BANK OF ENGLAND

Staff Working Paper No. 753

Business investment, cash holding and uncertainty since the Great Financial Crisis

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August 2018

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Pawel Smietanka,[1] Nicholas Bloom[2] and Paul Mizen[3]

Abstract

The Lehman Brothers event in 2008 created a large uncertainty shock that triggered an economic slowdown lasting a decade. The macroeconomic effects are well documented, but the effect on business decisions much less so. In this paper, we explore corporate data to investigate how economic uncertainty affected investment, dividend payouts and cash holdings, based on over 10,000 UK firm-year observations. We offer new insights into the relationship between business decisions and uncertainty, by exploiting two surveys of macroeconomic uncertainty from professional forecasters and CFOs collected by the Bank of England. These data demonstrate that heightened economic uncertainty lowered investment even after controlling for investment opportunities, sales growth, and the firm's own stock volatility. Economic uncertainty also explains the rise in cash holdings and the fall in payouts. Hence, our results help explain why UK firms invested so little and held so much cash at a time of historically low interest rates, and also why they paid out smaller dividends. These results may help explain recent sluggish productivity in the UK economy, and they also are important, because they provide a benchmark for future studies of Brexit-related uncertainty.

Key words: uncertainty, investment, cash holdings, dividend policy, survey forecasts.

JEL classification: E22, G31, G32, G35.

(1) Bank of England. Email: pawel.smietanka@bankofengland.co.uk (corresponding author)
(2) Stanford University. Email: nbloom@stanford.edu
(3) University of Nottingham. Email: paul.mizen@nottingham.co.uk

The views expressed in this paper are those of the authors, and not necessarily those of the Bank of England or its committees. The authors would like to thank Phil Bunn, Andrea Caggese, Steve Davis, Richard Disney, Rachel Griffiths, Jonathan Haskel, Steve Machin, Dennis Novy, Giacomo Rodano, Christoph Weiss, Garry Young and seminar participants at conferences hosted by the Royal Economic Society, the Money, Macro and Finance Research Group, CASS Business School, and the Banque de France, Banca D'Italia and Science Po.

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Publications and Design Team, Bank of England, Threadneedle Street, London, EC2R 8AH
Telephone +44 (0)20 7601 4030 email publications@bankofengland.co.uk

ISSN 1749-9135 (on-line)

1 Introduction

The Lehman Brothers event in 2008 was the largest economic shock to the financial system since the Great Depression. It triggered a slowdown in economic activity known as the Great Recession, which was unusual for its long duration. A decade on, we are able to observe the effects of this episode on macroeconomic variables such as the level of real GDP and real investment. The top two panels of Figure 1 show that UK real GDP fell sharply in 2009 and did not return to pre-crisis level till 2013; similarly real investment by private non-financial companies (PNFC) experienced a sharp downturn in 2009 and remained below its 2007-peak till 2015, according to official statistics. The bottom two panels in Figure 1 show that the EU-exUK experience was remarkably close to that of the UK between 2007-2009, but a further decrease occurred around the sovereign debt crisis, 2010-2013.[1] At the same time economic uncertainty increased as documented in Figure 2, where U_t denotes the uncertainty defined by Boero et al. (2008) and U_t^{EPU-UK} denotes the Economic Policy Uncertainty (EPU) measure based on Baker et al. (2016).[2] There is a well-established connection between these macroeconomic outcomes and economic uncertainty.[3] This has made the higher level of economic uncertainty in the macroeconomy a defining feature of the post-crisis period, as shown by the growing literature (see Bloom (2014) for a review).

What is rather less well known is the effect of higher uncertainty over this period on decisions made at the level of the firm concerning for example investment, dividends payouts and cash holding.[4] The actual historical experience is revealed in differences between pre- and post-crisis changes in firm-level investment, payouts and cash holdings summarised in Table 1. The table shows aggregated data from company accounts, revealing that the investment and dividend ratios were both lower on average after the crisis than they had been beforehand, and the ratio of cash holdings to total assets was higher after the crisis compared to before the crisis.[5]

When we consider the relationship between investment and uncertainty, based on the professional forecasts from the Survey of External Forecasters gathered at the Bank of England, we see a striking relationship. Figure 3 shows a negative cross-correlation between the firm-average investment ratio in each year and uncertainty in the same year. More importantly, the observations referring to the post-crisis period lie in a cluster at the bottom right-hand corner where the low investment ratios after 2009 coincide with high economic uncertainty. When we fit a

[1] We use real gross fixed capital formation for UK and EU-exUK because real investment by private non-financial companies is not available for the EU. Real gross fixed capital includes public and private investment spending.

[2] This same pattern can be observed for many other countries, not just the UK.

[3] Much of the work on economic uncertainty since the crisis has focused on macroeconomic variables - real industrial production and private payroll employment (see Caldara et al. (2016)); unemployment and inflation (see Leduc and Liu (2016)); real GDP, employment, retail sales, business sentiment and personal income (see Scotti (2016)); real GDP and inflation (see Andrade et al. (2016)).

[4] The most well known papers by Bond et al. (2003) and Bloom et al. (2007) refer to the pre-crisis period only.

[5] It is surprising that firms should have chosen to hold larger amounts of cash on the balance sheet, particularly when interest rates were very low. These data are from the balance sheets of UK firms but US firms have similarly high levels of cash. Unlike in the US, the UK had no tax laws that created incentives to hold large cash stocks, but the data show an increase on average over the post-crisis period.

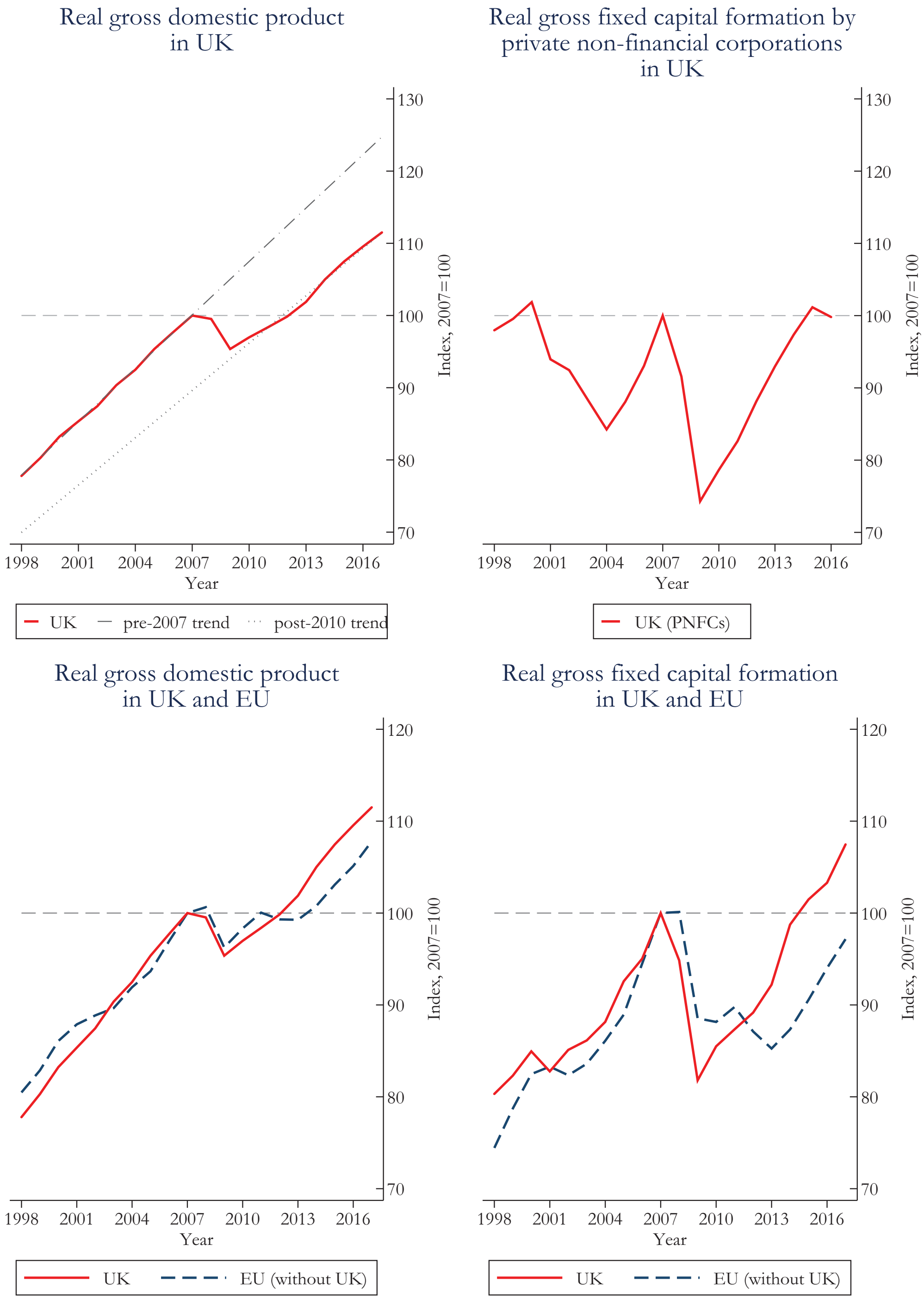

Figure 1: Real GDP and gross fixed capital formation between 1998 and 2016 in the UK and the European Union.

Table 1: Pre- and Post-Crisis Values of Investment, Cash Holdings and Dividend Payouts.

$Var.$	$Mean$	$Std.Dev.$	$Min.$	$Max.$
$INV_{it}/K_{it-1\leq 2006}$	14.64	15.41	−55.41	91.56
$INV_{it}/K_{it-1\geq 2010}$	13.33	12.82	−33.62	92.80
$CS_{it}/TA_{it\leq 2006}$	9.78	11.67	0	80.41
$CS_{it}/TA_{it\geq 2010}$	12.36	12.23	0.01	74.19
$DIV_{it}/EARN_{it\leq 2006}$	35.57	54.02	0	811.54
$DIV_{it}/EARN_{it\geq 2010}$	24.70	39.59	0	464.57

dashed line to the data points from 2008 onwards we see a much steeper negatively sloped line, compared to the fitted solid line for the full sample. This is clear evidence that average firm-level investment ratios and uncertainty are strongly negatively related in the post-crisis period. We will show that this negative relationship is robust to adding many explanatory variables typically included in investment equations.

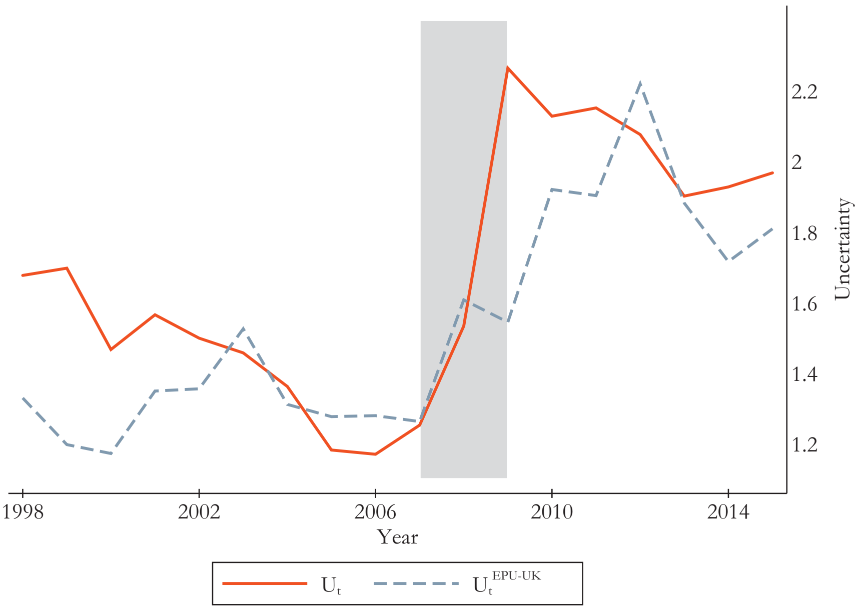

Figure 2: Measure of macroeconomic uncertainty over time. This figure depicts the values of two measures of macroeconomic uncertainty, U_t and U_t^{EPU-UK}, between 1998–2015. The first measure, U_t, is based on responses to the Survey of External Forecasters conducted by the Bank of England. The second measure, U_t^{EPU-UK}, is based on Baker et al. (2016). The shaded area highlights years of the financial crisis.

