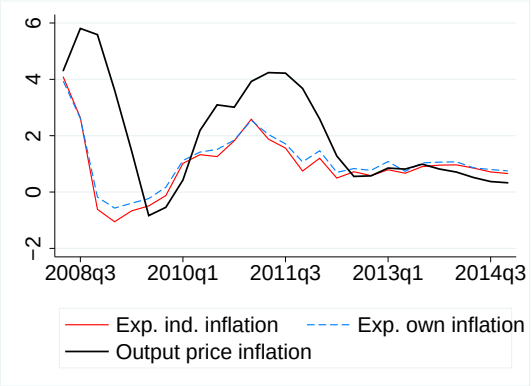
Choice of sample In principle the survey is a panel with firms approached repeatedly. Unfortunately, however, as shown in Figure 4, there is a sizable number of firms for which we observe only a few consecutive quarters. In other words, the panel is unbalanced and the number of exits and re-entrants 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 snap-shot of the state of the economy and the CBI does not follow up very late respondents and does not revise the figures after they have been published.

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 1717 firms which reply to the survey over this period only five firms provide complete records for the full sample period.

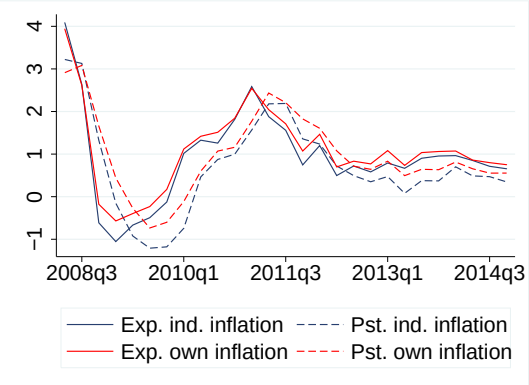
This characteristic of our data poses some challenges on how to select a reliable and

[4]One possible reason for this difference in levels is that firms exclude the effects of taxes such as 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 inflation 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.

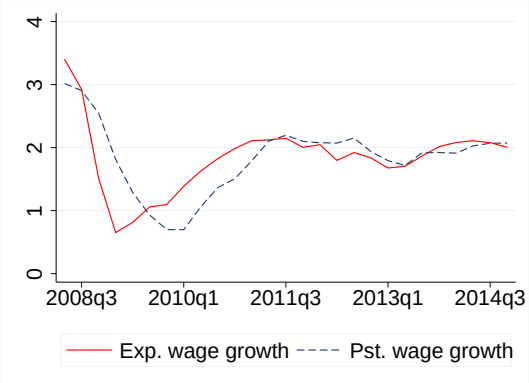
Figure 2: Cross-sectional averages of inflation and wage expectations and perceptions



