Political Uncertainty Exposure of Individual Companies: The Case of the Brexit Referendum*

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Abstract

This paper studies cross-sectional determinants of the exposure of U.K. firms to Brexit, an event which resulted in an unprecedented rise in political uncertainty. We find that internationalization has a moderating effect on Brexit exposure which goes beyond the pure currency translation effect and is consistent with international activities acting as a diversification mechanism for domestic risks. The beneficial effect of foreign activities is driven by non-European activities, which suggests that to mitigate the impact of Brexit a primary focus of U.K. companies should be seeking out diversification opportunities outside Europe. Larger, high-growth and less profitable firms are more affected by the uncertainty associated with Brexit but we find no link between the percentage of European employees and Brexit exposure. The high exposure of growth companies to Brexit underlines the fact that clarity over future trading arrangements and regulations cannot come soon enough to protect investment. At the industry level, we show that Financials have the highest exposure to Brexit-related uncertainty and we suggest that this sector in particular, which contributed 7.2% of the U.K.'s gross value added in 2016, will require interventions to ameliorate the impact of Brexit.

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"Economics, policy and politics have already taken so many surprising turns in recent years that we believe the only certainty we have is uncertainty."

Valentijn van Nieuwenhuijzen, Head of Strategy at NN Investment Partners, cited in the *Financial Times* (March 27, 2016)

1. Introduction

On June 23, 2016, the United Kingdom voted for Brexit – withdrawal from the European Union (E.U.) – and this paper analyzes the extent to which individual British companies were affected by this vote. At the present time, there is limited information to allow companies, business representatives, investors, the U.K. government and governmental agencies to determine the possible variation in the exposure of U.K. companies to Brexit, and it will be some time before data from company financial reports will allow the impact of Brexit on corporate policies to be assessed. We employ information provided by U.K. stock prices during the four-month referendum period to allow us to comment on the variation in Brexit exposure. As Estrella and Mishkin (1998) argue, beyond forecasting accuracy, employment of leading financial indicators, such as the stock market, 'allows the economic analyst to think about the causal relationships that may lead to a specific result' (page 45). Understanding the variation in the exposure of individual firms to Brexit is important to allow corporate managers to prepare for and mitigate its impact, to allow investors to manage their exposure to individual firms or sectors when political uncertainty is high, and to allow policymakers to understand where the effects of uncertainty are likely to be felt most, and potentially take remedial action to limit its impact on employment and investment.

Our analysis provides insights into a broader, increasingly important issue, the characteristics of individual firms that determine their exposure to uncertainty associated with political events. The Brexit vote, followed shortly by the unexpected election of Donald Trump as the President of the United States, lifted political uncertainty around the world to unprecedented levels (Davis, 2016), yet we know surprisingly little about how this uncertainty affects different firms and industries. Academic literature documents that uncertainty associated with, for example, elections or global summits, affects stock prices at the aggregate level (e.g. Bialkowski *et al.*, 2008; Pastor and Veronesi, 2013; Brogaard and Detzel, 2015; Kelly *et al.*, 2016), however it is reasonable to expect that some firms are more affected than others.

The impact of the Brexit vote on businesses is complex but we posit that, above all, Brexit is an event associated with heightened political uncertainty, as defined in the earlier

theoretical finance literature. Pastor and Veronesi (2012) identify political uncertainty as uncertainty about whether the prevailing government policy will change.[1] Similarly, Pastor and Veronesi (2013) broadly interpret political uncertainty as 'uncertainty about the government's future actions' (page 521).[2] The context of Brexit fits such a notion very well and therefore the Brexit referendum provides a unique and particularly interesting setup to study political uncertainty. Unlike general parliamentary or presidential elections in which debates focus on selected policies, for example taxation or healthcare, consequences of the Brexit referendum are wide-reaching, affecting virtually all government policies. The decision to leave the E.U. is associated with uncertainty about the U.K.'s future legal and regulatory framework which is currently driven by E.U. laws and regulations. It is associated with uncertainty about the U.K.'s international trading agreements and immigration policies. David Cameron, then U.K. Prime Minister, compared it to a 'leap in the dark'.[3] Not surprisingly, in the months around the referendum, the news-based U.K. economic policy uncertainty index of Baker *et al.* (2016) sharply increased, far exceeding the levels it reached during the financial crisis of 2007-2008 and the Eurozone crisis of 2011-2012.[4]