By investigating the connection between business decisions and the rise in economic uncertainty we aim to provide more information that will help understand the puzzlingly low level of investment after the crisis. We use individual firm-level data and control for the many influences on firm-level decisions, focussing on economic uncertainty as a key explanatory variable due to its apparently pivotal role in Figure 3. We will also observe any relationship between higher uncertainty and lower dividend payouts and the increase in cash holding. This information may offer vital clues to help others investigate the productivity puzzle and will provide a benchmark against which future studies of business decisions under Brexit-related uncertainty can be compared.

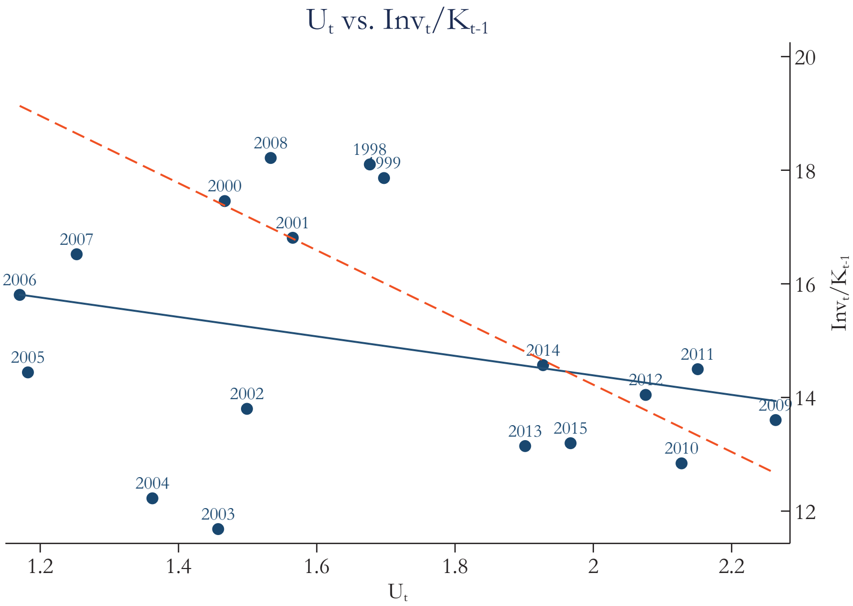

Figure 3: Uncertainty and Investment. The scatter plots the negative relation between macroeconomic uncertainty and average investment ratios. The solid blue line is a fitted line based on the whole sample. The dash red line is a fitted line based on post-2008 sample.

But first we ask 'How would greater uncertainty affect firm-level decisions?' Theory argues that irreversibility of investment and the real option value of waiting would create incentives for firms to delay making investments whenever uncertainty is high (see Dixit and Pindyck (1994), Davis and Haltiwanger (1992), Caballero et al. (1995), Abel and Eberly (1996), and Cooper and Haltiwanger (2006)). Risk-averse firms tend to be more negatively affected by uncertainty than risk-neutral firms especially after a financial crisis (see Bloom et al. (2007)). Leahy and Whited (1996), Guiso and Parigi (1999) and Bloom et al. (2007) offer supporting evidence on uncertainty shocks reducing firm investment levels. Alfaro et al. (2018) propose a theoretical model in which heterogeneous firms that face uncertainty shocks and financial frictions reduce investment in physical capital, and they also hold more cash and pay out less in dividends. The literature on precautionary saving by firms (Opler et al. (1999)), referring to the sensitivity of cash balances to variation in cash flows (Almeida et al. (2004) and Faulkender and Wang (2006)) and the option value of holding more cash when external finance becomes constrained (Denis and Sibilkov (2010)) shows firms are expected to hold more cash and reduce payouts at these times. Bliss et al. (2015) hypothesize that there will be an increase in the marginal benefit of holding cash and potentially a pecking order that prioritizes reductions in payouts rather than reduction in investment expenditure.

Our paper makes three contributions to the literature. First, we establish a connection between first and second moments in surveys of uncertainty from professional forecasters and surveys of uncertainty from CFOs. After deriving a macroeconomic uncertainty measure from a survey of professional forecasters[6] we show it closely matches the mean and standard deviation from survey data provided by CFOs, collected through the Decision Maker Panel (see Bloom et al. (2017)).[7] We conclude that this measure of macroeconomic uncertainty is particularly apt to test our hypotheses that economic uncertainty plays a role in explaining the recent low investment, high cash and low dividend ratios, since it is a decent proxy for CFOs' own views of economic uncertainty.[8] It also shows similarity to the Economic Policy Uncertainty (EPU) measure developed by Baker et al. (2016), which we use to cross check our results.

Second, we exploit detailed corporate data before and after the Great Financial Crisis to evaluate three hypotheses about the effects of uncertainty shocks on firms' investment expenditure, cash holdings and dividend payouts in the UK.[9] Hypothesis 1 tests whether investment is significantly lower when economic uncertainty increases following the literature on irreversibility of investment and the real option value of waiting (see Davis and Haltiwanger (1992), Dixit and Pindyck (1994), Caballero et al. (1995), Abel and Eberly (1996), Cooper and Haltiwanger (2006), and Bloom et al. (2007)). We explore this hypothesis for the full sample, sub-samples of pre- and post-crisis data and for individual years. Hypothesis 2 tests whether firms also hold additional cash to build precautionary savings in more uncertain times as suggested by Opler et al. (1999), Almeida et al. (2004), Faulkender and Wang (2006), Campello et al. (2011) and Bliss et al. (2015). Hypothesis 3 tests whether firms overcome their reluctance to reduce payouts in more uncertain times as discussed by Brav et al. (2005), and Floyd et al. (2015). We show that our data confirm all three outcomes and our results are robust to different estimation methods and to using the Economic Policy Uncertainty (EPU) measure presented in Baker et al. (2016).

Third, having explored the effects of uncertainty shocks arising from the Great Financial Crisis and their impact on ratios of investment, cash and dividend payouts we provide material that may inform studies of the productivity slowdown in this period. The productivity puzzle is one of the unsolved mysteries since the Great Financial Crisis, and our results on the effects of economic uncertainty may provide vital evidence. We document the decline in investment and dividends due to higher economic uncertainty in the years 2007-2009, and the increase in unproductive cash.

[6]The survey gives the expected distribution of real GDP growth rates in the UK provided by regular surveys of professional forecasters, and is collected by the Bank of England.

[7]We use the Survey of External Forecasters because it has a longer back run of data than the Decision Maker Panel, on first and second moments from real GDP forecasts.

[8]Other uncertainty measures (see Bekaert et al. (2013), Leduc and Liu (2016), Scotti (2016)) clearly have their merits for different purposes, but ours is particularly appropriate to explain firm-level decision making.

[9]The crisis provides an exogenous shock that affects all firms through an increase in economic uncertainty.

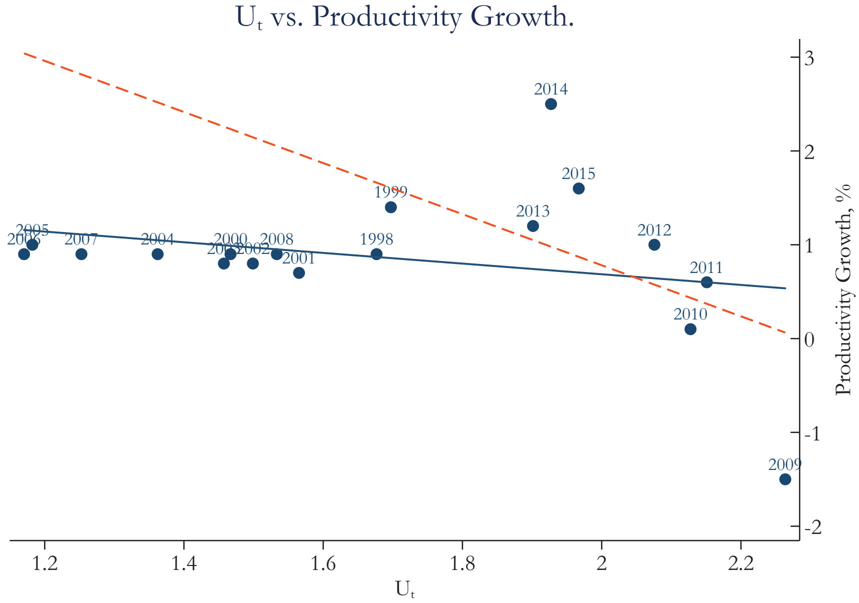

Figure 4: Uncertainty and Productivity. The scatter plots the negative relation between macroeconomic uncertainty and the growth in productivity jobs. The solid blue line is a fitted line based on the whole sample. The dash red line is a fitted line based on post-2008 sample. Productivity jobs is a measure of labour productivity, with the labour input being measured by the number of filled jobs. Filled jobs (or workforce jobs) is the sum of employee jobs measured primarily by employer surveys, self-employment jobs from the Labour Force Survey (LFS), and government-supported trainees (GST) and Her Majesty's Forces from administrative sources and LFS.

The effects will have reduced the level of capital in the economy, which may have contributed to lower output per worker, tapered the payouts to shareholders reducing demand and left cash sitting on the balance sheet of firms. Figure 4 shows a cross plot of productivity measured as growth in output per job filled against uncertainty (U_t) and we see lower productivity growth clustered in the lower right hand corner in the same way that investment was clustered after 2008. There is a clear negative relationship between productivity growth and uncertainty. We also provide a benchmark against which to evaluate the effects of subsequent uncertainty shocks e.g. due to Brexit, following the decision to leave the European Union in June 2016. Firm-level uncertainty data is already being collected (see Bloom et al. (2017)) and this paper should provide a basis for comparing the full size and impact of Brexit uncertainty shocks, once they are known, against the effects of uncertainty shocks from the Great Financial Crisis.

The paper is organised as follows: in the next section, we describe the methodology followed by a description of the data sources and variable construction and summary statistics in Section 3. Our main results follow and are split into an assessment of the suitability of our uncertainty measure for evaluation of corporate decisions and the effects in three parts on investment, cash and payout ratios in Section 4. We then consider the effects of the crisis in Section 5. The final section concludes.

2 Economic Uncertainty

2.1 Measurement

The measure of economic uncertainty used in this paper relies on a definition taken from Boero et al. (2008) that is commonly used elsewhere. Total uncertainty is the square root of the average subjective individual variances of forecasters plus the extent of their average disagreement.

$$U_t = \sqrt{\frac{1}{n_t}\sum_{i=1}^{n_t}\sigma_{it}^2 + \frac{1}{n_t}\sum_{i=1}^{n_t}(\hat{y}_{it} - \hat{y}_t)^2} \tag{1}$$

where U_t denotes the uncertainty at time t, σ_{it}^2 denotes subjective uncertainty using the variance for individual forecasters, $\hat{y}_{it}$ denotes the individual point forecasts and $\hat{y}_t$ denotes the average point forecast. The difference between individual point forecasts and the average point forecast is a measure of disagreement, and the average disagreement contributes to the overall level of economic uncertainty. Subjective uncertainty and average disagreement are equally weighted.