(a) Inflation expectations and realized inflation

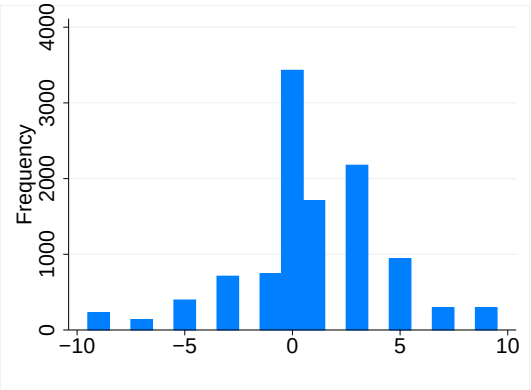


(b) Inflation perceptions and expectations

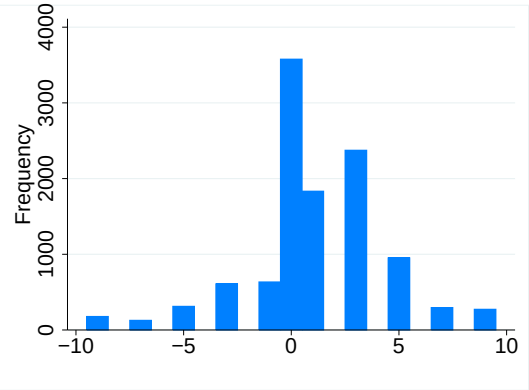


(c) Wage perceptions and expectations

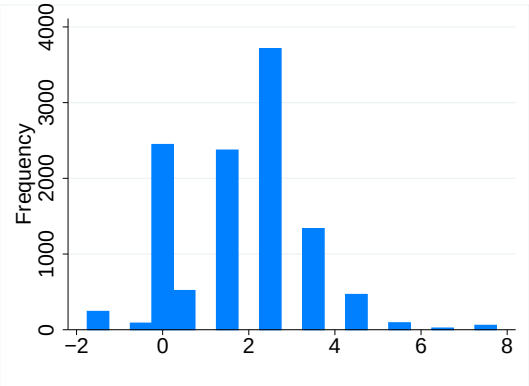
Figure 3: The distribution of inflation and wage expectations



(a) Exp. industry inflation

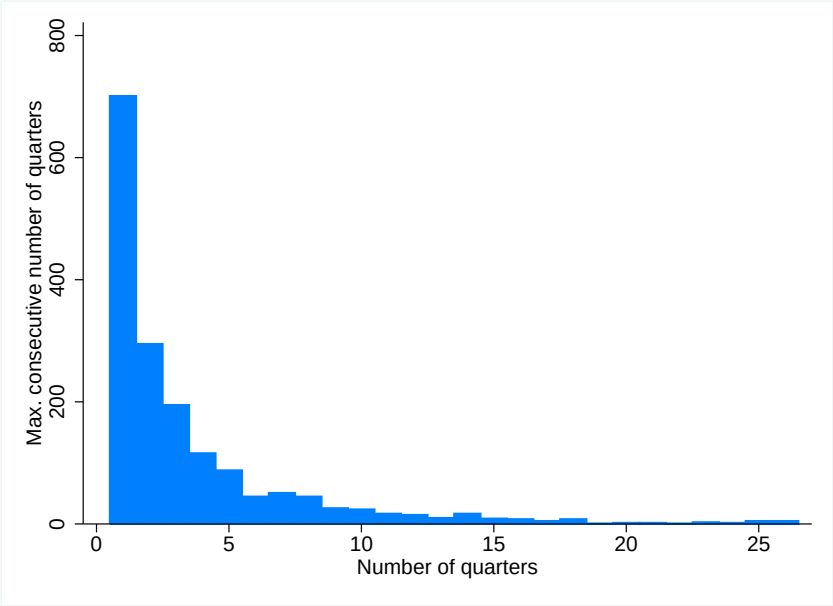


(b) Exp. own inflation



(c) Exp. wage inflation

Figure 4: Maximum number of consecutive quarters



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

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 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 A.3 we discuss sample selection in more detail. Specifically we formally test whether the distribution of the depend variables changes as we use alternative criteria to select our sample. Reassuringly we fail to reject the equality of distributions as we limit to sample to firms observed for at least four quarters compared to other sample choices.