To measure a firm's exposure to Brexit uncertainty we estimate the link between the firm's daily stock returns and changes in the probability of a leave (Brexit) vote calculated from bookmakers' odds over four months of the referendum campaign. We find a large variation in the exposure of individual companies to the uncertainty associated with Brexit. To develop predictions regarding the determinants of Brexit exposure we refer to the theoretical and empirical literature on policy uncertainty and political risk. We also look at factors specific

[1] Pastor and Veronesi (2012) identify so defined political uncertainty as one of the elements of government policy uncertainty. The other element is impact uncertainty which refers to uncertainty about the impact of a new government policy on firms' profitability.

[2] In the model in Pastor and Veronesi (2013), investors react to the flow of political news (political shocks) on the basis of which they update their beliefs about the likelihood of the adoption of various government policies in the future. Political shocks are orthogonal to fundamental economic shocks affecting the supply of aggregate capital and beliefs about the impact of the current government policy.

[3] See, 'EU Referendum: Leaving EU a 'leap in the dark' says Cameron', *bbc.co.uk*, February 22, 2016. See also, 'After Brexit: Roadmap for a leap in the dark', *Reuters*, June 1, 2016 and 'Britain's Brexit Leap in the Dark', *New York Times*, June 24, 2016. It was expected that the Prime Minister would step down in the event of a Brexit vote (as he did on the referendum result day), leading to a potentially long leadership transition process, with early parliamentary elections possible. Further, the Finance Minister (Chancellor), responsible for fiscal policy, warned that an emergency budget with tax increases and spending cuts would be necessary in the event of Brexit. Taken together, the Brexit vote led to uncertainty about future government policies reshaping in a major way the environment in which all British companies operate.

[4] The index reached between 429 and 479 points during the referendum campaign in March-May, 800 points in June and an all-time-high of 1,142 points in July 2016. During the financial crisis of 2007-2008 it reached a maximum of 251 points in October 2008, and during the Eurozone crisis of 2011-2012 the maximum was 408 points in November 2012. The long-term average monthly value of the index between January 1997 and June 2017 is 161 points. The index is available at www.policyuncertainty.com.

to the U.K.'s links with the E.U. and the European Single Market[5] to highlight uncertainty regarding policies likely to change after Brexit. At the sectoral level we consider both bottom up effects, in which the sector effect can be predicted from the summation of the characteristics of individual firms, and top down effects relating to sector-level characteristics, most notably regulation.

The first group of possible determinants of Brexit exposure are the firm's growth and investment opportunities. We expect that growing firms and firms with greater investment opportunities, that is firms which are likely to require uninterrupted investment in physical and human capital to support their growth, have a larger exposure. We base this prediction on the theoretical arguments (e.g., Aizenman and Marion, 1993; Bloom, 2009; Pastor and Veronesi, 2012) and empirical evidence (e.g. Baker *et al*, 2016; Hassan *et al.*, 2016) that firms cut investment and reduce employment when political uncertainty increases. In line with our prediction we find that growth firms (higher market-to-book ratio firms) are more exposed to Brexit uncertainties which could distort the investment process.

The second group of factors captures the firm's international exposure. Previous literature provides contradictory evidence on the effect of foreign activities on the exposure to political uncertainty in the domestic market. On the one hand, companies can diversify domestic risks by operating internationally, assuming that risks are not perfectly correlated across countries (e.g. Shapiro, 1978; Kwok and Reeb, 2000). Moreover, the weakening of the pound (GBP) in response to higher probabilities of a Brexit vote increased the GBP-denominated value of foreign sales or assets. On the other hand, uncertainty regarding post-Brexit foreign trade agreements adversely affects firms operating internationally (similar arguments are provided by Boutchkova *et al.* (2012) and Handley and Limao (2015)). We find that firms with larger international exposure, measured with foreign sales, foreign assets, or the number of foreign countries mentioned in the firms' annual reports, are less exposed to the uncertainties of Brexit. We rule out the possibility that these results are solely driven by the effect of currency movements and the finding is consistent with the diversification benefits of international activities. To further test the diversification effect, we split foreign activities into European and non-European. In line with the expectation that Brexit effects are likely to ripple through the rest of Europe, and thus European operations provide a weaker diversification mechanism, we find that the beneficial effect of foreign activities is driven by non-European activities.