The individual point forecast is defined as $\hat{y}_{it} = \sum_{j=1}^{k_t} p_{ijt}\bar{v}_{jt}$ where p_{ijt} denotes the probability assigned by forecaster i to the bin j at time t, k_t denotes the number of bins, and $\bar{v}_{jt}$ denotes the value of the bin j. The bins are defined as ranges by the Bank of England, and their number and their lengths have been revised several times in the past. Initially, there were six bins for the output growth rates. After several adjustments the Bank returned to their initial arrangement of six bins, but the ranges differ from those used in the initial survey. The details are provided in Table 5 in the Appendix.

Following Boero et al. (2008) and many others, we calculate the middle value for each bin and use it in the equation above.[10] For open-ended bins we assume that the bin is twice as long as a closed-ended bin. The individual variance is defined as $\sigma_{it}^2 = \sum_{j=1}^{k_t} p_{ijt}(\bar{v}_{jt} - \hat{y}_{it})^2$.

To calculate the value of our measure of uncertainty we use data from the Survey of External Forecasters compiled by the Bank of England from up to 37 professional forecasters each quarter since 1998q1. Forecasters are professionals but their identities are not known. The respondents participating in the survey are asked to provide their forecasts of the annual real GDP growth rate that they expect to prevail eight quarters ahead of the time that the survey is conducted. In the current version of the survey the forecasting horizon is fixed, i.e. respondents are always asked to provide a forecast eight quarters ahead, irrespective of the quarter in which the question is asked. What distinguishes this survey from other surveys of economic forecasters and makes it so valuable for our analysis is the fact that each respondent provides his/her forecast in the form

[10] Boero et al. (2008) note that 'the time series of variances estimated by [our] method and the normal approximation are virtually indistinguishable from one another.'

of a histogram that has a similar distribution to the responses of the Decision Maker Panel. It is possible to construct first and second moments of the forecast distribution and to construct our economic uncertainty measure because we have each respondent's estimate of the probabilities of the annual real GDP growth rate falling into predefined bins.

2.2 Interpretation

Due to the construction of U_t the measure rises when individual uncertainty increases (higher variation around the each individual forecaster's point forecast) or when dispersion of individual forecaster's point forecasts around the average point forecast gets bigger. After an economic shock we tend to observe an increase in both. However, as the shock recedes we see individual variances contract and the dispersion around the average point forecast falls. This explains the tendency for U_t to rise after a major shock and then decline gradually as seen in Figure 2. This behaviour is observed in many different countries after the crisis, although we do not illustrate it here.

It has been remarked that U_t denotes economic uncertainty that varies over time but not between firms. The question then arises how does it capture firm-level uncertainty? The answer is that it does not capture idiosyncratic uncertainty of firms, but it does reflect the macroeconomic uncertainty that influences all firms. There are times when the macroeconomic uncertainty will dominate other sources of uncertainty, for example, when a crisis occurs. However, to ensure that we recognize individual firm uncertainty we also measure firm-specific uncertainty, $Vol_{it}^r/Vol_{it}^{mkt}$, initially proposed by Leahy and Whited (1996) and modified to form a relative measure in Bloom et al. (2007). This variable shows the idiosyncratic uncertainty of the firm as the relative variability in its share price increases compared to the variability of the stock market on which it is quoted. In the next section we will observe that both U_t and $Vol_{it}^r/Vol_{it}^{mkt}$ have an economic and statistical significance when included in the same regression.

It is also noted that U_t is just one of many macroeconomic variables that could be used to explain the levels shift in investment, cash and dividend payouts. In previous versions of this paper we included the average level of activity and a crisis dummy as well as U_t in our model specifications. These variables did not eliminate the strong negative impact of uncertainty. Even when we included time dummies to capture any source of time variation we still found individual volatility in firm-specific uncertainty to be strongly significant and negative. However, we should not confuse first and second moment effects, and our results are without doubt second-moment effects.

3 Modelling Firm-Level Responses to Uncertainty

Our modelling approaches for investment, payout and cash ratios are given in this section. They follow standard practice as far as possible to enhance comparability with previous studies. What is new is the addition of firm-specific uncertainty, based on the volatility of the stock price versus market volatility (all our firms are listed firms) and a measure of the economic uncertainty taken from the Survey of External Forecasters at the Bank of England, or the UK Economic Policy Uncertainty measure derived by Baker et al. (2016).

3.1 Investment

We expand a simple version of the stochastic Tobin's Q model to investigate the uncertainty-investment relation following the foundational papers by Davis and Haltiwanger (1992), Dixit and Pindyck (1994), Caballero et al. (1995), Abel and Eberly (1996), Cooper and Haltiwanger (2006), and Bond and Lombardi (2007) to give:

$$\frac{I_{it}}{K_{it-1}} = \beta_0 + \beta_1 \frac{I_{it-1}}{K_{it-2}} + \beta_2 \frac{I_{it-2}}{K_{it-3}} + \beta_3 Q_{it} + \beta_4 Q_{it-1} + \beta_5 \frac{CF_{it}}{K_{it-1}} + \\ + \beta_6 \frac{CF_{it-1}}{K_{it-2}} + \beta_7 \Delta S_{it} + \beta_8 Vol^r_{it}/Vol^{mkt}_{it} + \beta_9 U_t + u_{it} \quad (2)$$

The model presented in Eq. 2 is a familiar investment equation that relates the current investment rate to the first and second lag of investment, $\frac{I_{it-1}}{K_{it-2}}$ and $\frac{I_{it-2}}{K_{it-3}}$, the current and lagged Tobin's Q, Q_{it} and Q_{it-1}. Cash flow ratios, CF_{it}/K_{it-1} and CF_{it-1}/K_{it-2}, and sales growth rate, ΔS_{it}, are included to allow for the potential constraints on the investment by firms that cannot access external finance. The novelty in this equation is the introduction of two variables measuring uncertainty: the firm-specific uncertainty, $Vol^r_{it}/Vol^{mkt}_{it}$, and the macroeconomic uncertainty, U_t, which are our main variables of interest. The former controls for uncertainty surrounding the relatively high volatility of the stock price versus market volatility proposed by Leahy and Whited (1996) and modified to form a relative measure in Bloom et al. (2007), while the second is the assessment of uncertainty from the Survey of External Forecasters. As explained earlier these variables are the main focus of our enquiry. We make the usual one-way decomposition of the error term $u_{it} = \eta_i + \upsilon_{it}$ where υ_{it} is an idiosyncratic i.i.d. error term and η_i is an unobserved firm-specific fixed effect.

Having estimated an equation for the full sample period, we then explore the relationship between investment and economic uncertainty in sub-periods of the sample, such as the pre- and post-crisis sample periods:

$$
\begin{aligned}
\frac{I_{it}}{K_{it-1}} =& \beta_1 \frac{I_{it-1}}{K_{it-2}} + \beta_2 \frac{I_{it-2}}{K_{it-3}} + \beta_3 Q_{it} + \beta_4 Q_{it-1} + \beta_5 \frac{CF_{it}}{K_{it-1}} + \\
&+ \beta_6 \frac{CF_{it-1}}{K_{it-2}} + \beta_7 \Delta S_{it} + \beta_8 Vol^r_{it}/Vol^{mkt}_{it} \\
&+ \beta_9 U_{it} \times \mathbb{1}\{Pre\text{–}Crisis\} + \beta_{10} U_{it} \times \mathbb{1}\{Post\text{–}Crisis\} + u_{it}
\end{aligned} \tag{3}
$$

where the dummy variables $\mathbb{1}\{Pre\text{–}Crisis\}$ and $\mathbb{1}\{Post\text{–}Crisis\}$ take values equal to one for dates prior to 2007 and post 2008 respectively. We also estimate the effects of uncertainty shocks in particular years (2007-2009) to establish the marginal impact of uncertainty on investment ratios when uncertainty was at its highest point.

3.2 Cash Holding

Our baseline empirical model for the analysis of cash holdings draws on insights from Opler et al. (1999), Almeida et al. (2004), Faulkender and Wang (2006), Denis and Sibilkov (2010) and Bliss et al. (2015). It can be written as:

$$
\begin{aligned}
\frac{CASH_{it}}{TA_{it}} = & \beta'_0 + \beta'_1 \frac{CASH_{it-1}}{TA_{it-1}} + \beta'_2 \frac{TD_{it}}{TA_{it}} + \beta'_3 \frac{CF_{it}}{TA_{it}} + \beta'_4 CFV^{5y}_{it} + \\
& \beta'_5 MTB_{it} + \beta'_6 log(FA_{it}) + \beta'_7 \frac{NWC_{it}}{TA_{it}} + \beta'_8 \frac{INV_{it}}{FA_{it}} + \beta'_9 Vol^r_{it}/Vol^{mkt}_{it} + \beta'_{10} U_t + u_{it}
\end{aligned} \tag{4}
$$

This equation is less familiar than the investment equation, so we take more space to explain the regression for the cash-to-asset ratio, $CASH_{it}/TA_{it}$. TD_{it}/TA_{it} describes the ratio of total debt to total assets, which is included to allow for the fact that indebted companies face higher opportunity costs of holding cash (see Ferreira and Vilela (2004)). CF_{it}/TA_{it} is the ratio of cash flow to total assets. We expect the effect to be positive as it describes the relationship between cash stock and cash flow (see Almeida et al. (2004)), but firms may accumulate cash stocks from their retained profits or through sales of other assets over a longer period of time, so we do not necessarily expect this variable to be significant. CFV^{5y}_{it} describes volatility of cash flow growth rates over a 5-year period, which reflects the fact that firms with more volatile cash flows are found to hold more cash due to a precautionary motive, as documented among others by Opler et al. (1999) and Han and Qiu (2007). MTB_{it} is the market-to-book ratio, to ensure that firms with good investment opportunities typically hold more cash as they may face high outlays in the future, and in this respect we follow Bliss et al. (2015). $log(FA_{it})$ measures the size of a company in terms of the value of fixed assets, to reflect the observation that larger companies with easier access to external finance may hold less cash, as noted by Martinez-Carrascal and von Landesberger (2010). NWC_{it}/TA_{it} is the ratio of net working capital to total assets, to allow for lower cash holdings by firms that hold other cash substitutes on their books. Finally, we include INV_{it}/FA_{it} because firms with higher ratio of investment expenditures to fixed assets hold less cash as documented by Almeida et al. (2004), Palazzo (2012) and Arslan et al. (2006). Firm-specific uncertainty, $Vol^r_{it}/Vol^{mkt}_{it}$, controls for the effects of a relatively volatile stock price. Finally, U_t denotes economic uncertainty, which is our main variable of interest in this regression. Like in Eq. 2, we make the usual one-way decomposition of the error term $u_{it} = \eta_i + \upsilon_{it}$ where υ_{it} is an idiosyncratic i.i.d. error term and η_i is an unobserved firm-specific fixed effect.