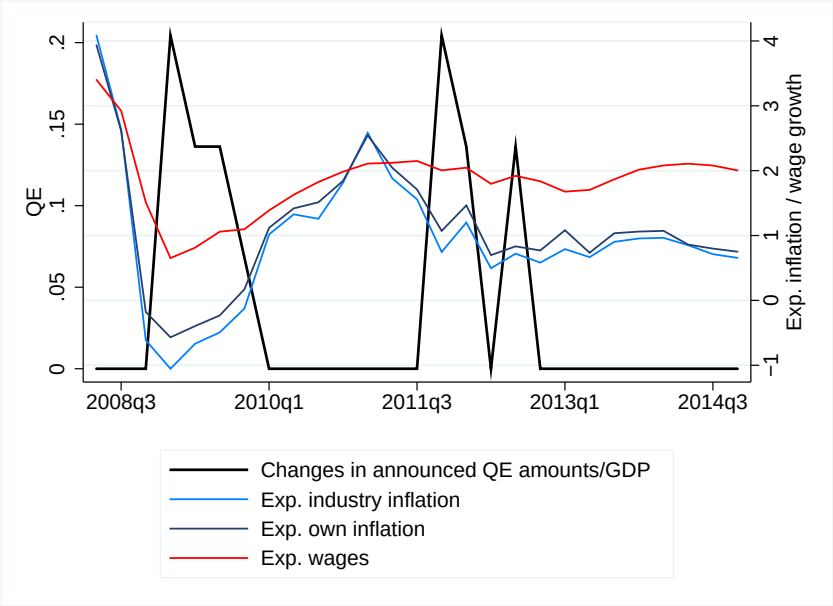
Unconventional monetary policy measures Between 2009 and 2014, the Bank of England deployed three main unconventional policy measures to stabilise output and prices following the onset of the Great Recession: QE, which largely involved the purchase of government securities from the private sector using newly created central bank reserves[5]; the Funding for Lending Scheme, which offered banks discounted access to funding conditional on increasing lending; and, the Bank provided forward guidance on when it would consider raising Bank Rate from 1/2 per cent, regarded at the time as the effective lower bound. The key announcement dates can be seen in Figure 1.[6]

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

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

[6]Appendix A.2 discusses how the timing of the survey field work relates to the timing of the unconventional policy actions in the UK.

Figure 5: Inflation expectations and additional announcements of asset purchases



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 UK, QE was also typically implemented shortly after announcement, with purchases of £25 billion per month. This is different from the US, where purchases were implemented over a longer horizon following QE announcements. At 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 *additional announcement of asset purchases* in a given quarter scaled by nominal GDP in 2009Q1.[7] 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 the forward guidance in 2013Q3 and 2014Q1.[8] As noted in Dale and Talbot (2013) "the

[7]Which is equivalent to the change in the intended stock of assets purchased.

[8]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 Draghi's "whatever it takes" speech (which was widely reported as having helped stabilise economic conditions in the Eurozone), we don't pay much attention to this policy intervention.

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.

3 Econometric Methodology

To investigate the effects of QE on firms' inflation and wage 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 12 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.[9] 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 cause both the independent and the dependent variables. Formally, we require strict exogeneity of the form

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

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

[9] 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.

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 only change slowly over 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 our results are unaffected by excluding these.

4 The Effects of QE on Firms' Inflation and Wage Expectations

Table 1 reports our main results. We find that QE has a positive and significant effect on inflation and wage expectations. QE is measured as the announced increase in asset purchases scaled by nominal quarterly GDP in 2009Q1. This implies for £50 billion of QE, firms' own-price inflation expectations (for inflation over the next year) increase by 0.22 percentage points.[10] 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 caveat in interpreting these estimates is the co-incidence between the first QE episode and the final cut in Bank Rate to 1/2 per cent per annum. As such, strictly our estimates should 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.

Table 1 also shows that the effects forward guidance on inflation and wage expectations are insignificant. This result, however, does not imply that forward guidance does not affect firms' expectations in general. It is possible that alternative forms of forward guidance as, for example, "lower for longer" policies, can stimulate firms' expectations.

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

In terms of wider macroeconomic variables, inflation and wage expectations are positively related wage growth and negatively to credit spreads and VIX. VIX is a measure of volatility that is computed from stock market options in the UK. The negative effect

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

Table 1: Fixed effects regressions of inflation and wage expectations on QE

	Exp. ind. infla.	Exp. own infla.	Exp. wages
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 ER 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/1000	-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	7189	7277	7499
Adjusted R^2	0.122	0.105	0.159

t statistics in parentheses

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

seems reasonable given that 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 that are 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.

We also include a dummy for the quarter where two other policy interventions occurred: the Bank of England's Funding for Lending Scheme and European Central Bank Signor Draghi's "whatever it takes" speech (which was widely reported as having helped stabilise economic conditions in the Eurozone). Interesting, this dummy has a significant and positive effect on inflation and wage expectations, although we believe it would be hard to disentangle these effects.

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 inflation and wage expectations.