[5] See Appendix A for definitions.

A third group of factors that are potentially linked with Brexit exposure reflect the firm's financial strength. We argue that firms in a weaker financial position are more exposed to uncertainty about future government policy based on the evidence that uncertainty about economic policies leads to weaker future overall economic conditions (e.g. Fernandez-Villaverde *et al.*, 2015; Baker *et al.*, 2016). *Inter alia*, we measure financial strength using profitability (return on equity) and find that more profitable firms are significantly less exposed to Brexit, consistent with the notion that better performing and hence stronger firms are better placed to cope with uncertainty about future government policies. Large firms are more stable and less likely to get into financial distress which would be expected to make them more immune in the period of increased uncertainty associated with Brexit. However, we find evidence that larger firms are more affected by Brexit, which is consistent with the theoretical insights in Pastor and Veronesi (2012) who show that larger firms command a higher government policy uncertainty risk premium, and with the political cost hypothesis (Zimmerman, 1983) which posits that larger firms are subject to greater government scrutiny. We find insignificant results for other measures of financial strength such as leverage and liquidity, both of which are related to financial distress risk. This may be driven by the fact that financial distress risk is at low levels in our sample, which comprises companies with a premium listing (i.e. meeting higher listing and corporate governance standards) on the Main Market of the London Stock Exchange.

We fail to find significant results for a number of other factors which we consider as potential determinants of Brexit exposure. Chief among these is the impact of possible changes in immigration policies. U.K. membership of the E.U. is associated with the freedom of movement of people. The Brexit vote is therefore linked with uncertainty about future government immigration policies and access of the European Single Market citizens to the U.K. labor market. We therefore expect that firms reliant on the single market workforce, and/or labor-intensive firms, would have higher exposure to Brexit uncertainty. We find no evidence that this is the case. We also examine the impact of a firm's political lobbying, which might reflect either a firm's reliance on the political climate or that a firm aims to actively manage political exposure (Hassan *et al.*, 2016). However, we find no evidence that the extent of E.U. lobbying is related to Brexit exposure.

The industry-level analysis reveals that Financials and firms in the Consumer Goods and Consumer Services sectors have the highest exposure. London is one of the global financial centers and it is not surprising that U.K. firms in the financial sector are affected by the uncertainty regarding international agreements on access to foreign markets, including

passporting rights which allow financial firms based and regulated in one European Economic Area (E.E.A.)[6] country to operate freely in any other E.E.A. country. More broadly, our results indicate that the highly-regulated nature of the financial sector makes it particularly vulnerable to political uncertainty. The high Brexit exposure of the consumer-facing companies is in line with evidence that households reduce consumption and increase savings in periods of higher policy uncertainty (Giavazzi and McMahon, 2012).

We find that firms in the Basic Materials and Healthcare sectors are at the other end of the Brexit exposure spectrum. Companies in those sectors are mainly multinational firms with operations diversified across countries and less dependent on domestic market conditions. In this case the sector-wide effect reflects the aggregation of the impact of international diversification at the level of individual firms, as discussed above.

All our cross-sectional results are robust to estimating Brexit exposure using different empirical methods, including a method that explicitly controls for other global macro factors and global economic uncertainty captured by changes in the S&P500 index and the VIX index. Our analysis suggests that to mitigate the impact of Brexit, a primary focus of U.K. companies and government agencies should be seeking out diversification opportunities outside Europe. The high exposure of growth companies to Brexit underlines the fact that clarity over future trading arrangements and regulations cannot come soon enough to protect investment. We also suggest that the Financial sector, in particular, will require U.K. government support in ameliorating the impact of Brexit, a sector which in 2016 contributed 7.2% of the U.K.'s gross value added and employed 3.1% of the U.K. workforce (Tyler, 2017).