3.3 Equity Payouts

Drawing on the comprehensive survey of payout policy by Allen and Michaely (2003) and Bliss et al. (2015) we use the following econometric model specification for firm i at time t:

$$\begin{aligned}\frac{DIV_{it}}{EARN_{it}} = \beta''_0 + \beta''_1\frac{DIV_{it-1}}{EARN_{it-1}} + \beta''_2\frac{RETAIN_{it}}{TA_{it}} + \beta''_3 log(FA_{it}) + \beta''_4 MTB_{it} \\ + \beta''_5\frac{CS_{it}}{TA_{it}} + \beta''_6\Delta Sales_{it} + \beta''_7 ROA_{it} + \beta''_8\frac{TD_{it}}{TA_{it}} \\ + \beta''_9 Vol^r_{it}/Vol^{mkt}_{it} + \beta''_{10}U_t + u_{it}\end{aligned} \tag{5}$$

with the usual one-way decomposition of the error term $u_{it} = \eta_i + \upsilon_{it}$. Once again the equation is less familiar so we define our variables. $DIV_{it}/EARN_{it}$ denotes the dividend-to-earnings ratio. We expect companies to reluctantly change their payout policy, and particularly so for the dividend policy (see Brav et al. (2005) and Floyd et al. (2015)), because there is a disproportionately negative reaction of markets to dividends cuts. But there will be other factors at the firm-level that drive payout behaviour, therefore we include several other controls. $RETAIN_{it}/TA_{it}$ is the ratio of retained earnings to total assets, and we expect firms with high level of retained profits in relation to their assets to payout more as documented by DeAngelo and DeAngelo (2006) and Denis and Osobov (2008). We then include a size variable measured by logarithm of fixed assets, $log(FA_{it})$, because large companies pay out dividends in smaller amounts but more often according to La Porta et al. (2000) and Lie (2000) among others. MTB_{it} denotes the market-to-book ratio, and this represents firms' investment opportunities. Lie (2000) has shown that a firm with a higher market-to-book ratio returns smaller shares of their profits to shareholders on average. CS_{it}/TA_{it} is the cash-to-asset ratio, allowing for the fact that payout measures can be negatively related to cash holdings. ΔS_{it} denotes the annual growth rate of sales, ROA_{it} describes return on assets, TD_{it}/TA_{it} measures total debt to total asset ratio. We expect higher sales growth and greater debt to weigh on payouts, but greater profitability to improve them (Khan (2006), Jiraporn et al. (2011), Grullon and Michaely (2002) and DeAngelo et al. (2006)). We control once again for firm-specific uncertainty, $Vol^{r}_{it}/Vol^{mkt}_{it}$. Finally, U_t denotes the economic uncertainty which is our main variable of interest.

4 Empirical Results

In this section we compare the uncertainty measures from the Survey of External Forecasters and CFOs' forecasts from the Decision Maker Panel survey to verify that they are comparable. We then explain our sample frame and present our main results beginning with the investment equation followed by cash and then payouts. Our results show that economic uncertainty has the expected effects on each of these firm-level variables.

4.1 Survey of External Forecasters and CFO Forecasts Compared

Data from the Survey of External Forecasters at the Bank of England provide a measure of economic uncertainty comprising the average subjective uncertainty plus the average disagreement between forecasters. We are able to create an uncertainty measure for each quarter, which will prove useful as a time series measure of uncertainty before and after the Great Financial Crisis. But it is legitimate to ask whether this measure of uncertainty is any more likely to be relevant than any other measure of economic uncertainty, of which there are many. Rather than compare all the measures of uncertainty against each other, which is prohibitively time consuming, we take a new approach by comparing the distribution of uncertainty we obtain from the Survey of External Forecasters with a new survey that asks CFOs to provide analogous information. If the two distributions overlap substantially then we can argue our measure of uncertainty is relevant to decision making about investment, cash holding and payouts made by senior executives. The new CFO survey is provided by the Decision Maker Panel of participating CFOs collected by the Bank of England.[11] Executives in firms were asked to allocate probabilities across seven bins labelled -2% or lower, -1%, 0%, 1%, 2%, 3% or higher. These can be directly compared to the forecasts of professional forecasters used to construct our uncertainty measure surveyed for the February 2017 *Inflation Report*. The resulting distribution given in Figure 5 shows a striking similarity between the distribution of Decision Maker Panel and the Survey of External Forecasters in terms of the simple average, the contributions to each bin and the weight in the tails. Furthermore, the expected growth rate of 1.1% for professionals (using mid-points of the ranges) is very close to the expected growth rate of 0.9% for Decision Maker Panel members (using bin values).

This establishes that the Survey of External Forecasters gives a similar distribution (and

[11] Executives were asked in three separate waves to assess the risks to their business from forecast GDP growth. The question asked in February 2017 was "We would now like to ask you about your expectations for the UK economy as a whole. Please indicate what probabilities you would attach to the following possible outcomes for year-ahead UK economic growth (real GDP growth, %)."

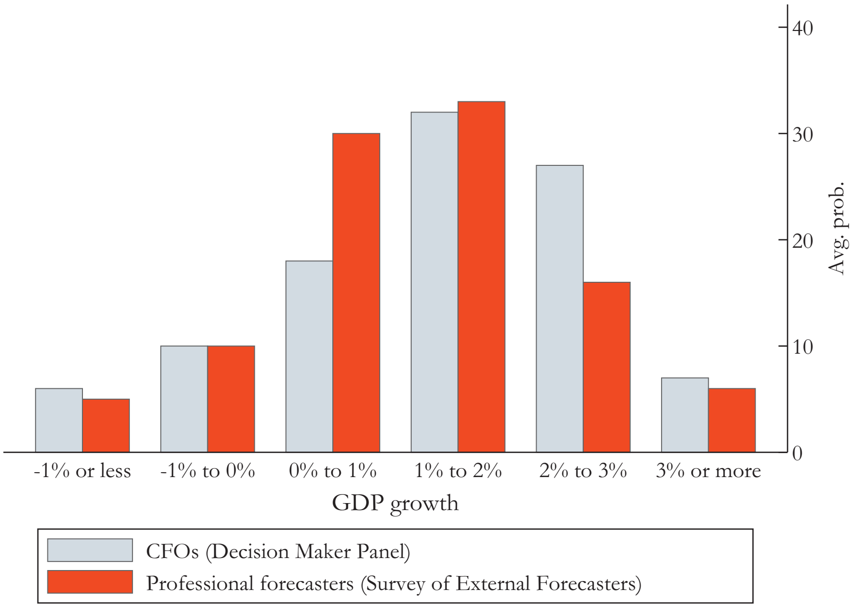

Figure 5: Average probability assigned by chief financial officers (light grey bars) and professional forecasters (orange bars) to various GDP growth scenarios in 2017q1. Bins used in the Decision Maker Panel were slightly different to the bins depicted in the graphs: -2% or lower, -1%, 0%, 1%, 2%, 3% or more.

hence a closely matched measure of uncertainty) to responses from firm CFOs. Figure 5 shows that the surveys of professional forecasters overlap substantially with the surveys of senior executives conducted by the Decision Maker Panel, and measures of uncertainty derived from them are essentially the same, allowing us to use the responses recorded by the Survey of External Forecasters. Nor does it affect our results if we use another popular measure of uncertainty based on Baker et al. (2016), the EPU measure instead.[12]

Using these survey data we can explore the changes in uncertainty that firms would have experienced in the pre-crisis and post-crisis periods by looking at the histograms of the Survey of External Forecasters. We do this for two dates: 2006q4 and 2009q4. Figure 6 shows a line plot linking the average probability in each bin in 2006q4, just before the recent financial crisis, and the same measure for 2009q4 after the crisis. The average values of each bin are connected by the bold line, and around these average values we show the 95%-confidence intervals with dashed lines. We observe that the distribution (based on the average probabilities across bins) shifts from being peaked at 2-3% in 2006q4 to being much more dispersed over all four bins in 2009q4; this implies uncertainty increased in 2009q4 compared to 2006q4. From observing the width of the standard error bands we note that the probability mass is more concentrated in the centre of the distribution in the pre-crisis period compared to the post-crisis period. The reason

[12] As we have already seen in the introduction, it is apparent that since the crisis that our measure of uncertainty, U_t, and the EPU, U_t^{EPU-UK}, have risen and remained elevated.

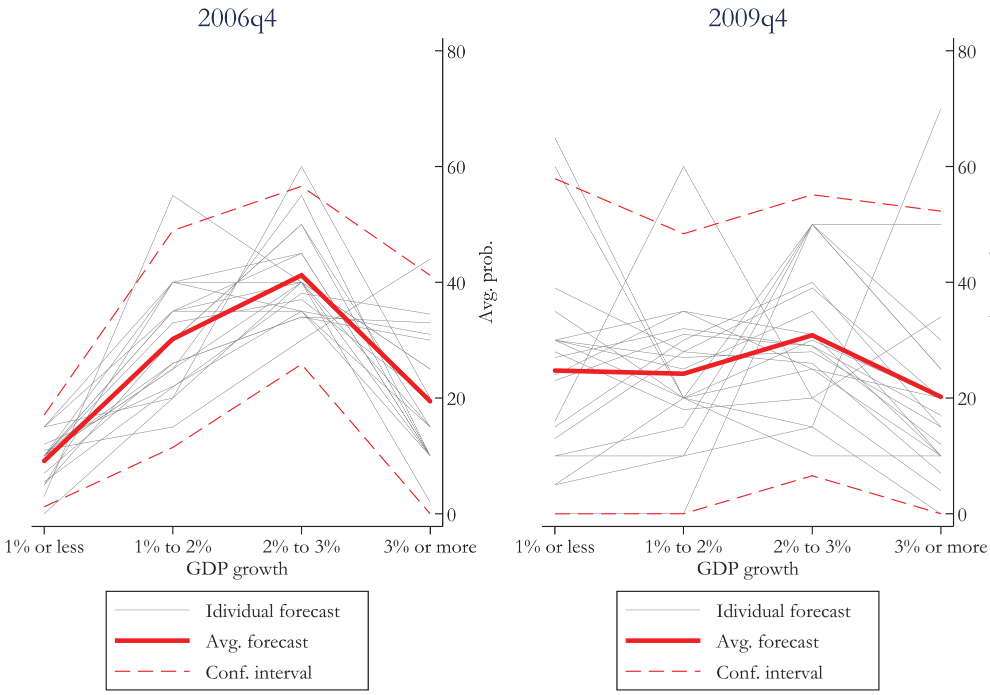

Figure 6: Average probability assigned by professional forecasters to various GDP growth rates in 2006q4 and 2009q4. This graph shows the changes in the distribution of average probabilities assigned by a group of professional forecasters before and after the financial crisis. Grey lines indicate individual forecasts. Bold solid lines indicate average probabilities and dashed bold lines indicate 95%-confidence intervals.

for this can be seen from the light grey lines showing the responses from individual professional forecasters. These are quite concentrated around the average value in bold for 2006q4, but they become much more variable and more widely dispersed in 2009q4.

4.2 The Sampling Frame

Data on firms' balance sheets, cash flow and income statements are drawn from Bloomberg to provide an unbalanced panel of over 10,000 UK listed firm-year observations over the period 1998 to 2015. The sample includes years prior to the Global Financial Crisis when uncertainty was lower and the period afterwards when it increased. We end the sample in 2015 to avoid contamination of our results with data affected by the run-up to the Brexit vote in 2016 and the subsequent after-effects.[13]

[13] Not only did uncertainty increase before the election day due to the possibility of a majority vote to leave, but the realisation after the result was announced that there was a majority for Brexit triggered one of the largest uncertainty shocks in the past 20 years (according to the EPU measure of uncertainty, the shock was more than twice the size of any previous uncertainty shock in two decades) introduced a different source and scale of uncertainty altogether. It is quite possible that coefficient estimates in investment, cash holding and payout

All companies included in our sample are listed and have their headquarters in the UK. Although public companies make up only a small fraction of the total number of companies in the British economy and employ a small part of the total workforce, they contribute a large part of UK total fixed assets investment. We analyse listed companies because they have information about their capital market value to compute Tobin's Q values and we can observe their dividend payouts.