5 Robustness Analysis 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 mid-point of this buckets, with a corresponding treatment of those lower than the lowest bucket. This means that our data are censored and failure to take account of this 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 labelling.

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 inflation and wage 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.[11]

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.

Table 2: Fixed effects regressions of inflation and wage expectations on QE (fewer macro controls)

	Exp. ind. infla.	Exp. own infla.	Exp. wages
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	7189	7277	7499
Adjusted R^2	0.103	0.092	0.148

t statistics in parentheses

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

Notes: The same set of control variables as in Table 1 is included with exception of exchange rate growth, oil price growth and VIX.

Table 3: Fixed effects regressions of inflation and wage expectations on QE (controlling for US QE)

	Exp. ind. infla.	Exp. own infla.	Exp. wages
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)
US QE	0.001**	0.001**	0.000
	(4.25)	(3.87)	(1.18)
Observations	7189	7277	7499
Adjusted R^2	0.124	0.107	0.159

t statistics in parentheses

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

Notes: The same set of control variables as in Table 1 is included.

Next, we consider adding an extra control for US QE, an important potential omitted

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

variable. Table 3 again shows that out findings are very similar in magnitude. Interestingly, the forward guidance dummy now becomes significant. While controlling for US 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 steer in whether it affected firm's 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 re-estimates 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.

Table 4: Fixed effects regressions of inflation and wage expectations on QE (including industry controls)

	Exp. ind. infla.	Exp. own infla.	Exp. wages
QE	1.699*	1.590*	2.162**
	(2.31)	(2.31)	(7.29)
FG	0.144	0.095	0.045
	(1.50)	(1.01)	(0.86)
Observations	7062	7151	7373
Adjusted R^2	0.126	0.107	0.159

t statistics in parentheses

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

Notes: 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).

Table 5: Fixed effects regressions of inflation and wage expectations on QE (excluding firm-specific controls)

	Exp. ind. infla.	Exp. own infla.	Exp. wages
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	7189	7277	7499
Adjusted R^2	0.121	0.105	0.158

t statistics in parentheses

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

Notes: The same set of control variables as in Table 1 is included with exception of firm-specific variables.

Finally, one 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.

5.3 Alternative Sample Restrictions

Our baseline specification restricts the sample to firms that are observed for at least 4 consecutive quarters. Tables 6 and 7 assess the sensitivity to this choice by restricting the sample to firms that answered the survey for at least 2 and 6 consecutive quarters, respectively. When estimating equation (1) using these alternative samples, we find that the effects of QE are similar compared to our baseline results.

Table 6: Fixed effects regressions of inflation and wage expectations on QE using firms with at least 2 consecutive quarters

	Exp. ind. infla.	Exp. own infla.	Exp. wages
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	9924	10025	10213
Adjusted R^2	0.120	0.107	0.162

t statistics in parentheses

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

Notes: The same set of control variables as in Table 1 is included.

Table 7: Fixed effects regressions of inflation and wage expectations on QE using firms with at least 6 consecutive quarters

	Exp. ind. infla.	Exp. own infla.	Exp. wages
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	5072	5159	5365
Adjusted R^2	0.121	0.106	0.151

t statistics in parentheses

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

Notes: The same set of control variables as in Table 1 is included.

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 4 consecutive quarters are equal to the coefficients in the sample with at

least k consecutive quarters, where k=2,3,5,..,8.[12] We fail to reject the hypothesis that the effects of QE vary across alternative samples.[13]

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 2009Q1. 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 2009Q1. As documented in Tables 8 and 9, our baseline results are robust to using these alternative QE measures.

Table 8: Fixed effects regressions of inflation and wage expectations on outstanding amounts of QE

	Exp. ind. infla.	Exp. own infla.	Exp. wages
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	7189	7277	7499
Adjusted R^2	0.122	0.105	0.161

t statistics in parentheses

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

Notes: The same set of control variables as in Table 1 is included.

Table 9: Fixed effects regressions of inflation and wage expectations on a binary QE measure

	Exp. ind. infla.	Exp. own infla.	Exp. wages
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	7189	7277	7499
Adjusted R^2	0.122	0.105	0.160

t statistics in parentheses

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

Notes: The same set of control variables as in Table 1 is included.

[12]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.

[13]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.

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 to which extent 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 dataset from the UK.

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 UK. Our findings suggest that inflation expectations play a role in transmission of QE to the real economy. In contrast, the effect of the MPC's forward guidance is not statistically significant.

The ability of central banks to stabilise 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 suggests that QE interventions played a modest role in stabilising inflation expectations in the United Kingdom in recent years. Our findings for other policy interventions were not conclusive but precisely estimating the effects of other unconventional policies on expectations remains an interesting avenue for future research.

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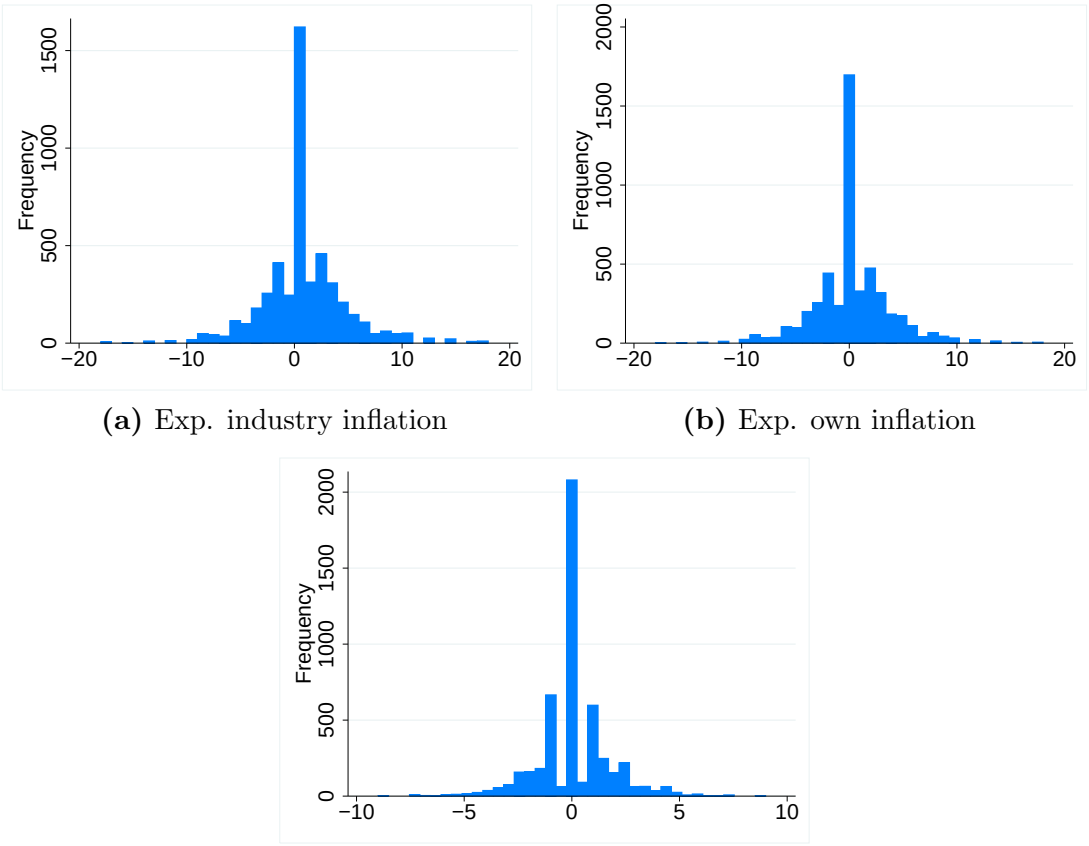
Figure 6: Distribution of forecast errors