Data are observed on company accounts in Bloomberg. With similarities to Bloom et al. (2007) our data for investment, as well for cash and payout ratios, are triple aggregated. First, across types (structures, equipment and vehicles for investment; cash and near-cash assets for cash; and across dividends, share repurchases and cancellations for payout ratios); second, across plants and subsidiaries within the firm; and third, over time, since the variation in these variables is likely to be higher frequency than annual. We do not need to explain the responses at the fully disaggregated level by type, within establishment or within the year to understand the firms' responses to changes in explanatory variables, particularly uncertainty.

We apply the usual exclusion criteria to the data (see Bond et al. (2003)) removing firms from finance, insurance, defence, public administration, and real estate sectors. The unbalanced panel has the advantage of avoiding the selection and survivorship bias. The average number of observations per firm is close to five. Full details of the variable construction and the descriptive statistics are reported in the Data Appendix.

4.3 Macroeconomic Uncertainty and Firm Decisions

4.3.1 Investment and Uncertainty

Table 2 contains our main results of our empirical analysis for investment. Columns (1) and (2) contain estimation results of two basic OLS regressions, and column (3) offers a dynamic fixed effects model. This is followed by a number of versions of a dynamic Tobin's Q model that add variables allowing for cash flow (financial constraints) and sales growth (growth in demand) and other controls in columns (4)-(5), which show similar signed coefficients to Bond et al. (2003) and Bloom et al. (2007). The results show, as expected, that current and lagged values of Tobin's Q positively and significantly influence investment ratios. Moreover, the lagged cash flow ratio and the sales growth rate also help to explain some variation in investment ratios. Firms with greater cash flow ratios in the past or greater sales dynamic tend to invest more. The results are robust to choices over different lags of instruments and the treatment of different variables as endogenous. In addition our results satisfy the test for autocorrelation and show that the test of the overidentifying restrictions cannot be rejected. As a result, our set of instruments appears

equations may be found to differ substantially in the Brexit period versus the period directly after the Great Financial Crisis, but at the time of writing the 1-2 additional years of available data are not sufficient to assess this possibility.

to be valid and exogenous. These results therefore provide a robust benchmark for our analysis of uncertainty.

We control in many specifications for individual firm uncertainty denoted by $Vol_{it}^{r}/Vol_{t}^{mkt}$. Individual uncertainty is connected with the average daily volatility of the stock price of the firm relative to the average daily volatility of the market explains a significant part of investment behaviour. This type of uncertainty decreases the investment ratio by 0.4 p.p. on average. Relatively choppy stock prices capture firm-specific effects that are not recorded elsewhere on the balance sheet or income statement, and they do reduce investment ratios.

Our main result focuses on economic uncertainty, denoted by U_t, which is expected to have a significant negative impact on investment ratios of firms. The variable is standardized to give the effect of a one standard deviation change on the investment ratio, which has the advantage that the response to different measures of uncertainty can be compared with each other. On average the standard deviation of U_t in our sample is 0.33, which is comparatively small, but around the 2008 crisis it jumped from a value of 1.2 to 2.2 or approximately three standard deviations.

We find in every column that uncertainty has a negative effect on the investment ratio, and the result is robust to the estimation method and the model specification. We maintain the negative effect even after controlling for usual forward-looking variables such as Tobin's Q that have been shown to influence investment in the empirical literature and also after controlling for individual firm-specific uncertainty. This establishes that U_t is not recording uncertainty that is connected to investment opportunities or to the stock price variation. As shown in column (5), all other factors being constant, an increase in economic uncertainty decreases the investment ratio by 0.5 p.p. on average. The result using the EPU measure of uncertainty reported in column (6) has very similar magnitude. Higher uncertainty after the global finance crisis appears to have resulted in a lower investment ratio as observed in the cross-correlations in firm-average investment ratios and uncertainty reported earlier. The information in Table 2 shows that the relationship is found in data for individual firms in our sample, after controlling for other drivers of investment. Finally, we report the regression results when we drop U_t altogether and replace it with time dummies in column (8). The estimates show that individual uncertainty due to relative stock volatility remains negative and significant, while macroeconomic uncertainty is captured by time dummies.

When we take the residuals (after removing time trends) from the estimate in column (8) and plot these against economic uncertainty, U_t, in Figure 7 we observe that the negative relationship that we first highlighted in the introduction is robust to including the explanatory variables in our regression specification. There is evidently an increase in the slope in the post crisis period.

In a further exploration of the changing relationship between investment and economic uncertainty, we split the uncertainty measure into two by interacting it with two dummy variables $\mathbb{1}\{Pre\text{–}Crisis\}$ and $\mathbb{1}\{Post\text{–}Crisis\}$ that take values equal to one for dates prior to 2007 and post 2008 respectively. In the pre-crisis period, uncertainty is low and trending downwards, while

Table 2: Regressions of investment ratios on determinants of corporate investment decisions (INV_{it}/K_{it-1})[a,b]

	(1) OLS	(2) OLS	(3) FE	(4) GMM	(5) GMM	(6) GMM	(7) GMM	(8) GMM
Firm-level effects								
I_{it-1}/K_{it-2}	0.369***	0.337***	0.120***	0.276***	0.347***	0.342***	0.263***	0.222***
	(0.008)	(0.008)	(0.010)	(0.027)	(0.027)	(0.027)	(0.027)	(0.026)
I_{it-2}/K_{it-3}					0.091***	0.090***		
					(0.013)	(0.013)		
Q_{it}	0.241***	0.117***	0.232***	0.271***	0.352***	0.349***	0.275***	0.245***
	(0.011)	(0.016)	(0.020)	(0.087)	(0.131)	(0.130)	(0.088)	(0.086)
Q_{it-1}		0.111***	0.238***	0.076	−0.005	−0.001	0.081	0.109**
		(0.014)	(0.017)	(0.050)	(0.075)	(0.074)	(0.051)	(0.050)
CF_{it}/K_{it-1}	0.395***	0.058	−0.017	−0.059	0.183	0.174	−0.078	−0.136
	(0.062)	(0.070)	(0.090)	(0.178)	(0.299)	(0.296)	(0.177)	(0.173)
CF_{it-1}/K_{it-2}		0.379***	0.312***	0.360***	0.317***	0.317***	0.367***	0.350***
		(0.057)	(0.071)	(0.093)	(0.104)	(0.104)	(0.092)	(0.091)
ΔS_{it}		9.016***	6.342***	3.366***	3.780***	3.811***	3.093***	2.029**
		(0.480)	(0.536)	(1.046)	(1.134)	(1.132)	(1.037)	(0.965)
Vol^r_{it}/Vol^{mkt}_t		−0.352***	−0.651***	−0.449***	−0.430***	−0.430***	−0.314**	−0.380***
		(0.092)	(0.127)	(0.133)	(0.157)	(0.155)	(0.135)	(0.144)
Macro effects								
U_t	−0.456***	−0.352***	−0.501***	−0.569***	−0.452***			
	(0.134)	(0.132)	(0.150)	(0.158)	(0.171)			
$U_t^{pre-crisis}$							1.808***	
							(0.408)	
$U_t^{post-crisis}$							−1.429***	
							(0.379)	
U_t^{EPU-UK}						−0.449***		
						(0.151)		
Time FE	No	No	No	No	No	No	No	Yes
Firm FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	10203	10203	10203	10203	9041	9041	10203	10203
R^2	0.494	0.526	0.446	0.498	0.516	0.517	0.500	0.496
Hansen-p				0.563	0.998	0.998	0.574	0.136
AR(1)-p				0.000	0.000	0.000	0.000	0.000
AR(2)-p				0.009	0.296	0.282	0.013	0.085

[a] This table reports estimates of regressions relating investment decisions to the subjective uncertainty measure U_t, Tobin's Q values and lagged investment ratios alongside other factors that have been found to be relevant for corporate investment decisions. Current investment ratio is used as the dependant variable in all regressions. We use OLS estimator in columns (1)-(2) and the FE estimator in column (3). We use the system-GMM estimator to estimate the regression coefficients in columns (4)-(8). In equations (4)-(8), Tobin's Q, Q_{it}, the investment ratio, I_{it-1}/K_{it-2}, change in sales revenue, ΔS_{it} and cash flow ratio, CF_{it}/K_{it-1}, are treated as endogenous variables. $Vol^r_{it}/Vol^{mkt}_{it}$ controls for the effects of a relatively volatile stock price and U_t is macroeconomic uncertainty. Collapsed matrix with instruments reducing the number of instruments as described by Roodman (2009) are used. Robust standard errors of are displayed below regression coefficients. P-values are displayed in the last three lines in the bottom part of the table. The R^2 is calculated as $\rho(\hat{y}_{it}, y_{it})$ where ρ denotes a correlation coefficient.

[b] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

the post crisis period uncertainty jumps upwards immediately after the crisis and then trends down slightly. Uncertainty in the post-crisis period has a significant negative relationship with the investment ratio, which is picked up after controlling for other variables.[14] However, the Great Financial Crisis episode has a much larger estimated negative coefficient than the estimate for the full sample, which matches the observation we made in Figure 3 about the steeper responses in the investment ratio to economic uncertainty (on average across firms) in the post crisis period compared to the full sample.[15]

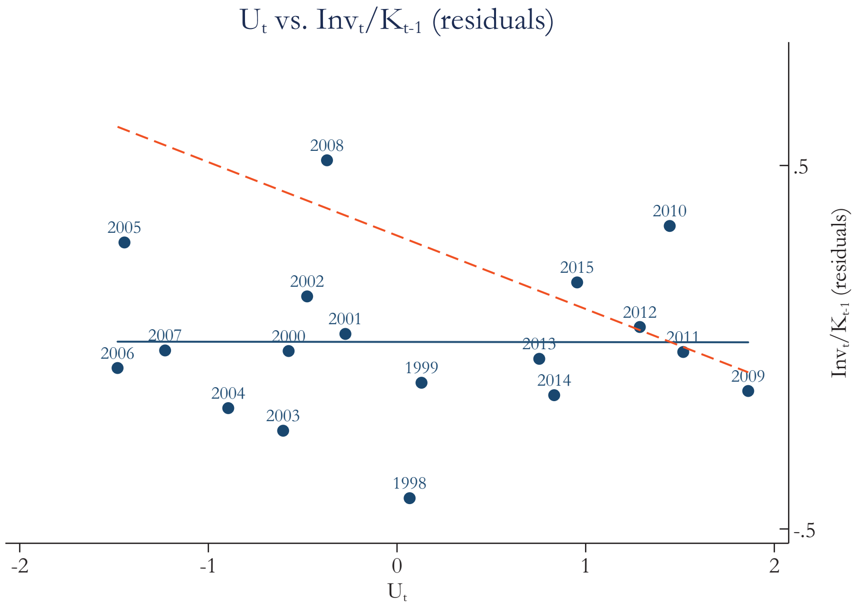

Figure 7: Uncertainty and Investment Residuals. The scatter plots the negative relation between macroeconomic uncertainty and average investment ratios residual. The residuals are calculated using specification in column (8) of Table 2. The solid blue line is a fitted line based on the whole sample. The dash red line is a fitted line based on post-2008 sample.