(a) Exp. industry inflation

(b) Exp. own inflation

(c) Exp. wage inflation

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

A Appendices

A.1 Forecast errors

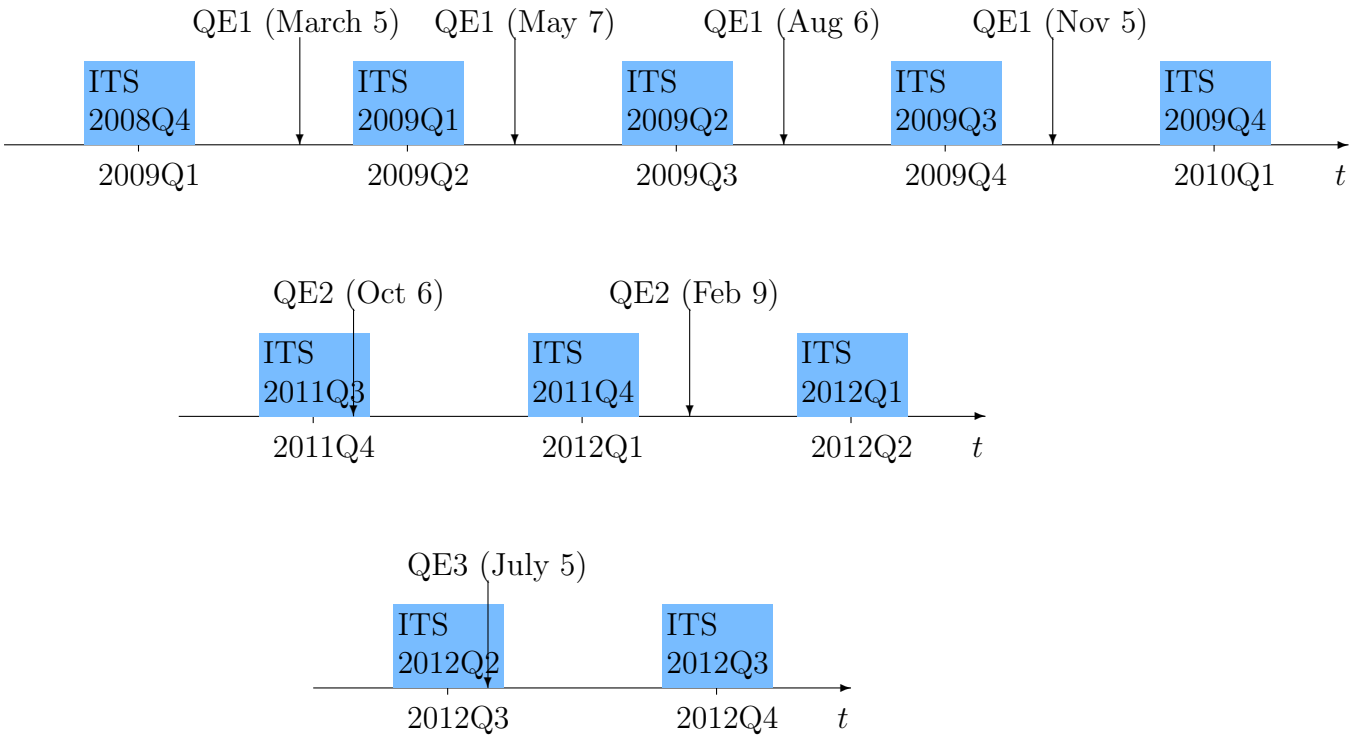
An interesting question is how accurate are firms' inflation expectations. Figure 6 reports histograms of the forecast errors from the perspective of the individual firm, that is, the difference between perceptions of inflation and wages over the past year and expectations formed one year ago. A possible interpretation of this difference is unanticipated aggregate or idiosyncratic shocks that realized in the interim period. The measures of forecast errors are centered around zero, but there is significant dispersion.

A.2 The timing of policy interventions

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

Figure 7: QE announcements and survey periods



Notes: The blue boxes denote the period where the field work for the survey was completed. The field work starts approx. 10 days before the end of the current quarter and ends approx. 10 days after the start of the next quarter.

A.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 a 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 to 4 quarters (where $k = 2, 3, 5, .., 8$). We fail to reject equality of distribution in all cases considered (except of one) meaning that restricting the sample does not produce any selection effects.