There are several reasons why the investment ratio might have fallen with higher levels of economic uncertainty in the post-crisis period. It might happen as firms take a 'real option' to wait rather than invest in costly and irreversible projects after such a large economic shock. This view would be consistent with evidence in Ramey and Shapiro (2001) and Cooper and Haltiwanger (2006). Uncertainty may further have influenced firms through pro-cyclical productivity. As uncertainty rises, investment, output and productivity all fall (see King and Rebelo

[14]The pre-crisis period shows no such relationship, and the highly cyclical investment ratio actually tends to be positively related to the mild variation around the downward trend in uncertainty. This is puzzling at first, but it arises from the down stage of the cycle in real fixed capital formation coinciding with a slight decline in U_t over the period 2000-2005. As mentioned earlier, U_t has a tendency to contract as individual variances and disagreement between forecasters fall as the impact of a large shock recedes.

[15]In deeper analysis of the year effects in the Appendix, we show that by estimating the relationship and leaving out one year at a time - using so-called Left-One-Out (LOO) regressions - we find 2009 to be a pivotal year, which results in a much smaller negative coefficient if left out, compared to when other years are omitted.

(1999)). If more productive firms invest less and unproductive firms contract less in response to uncertainty, there is a chilling effect on productivity-driving reallocation of resources (see Bloom (2014)) supporting the notion of an uncertainty-driven business cycle (see Bloom et al. (2018)). Productivity in the UK has fallen at the same time that firms have undertaken less investment, in fact productivity growth has been zero in the UK for a decade since the financial crisis (see Ramsden (2018)). As mentioned previously, a cross plot of productivity against uncertainty (U_t) reveals a strong negative relationship and dated observations for productivity after 2008 are clustered to the right hand side where uncertainty is high. We do not explore this relationship further but it indicates further work would be warranted.

We conclude that investment decisions of firms in the UK were significantly and negatively affected by economic uncertainty. This variable was important even when we control for many other standard variables used in empirical investment regressions. We now turn to other business decisions to explore whether they corroborate this finding by, for example, showing greater precautionary saving through higher cash ratios and lower payouts.

4.3.2 Cash Stock Analysis

In this section we present our analysis of cash ratios (cash holdings relative to total assets). Our main result is that cash ratios are also significantly affected by uncertainty even after controlling for other factors, and they move in a direction that is consistent with greater caution due to higher uncertainty. In particular, as uncertainty about future macroeconomic conditions increases, the more cash companies hold on their accounts.

Our main results are presented in Table 3. We report OLS and dynamic fixed effects models in columns (1)-(3) and then offer system GMM estimates in column (4)-(6). According to our estimates, all other factors being equal, more indebted and larger companies as well as those ones which are currently involved in large investment projects tend to hold less cash on average. Conversely, companies that used to hold lots of cash in the past as well as those with highly volatile cash flows, tend to hold more cash on average, *ceteris paribus*. Surprisingly, firms with higher levels of net working capital seem to hold more cash too. This can be possibly explained by the fact that in uncertain times net working capital becomes a complement to cash and cash equivalents, not a substitute.

The main variable of interest, U_t, is standardized and has the expected positive sign. It is highly significant in all five regression equations. Consequently, holding other factors constant, the higher is the degree of economic uncertainty, the larger share of assets will be kept by firms in the form of cash. The cash ratio in total assets rises by 0.3 p.p on average in response to an increase in uncertainty by one standard deviation according to column (4). Once again using EPU uncertainty in column (5) delivers a very similar result, with a coefficient estimate close to the one reported in column (4). Our result is robust to model specification and to the measure of economic uncertainty used. When we drop U_t and add time dummies, we find the individual

Table 3: Regressions of cash stock ratios on determinants of liquidity demand (CS_{it}/TA_{it})[a,b]

	(1) OLS	(2) OLS	(3) FE	(4) GMM	(5) GMM	(6) GMM
Firm-level effects						
CS_{it-1}/TA_{it-1}	0.758***	0.688***	0.373***	0.483***	0.481***	0.477***
	(0.012)	(0.012)	(0.018)	(0.034)	(0.034)	(0.029)
TD_{it}/TA_{it}		−1.239**	0.777	−2.051**	−1.957**	−1.428
		(0.534)	(1.132)	(0.941)	(0.934)	(0.891)
CF_{it}/TA_{it}		1.293	2.234**	2.277**	2.215**	1.639*
		(0.958)	(0.983)	(1.064)	(1.064)	(0.944)
$CFVol_{it}^{5y}/TA_{it}$	4.488***	4.086***	3.313***	6.241***	6.228***	5.778***
	(0.869)	(0.854)	(1.160)	(1.159)	(1.153)	(1.133)
$MKTVAL_{it}/TA_{it}$	0.519***	0.456***	0.093	0.158	0.164	0.332
	(0.102)	(0.099)	(0.123)	(0.279)	(0.279)	(0.232)
$log(FA_{it})$		−0.049	−0.874***	−0.182**	−0.183**	−0.157**
		(0.039)	(0.273)	(0.073)	(0.072)	(0.069)
NWC_{it}/TA_{it}		8.932***	24.773***	14.902***	15.046***	16.168***
		(0.527)	(1.587)	(1.173)	(1.174)	(1.159)
INV_{it}/TA_{it}		−6.177***	−7.978***	−9.720***	−9.093***	−9.409***
		(1.510)	(2.146)	(3.362)	(3.382)	(2.969)
$Vol_{it}^{r}/Vol_{t}^{mkt}$		0.302***	0.198**	0.300***	0.307***	0.299***
		(0.084)	(0.098)	(0.093)	(0.093)	(0.098)
Macro effects						
U_t	0.216***	0.276***	0.189**	0.318***		
	(0.077)	(0.076)	(0.089)	(0.089)		
U_t^{EPU-UK}					0.421***	
					(0.092)	
Time FE	No	No	No	No	No	Yes
Firm FE	No	No	Yes	Yes	Yes	Yes
Obs.	9332	8958	8958	8958	8958	8958
R^2	0.791	0.813	0.719	0.793	0.793	0.792
Hansen-p				0.129	0.156	0.102
AR(1)-p				0.000	0.000	0.000
AR(2)-p				0.623	0.676	0.380

[a] The dependant variable in all regressions is current value of cash stock ratio. The variable treated as endogenous in columns (4) - (6) is $CASH_{it}/TA_{it}$. We use up to two lags of the endogenous variable as instruments. The variables in the regression are TD_{it}/TA_{it}, the ratio of total debt to total assets; CF_{it}/TA_{it} the ratio of cash flow to total assets; CFV_{it}^{5y} the volatility of cash flow growth rates; MTB_{it}, the market-to-book ratio; $log(FA_{it})$ the log value of fixed assets; NWC_{it}/TA_{it} the ratio of net working capital to total assets; and INV_{it}/FA_{it}, investment expenditures to fixed assets. $Vol_{it}^{r}/Vol_{it}^{mkt}$, controls for the effects of a relatively volatile stock price and U_t is macroeconomic uncertainty. To estimate s.e. we use an estimator robust to heteroskedasticity and autocorrelation. We use a two-step procedure to obtain the variance-covariance matrix and apply Windmeijer's finite-sample correction.

[b] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

firm-level uncertainty measure remains positive and significant as reported in column (6).

From a purely accounting point of view our result could be the flip side of the earlier findings observed in Table 2. If firms are holding back from investment, either because they take the real option of waiting or have become more risk averse, we would expect to see the resources that would have been allocated to investment appear elsewhere on the balance sheet. Table 3 shows that cash stocks increase with uncertainty, and this is consistent with an interpretation that UK firms that hold back from investment also hold more cash.

Another interpretation, consistent with the findings of Gilchrist et al. (2014) is that uncertainty increases the borrowing costs of firms, which may reduce the availability of loans for investment. If this is the case firms may have to rely more heavily on internal funds, if they intend to invest, which would explain why they hold larger cash stocks and, as we shall see below, reduce their payouts. Campello et al. (2010) state that among constrained firms, CFOs report that investment was more likely to be cancelled than funded from cash stocks or cash flow in the US and Europe. A strong precautionary motive for cash may justify this behaviour (see Kim et al. (1998); Opler et al. (1999); Almeida et al. (2004)).

Whichever reason lies behind the result, it is consistent with the observation in the national accounts that firms have been holding much larger cash stocks since the crisis. Our analysis links this behaviour to economic uncertainty.

4.3.3 Payout Analysis

The final piece of the puzzle is the payout policy. If firms were more cautious due to higher economic uncertainty and it had a chilling effect on business decisions, we would expect payouts to fall. Besides, Bliss et al. (2015) show that a decision to lower dividend payouts can be a reflection of the desire for cash preservation in times of crisis.

The estimation results of the dividends equations are presented in Table 4. OLS and dynamic fixed effects are reported in columns (1)-(3) followed by system GMM estimates. As expected, the lagged value of the dependent variable is positive and highly significant, which means that firms are indeed reluctant to change their dividend policies. The coefficient on economic uncertainty is negative and highly significant, reducing payouts by about 1.4 p.p. on average in response to an increase in uncertainty by one standard deviation. This confirms that firms deal with elevated uncertainty by keeping larger share of their profits for themselves and returning less to their shareholders. Other coefficients have the expected sign, though there are a few surprises. The coefficient on the ratio of retained profits to total equity is negative, while the coefficient on the size variable is positive. Thus, our data does not confirm the life cycle hypothesis of dividend payments. The signs of the remaining coefficients are in line with our expectations. In particular, firms that are characterised by greater sales dynamic or are more indebted pay out smaller dividends. Conversely, firms that achieve higher returns on assets tend to pay out more to investors.

Table 4: Regressions of payout variables on determinants of dividend payouts ($DIV_{it}/EARN_{it}$).[a,b]

	(1) OLS	(2) OLS	(3) FE	(4) GMM	(5) GMM	(6) GMM
Firm-level effects						
$DIV_{it-1}/EARN_{it-1}$	0.389***	0.303***	0.047***	0.120***	0.118***	0.109***
	(0.008)	(0.009)	(0.010)	(0.025)	(0.025)	(0.025)
TD_{it}/TA_{it}		−8.360***	−8.295*	−11.645***	−12.262***	−11.271***
		(2.874)	(4.649)	(3.872)	(3.893)	(3.816)
$MKTVAL_{it}/TA_{it}$		0.256	−0.327	0.169	0.134	0.016
		(0.272)	(0.353)	(0.198)	(0.201)	(0.197)
$log(FA_{it})$		2.565***	3.936***	3.389***	3.349***	3.049***
		(0.186)	(0.633)	(0.270)	(0.270)	(0.271)
$RETAIN\,RATIO_{it}$		0.224*	0.127	−0.204	−0.198	−0.146
		(0.132)	(0.162)	(0.144)	(0.145)	(0.140)
CS_{it}/TA_{it}	−24.945***	−2.294	−7.206	−14.664**	−15.618**	−19.489***
	(2.209)	(3.104)	(4.597)	(6.599)	(6.607)	(6.240)
ΔS_{it}		−2.306***	−0.694	−1.436***	−1.421***	−1.270***
		(0.523)	(0.573)	(0.304)	(0.308)	(0.313)
ROA_{it}		17.928***	2.541	19.812***	19.669***	18.014***
		(2.527)	(3.812)	(2.382)	(2.408)	(2.355)
$Vol^{r}_{it}/Vol^{mkt}_{it}$		−3.021***	−1.277***	−2.448***	−2.478***	−3.272***
		(0.299)	(0.382)	(0.287)	(0.288)	(0.346)
Macro effects						
U_t	−1.446***	−1.872***	−1.429***	−1.385***		
	(0.363)	(0.414)	(0.471)	(0.525)		
U_t^{EPU-UK}					−1.856***	
					(0.461)	
Time FE	No	No	No	No	No	Yes
Firm FE	No	No	Yes	Yes	Yes	Yes
Obs.	14378	11892	11892	11892	11892	11892
R^2		0.189	0.124	0.162	0.161	0.166
Hansen-p				0.019	0.008	0.021
AR(1)-p				0.000	0.000	0.000
AR(2)-p				0.027	0.027	0.031

[a] The variables treated as endogenous in regressions (4) - (6) are the dividend to earnings ratio, $DVD_{it-1}/EARN_{it-1}$, cash stocks to total asset ratio, CS_{it}/TA_{it} and the retained earnings ratio, $RETAIN\,RATIO_{it}$. We then include log of fixed assets, $log(FA_{it})$, ΔS_{it}, the annual growth rate of sales, ROA_{it} the return on asset, $DEBTRATIO_{it}$ short-term debt ratio to total assets, and $MKTVAL_{it}/TA_{it}$, market value to total assets ratio. $Vol^{r}_{it}/Vol^{mkt}_{it}$, controls for the effects of a relatively volatile stock price and U_t is subjective uncertainty. In all regressions, we instrument endogenous variables using their lags. We use up to two lags of the endogenous variables as instruments. To estimate s.e. we use an estimator robust to heteroskedasticity and autocorrelation. We use a two-step procedure to obtain the variance-covariance matrix and apply Windmeijer's finite-sample correction.

[b] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

As seen in column (4) the coefficient on our main variable of interest, economic uncertainty, U_t, is negative and highly significant. This result is evidence that in uncertain times firms restrict dividend payouts, thus returning less wealth to their shareholders. We have shown this controlling for other factors that are found to explain variability in dividend payouts. Once again this is a confirmation of the results indicating that firms become more cautious as uncertainty increases. It conforms with the picture seen in previous results where uncertainty lowers investment, increases cash holdings and as we see here reduces dividend payouts[16]. Replacing U_t with time dummies we find that a strong negative effect of individual uncertainty remains.

To sum up, regression results in the last three sections show that greater economic uncertainty has a statistically significant effect on companies decisions by limiting their willingness to undertake investment and payouts to their shareholders in the form of dividends. Firms also hold more cash on their balance sheets in response to uncertainty.

5 The Effects of the Great Financial Crisis on Business Decisions

Figure 2 showed that uncertainty increased substantially after the Great Financial Crisis and has remained elevated since 2007. Using our results reported in previous sections we can now show the extent to which higher economic uncertainty has reduced investment and payout ratios and increased cash holding relative to total assets. These results provide a benchmark measure of the magnitude of the Great Financial Crisis shock that could be used in the future to assess the scale of the Brexit uncertainty shock.

The response to the Great Financial Crisis can be shown as the response to shocks in three successive years (2007-2009) in three figures. Figure 8 shows the predicted path of the investment ratio, while Figures 9 and 10 show the predicted paths for cash and payouts respectively.

The solid line in the first panel in Figure 8 shows the path of the investment ratio when we allow for the impact of uncertainty shocks in 2007-2009. The investment ratio was at a peak of over 1%8 in 2007 and fell to a trough of around 13% by 2011. This can be compared to the counter-factual paths if we peel back the effects of the uncertainty shocks in 2007, 2008 and 2009. In graphical terms, the uppermost dashed line gives the counter-factual if there had been no uncertainty shocks at all, showing that the trough would have been close to 15% rather than 13% all other things equal. Comparison of the distance between the dashed lines in the left hand panel shows the magnitude of the shocks in each year: 2007 had quite a modest effect on investment ratios, while 2008 had a larger effect and the shock in 2009 was larger still, reducing the investment ratio substantially. The right panel shows the 95% confidence intervals around

[16] We got similar results, when we estimated the impact of economic uncertainty on stock buybacks and cancellation.

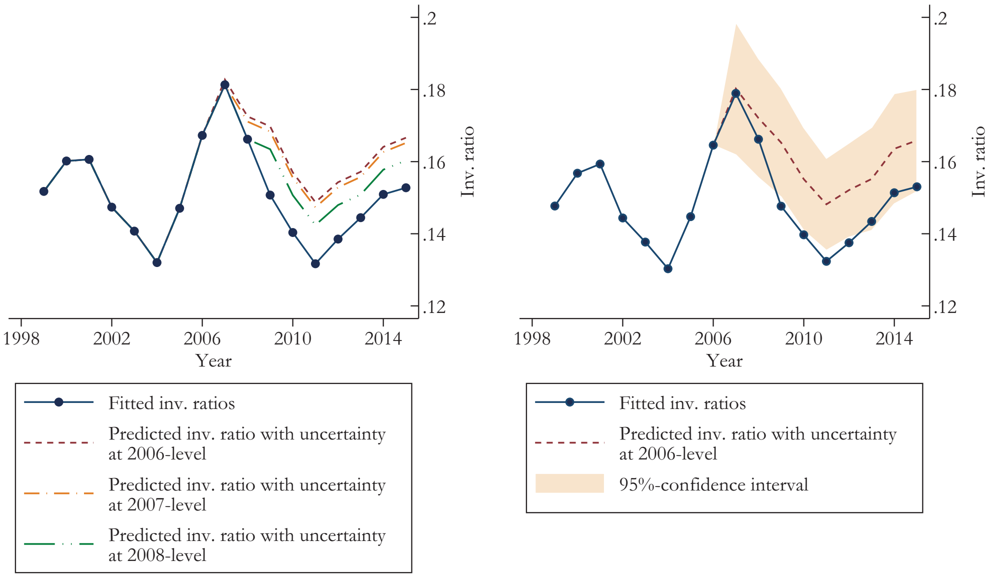

Figure 8: Impact of macroeconomic uncertainty on investment ratios. This left panel depicts the predicted values of investment ratios, INV_t/K_{t-1}, assuming that macroeconomic uncertainty, U_t, would have stayed at its 2006-level (short dash line), at its 2007-level (dash-dot line), or at its 2008-level (long dash-dot-dot line) compared to fitted values calculated using actual values of macroeconomic uncertainty variable. The right panel depicts the predicted values of investment ratios, INV_t/K_{t-1}, assuming that macroeconomic uncertainty, U_t, would have stayed at its 2006-level (short dash line) along 95%-confidence interval. The slight difference in fitted lines in left and right panel result from a slightly different model used to estimate the relation between investment and uncertainty, which allowed for calculation of confidence intervals around our predictions.

the predicted path, which shows that the combined effects of the shocks resulted in a deviation that was statistically significant at the 5% level. f

Figures 9 and 10 for cash stocks and payouts respectively show a similar pattern. Cash increased in successively larger amounts due to uncertainty shocks to a peak of more than 12% in 2013 compared to a value around 11% in 2007, and the dividend ratio fell from 33% in 2007 to 27% in 2009 and remained below 31% for the post crisis period. Cash holding did not increase in total by a statistically significantly amount compared with the counter-factual. Reductions in payouts, on the other hand, were successively larger due to uncertainty shocks and were reduced in total by a statistically significant amount.

In due course it will be possible to use these results to compare the full effects of Brexit uncertainty shocks in 2016-2019 with the effects of uncertainty shocks from the Great Financial Crisis in 2007-2009. The contribution here is to provide the benchmark for comparison.

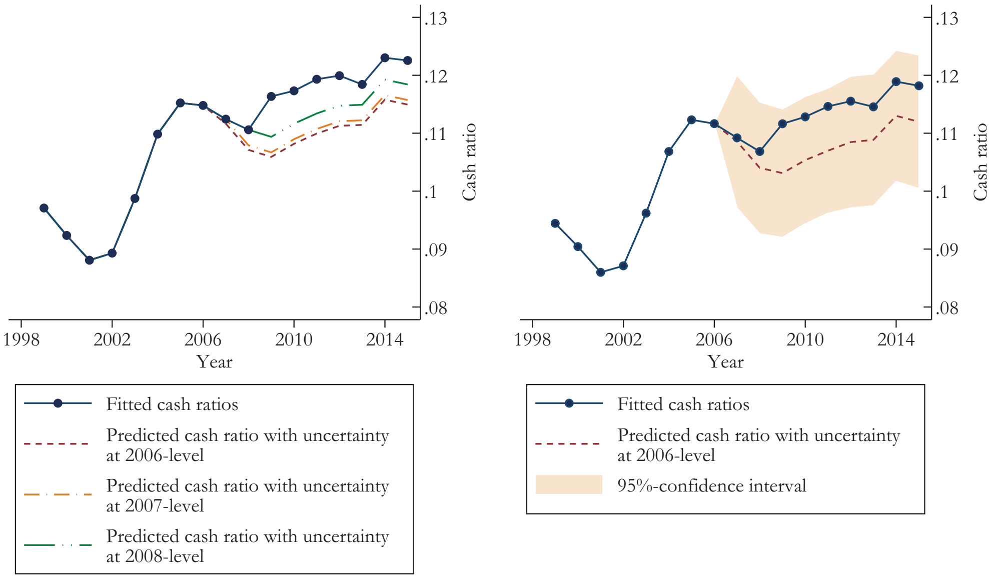

Figure 9: Impact of macroeconomic uncertainty on cash ratios. This left panel depicts the predicted values of cash ratios, CS_t/TA_t, assuming that macroeconomic uncertainty, U_t, would have stayed at its 2006-level (short dash line), at its 2007-level (dash-dot line), or at its 2008-level (long dash-dot-dot line) compared to fitted values calculated using actual values of macroeconomic uncertainty variable. The right panel depicts the predicted values of investment ratios, CS_t/TA_t, assuming that macroeconomic uncertainty, U_t, would have stayed at its 2006-level (short dash line) along 95%-confidence interval. The slight difference in fitted lines in left and right panel result from a slightly different model used to estimate the relation between investment and uncertainty, which allowed for calculation of confidence intervals around our predictions.

6 Summary and Conclusions

The Lehman Brothers event in 2008 created a large uncertainty shock that triggered an economic slowdown for a decade as documented in many studies of macroeconomic effects of the crisis. What is less well recognised is the impact that economic uncertainty had on firm-level decisions, particularly corporate investment, dividend payouts and cash holdings. Using results from over 10,000 UK firm-year observations, we offer a new insight into the effects of economic uncertainty on these decisions, which may also help focus attention on the underlying reasons for the productivity slowdown in the UK.

Our paper has exploited the similarities between first and second moments in surveys of macroeconomic uncertainty from professional forecasters and CFOs collected by the Bank of England. We have demonstrated that pervasive macroeconomic uncertainty lowered investment (and payouts) even after allowing for investment opportunities, sales growth, and the firm's own stock volatility. Uncertainty also explains the rise in cash holdings. Hence our results help explain why UK firms undertook a puzzlingly low level of investment in a time of record low

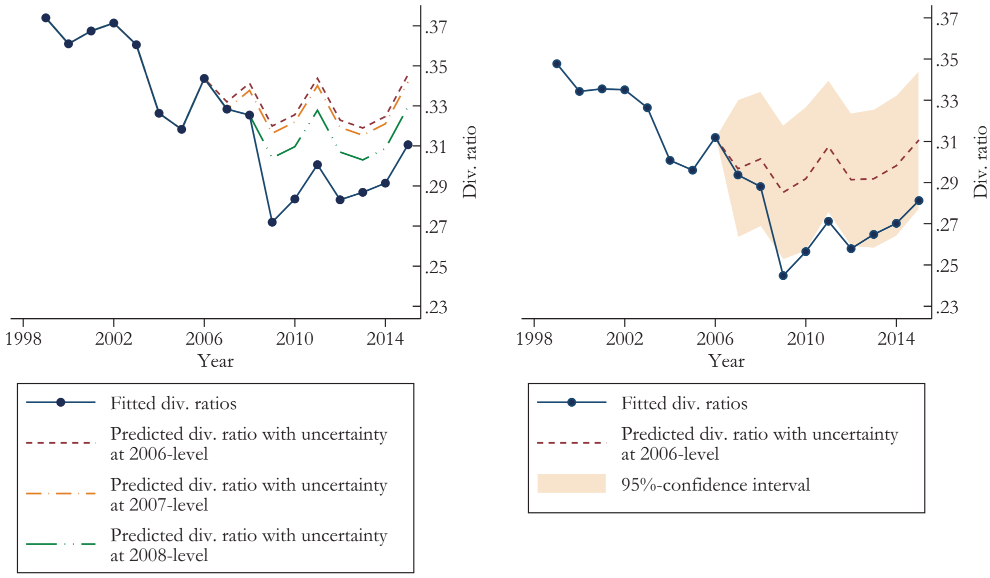

Figure 10: Impact of macroeconomic uncertainty on dividends ratios. This left panel depicts the predicted values of dividend ratios, $DIV_t/EARN_t$, assuming that macroeconomic uncertainty, U_t, would have stayed at its 2006-level (short dash line), at its 2007-level (dash-dot line), or at its 2008-level (long dash-dot-dot line) compared to fitted values calculated using actual values of macroeconomic uncertainty variable. The right panel depicts the predicted values of dividends ratios, $DIV_t/EARN_t$, assuming that macroeconomic uncertainty, U_t, would have stayed at its 2006-level (short dash line) along 95%-confidence interval. The slight difference in fitted lines in left and right panel result from a slightly different model used to estimate the relation between dividends and uncertainty, which allowed for calculation of confidence intervals around our predictions.

interest rates, offered lower dividend payouts and held more cash. These results could be part of the explanation for the low productivity experienced in the UK since 2008. Finally, the results provide an important benchmark against which future studies of Brexit uncertainty can compare the effects those uncertainty shocks to the period after the Great Financial Crisis.

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Appendix

Evolution of Survey Bins

Table 5 shows the evolution of the bins in the Survey of External Forecasters, collected by the Bank of England. Although the number and range of the bins have changed over time, these changes are not coincident with the variations in our uncertainty measure.

Data Appendix and Descriptive Statistics

Our dependent variables are calculated as follows.

The ratio of net investment in tangible fixed assets to the value of the capital stock at the beginning of the period. Using the perpetual inventory formula to obtain the capital stock we set the initial value to be equal to the net book value of fixed assets, updating the discounted value of capital stock from the previous period with net investment taken from the cash flow statement. We use the depreciation rate of of 6.9% which was calculated as a weighted average of the commonly used depreciation rates for buildings and other assets.

The cash stock is a balance sheet item and is defined as the amount of cash and cash equivalents on company's books.

We measure dividends using data on the ratio of cash dividends per share divided by the number of shares outstanding at the end of the period. We scale dividends by earnings.

The balance sheet variables used in the investment equations comprise Tobin's Q, cash flow, change in sales and individual firm-level uncertainty. Following Hayashi (1982) we calculate Tobin's Q as a ratio of the sum of the market value of a firm and gross current stock of debt (long-term borrowings less net current assets) and the value of capital stock at the replacement cost.[17] The cash flows ratio is equal to the ratio of the net income (profit after all expenses) plus depreciation and capital stock at the beginning of the period. Changes in sales is the annual growth rate of sales revenue from the balance sheet. Individual firm-level uncertainty we compute a measure equal to is the ratio of its stock return volatility scaled by the overall volatility of the stock market, using average volatility of daily stock returns of each firm,and the main stock market index.

The balance sheet variables used in the cash stock equations comprise leverage defined in a standard way as the ratio of total debt to total assets; cash flow is similarly the ratio of cash flow to total assets. The cash flow volatility measures volatility of cash flow growth rates over past five years. The market-to-book ratio is calculated as the market value of the company over the value of total assets. Size of a company is measured as the value of fixed assets. The net working capital is defined as the difference of two balance-sheet items: current assets and current liabilities. In the analysis, we use the ratio of net working capital to total assets. Because firms with a higher investment expenditures hold less cash we control for investment to total assets. We also allow for individual firm-level uncertainty as defined before.

Finally, the variables used in the payout equations are the ratio of retained earnings to total assets; size, annual growth rate of sales and the market-to-book ratio as already defined. The cash-to-asset ratio ia total cash and equivalents over total assets. We allow for the returns on assets and the ratio of short-term and long-term debt to total assets to control for profitability and leverage. We also allow for individual firm-level uncertainty as defined before.

Investment Results when Leaving One Year Out

The results for our regressions when we leave out a year and re-estimate the investment ratio relationship are shown in Figure 11. While estimates are very stable when omitting other years, the omission of 2009 shows a sharp change in the coefficient value (smaller negative). This is what we would expect if the 2009 observation was more heavily responsible for the negative relationship we estimate than other years.

[17]We excluded implausible observations where the value of the capital stock was negative or zero, the value of the Tobin's Q was negative, or where information about employment is missing. We winsorized the data, excluding observations if the value of Tobin's Q was larger or equal to the top decile, and the investment ratio or cash flow ratios were in the top (bottom) percentile respectively.

Table 5: Bins for real GDP growth rate forecasts provided by the Bank of England in the Survey of External Forecasters.

1998:q1 to 2002:q4 and 2003:q2 to 2003:q4	2003:q1 to 2003:q1	2004:q1 to 2008:q3	2008:q4 to 2008:q4	2009:q1 to *present*
<0.0%	<1.5%	<1.0%	<0.0%	<1.0%
0.0% – 1.0%	1.5% – 2.0%	1.0% – 2.0%	0.0% – 1.0%	-1.0% – 0.0%
1.0% – 2.0%	2.0% – 2.5%	2.0% – 3.0%	1.0% – 2.0%	0.0% – 1.0%
2.0% – 3.0%	2.5% – 3.0%	3.0%<	2.0% – 3.0%	1.0% – 2.0%
3.0% – 4.0%	3.0% – 3.5%		3.0%<	2.0% – 3.0%
4.0%<	3.5%<			3.0%<

Table 6: Descriptive Statistics

Var.	Obs.	Mean	Std. Dev.	Min.	Max.	Mean (pre-crisis)	Mean (post-crisis)
INV_{it}/K_{it-1}	9041	14.37	14.79	-66.29	92.8	14.64	13.33
Q_{it}	9041	6.8	11.54	0	193.56	5.5	8.87
CF_{it}/K_{it-1}	9041	0.17	1.83	-59.51	17.4	0.21	0.13
ΔS_{it}	9041	0.06	0.27	-1	1.98	0.07	0.04
$Vol^r_{it}/Vol^{mkt}_{it}$	9041	2.39	1.44	0	22.78	2.46	2.46
Unc_t	9041	1.66	0.33	1.17	2.26	1.47	2.03
CS_{it}/TA_{it}	8958	10.78	11.94	0	80.41	9.63	12.35
TD_{it}/TA_{it}	8958	0.19	0.17	0	1.67	0.19	0.17
CF_{it}/TA_{it}	8958	0.05	0.17	-3.23	0.46	0.05	0.04
$CFVol^{5y}_{it}/TA_{it}$	8958	0.08	0.15	0	3.18	0.08	0.08
$MKTVAL_{it}/TA_{it}$	8958	1.08	1.34	0.02	39.11	1.09	1.16
$log(FA_{it})$	8958	3.1	2.5	-6.21	9.33	3.28	2.88
NWC_{it}/TA_{it}	8958	0.14	0.22	-1.23	0.96	0.14	0.14
INV_{it}/TA_{it}	8958	0.04	0.06	-0.17	0.65	0.05	0.04
$Vol^r_{it}/Vol^{mkt}_{it}$	8958	2.39	1.39	0	22.78	2.45	2.5
Unc_t	8958	0	1	-1.49	1.79	-0.61	1.09
$DIV_{it}/EARN_{it}$	11892	33.15	49.47	0	811.54	38.71	28.46
$RetainRatio_{it}$	11892	-0.26	3.41	-64.8	32.33	-0.19	-0.33
$log(FA_{it})$	11892	2.59	2.72	-6.44	9.33	2.94	2.29
$MKTVAL_{it}/TA_{it}$	11892	1.22	1.6	0.01	35.99	1.28	1.28
CS_{it}/TA_{it}	11892	0.13	0.15	0	0.94	0.12	0.14
ΔS_{it}	11892	0.16	0.79	-1	26.09	0.17	0.1
ROA_{it}	11892	0.03	0.19	-3.45	0.42	0.04	0.01
TD_{it}/TA_{it}	11892	0.17	0.16	0	0.99	0.18	0.15
$Vol^r_{it}/Vol^{mkt}_{it}$	11892	2.55	1.53	0	17.99	2.62	2.7
Unc_t	11892	-0.01	1	-1.51	1.72	-0.66	1.03

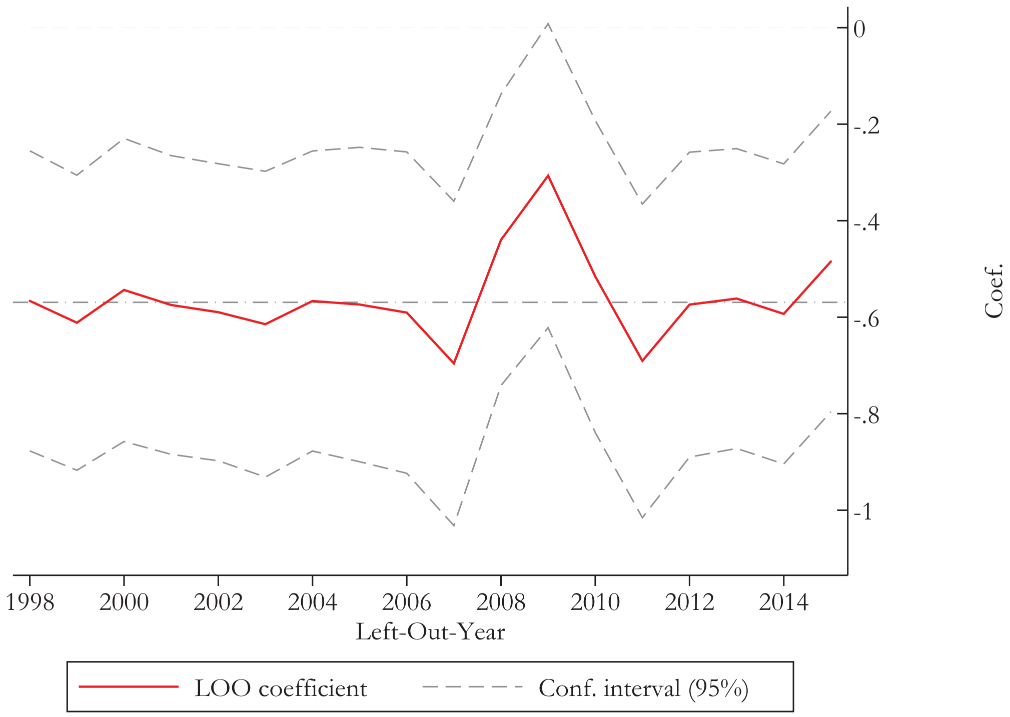

Figure 11: Marginal effects of uncertainty on investment estimated by leaving out one year. This graph shows the marginal effect of our uncertainty measure, U_t, on investment ratios, INV_t/K_{t-1}, after interacting it with a dummy variable that takes value one for all years but for the left-out year, $\forall_{X\in\{1998,\ldots,2015\}}\mathbb{1}\{year \neq X\}$