This paper complements existing studies which examine the impact of similar single political events on stocks: Beaulieu *et al.* (2005) analyze the 1995 Quebec independence referendum and Acker and Duck (2015) the 2014 Scottish independence referendum.[7] Our setting and sample allow a comprehensive analysis of political uncertainty exposure at the level of the individual firm, which the samples and/or settings employed in these studies do not. The limited exposure of U.K. firms to the Scottish independence referendum restricts the ability of Acker and Duck (2015) to explore cross-sectional variation in the exposure. The analysis of Beaulieu *et al.* (2005) is undertaken on portfolios of stocks across a relatively limited sample

[6] See Appendix A for definitions.

[7] The link between the behavior of financial markets and changing probabilities of a single election outcome is also analyzed by Gemmill (1992) for the U.K. 1987 parliamentary elections and by Wolfers and Zitzewitz (2016) for the 2016 US presidential election. Snowberg *et al.* (2007) focus on the 2004 US presidential elections.

of 71 firms, while our regressions are run on a much larger sample of almost 300 companies (which also improves the power of our test statistics).

Our cross-sectional evidence also extends and complements findings of a recent study by Liu *et al.* (2017) who analyze the impact of the Bo Xilai political scandal on the stock prices of Chinese firms. Their cross-sectional analysis is limited but they show that firms which are more sensitive to monetary and fiscal policy and firms with political connections are more affected when political uncertainty increases. In comparison with Liu *et al.* (2017) we consider the impact of a wider range of firm-level characteristics. Moreover, Liu *et al.* (2017) provide a standard event study which makes it difficult to fully capture the link between firm characteristics and political uncertainty exposure, as some firm characteristics may also proxy for alternative determinants of stock returns (e.g. firm size and market-to-book ratio) independent of political uncertainty. Our methodology which measures sensitivities of stock returns to the probability of Brexit rather than the level of stock returns on the referendum result day, as would be the case in a standard event study, allows us to measure the impact of those characteristics on political uncertainty exposure independently of its impact on stock returns.

This paper is also related to a study by Boutchkova *et al.* (2012) which provides a cross-country, industry-level analysis of political risk exposure. They find that higher political risk leads to greater return volatility for industries more dependent on foreign trade, contract enforcement and labor. The findings of Boutchkova *et al.* (2012) in respect of foreign trade contrast with those of Beaulieu *et al.* (2005), who find that firms with international exposure are less affected by political risk than firms without international exposure. We offer new evidence on these contradictory findings; we find that companies with more foreign activities are less affected by political uncertainty in relation to the Brexit vote, in line with Beaulieu *et al.* (2005).

The remainder of the paper is structured as follows. Section 2 presents the measure of political uncertainty exposure in relation to Brexit and Section 3 explores cross-sectional determinants of the exposure. Section 4 provides additional tests and robustness checks and Section 5 concludes the paper.

2. Measuring Political Uncertainty Exposure Associated with Brexit

2.1. Empirical Model

We start by estimating the Brexit exposure for each firm from the following time-series regression:

$$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \varepsilon_{it}, \quad (1)$$

where r_{it} is the return on stock i on day t and x_t is the change in the probability of a leave (Brexit) vote on day t calculated from bookmakers' odds, as defined and discussed in detail in the following subsection. The estimation is similar to the approach in Snowberg *et al.* (2007) who measure the link between financial market movements and changes in George W. Bush's chances for re-election in 2004 and in Wolfers and Zitzewitz (2009) who estimate the market impact of changes in the probability of the 2003 Iraq war.[8]

β_{Bi} estimated in Model (1) is our coefficient of interest and we interpret it as firm i's Brexit exposure. It measures the link between stock returns of company i and changes in the probability of a Brexit vote. We posit that an increasing (decreasing) probability of a Brexit vote is associated with increasing (decreasing) political uncertainty. If political uncertainty commands a risk premium (Pastor and Veronesi, 2013) and if it negatively affects economic growth and hence future cash flows (e.g. Bernanke, 1983; Aizenman and Marion, 1993; Bloom, 2009; Fernandez-Villaverde *et al.*, 2015), an increase (decrease) in the probability of a Brexit vote is expected to lead to a decrease (increase) in stock prices. Therefore we expect, on average, that β_{Bi} will be negative across our sample firms. For each individual firm, where β_{Bi} is more negative, the Brexit exposure is greater.[9]

Model (1) is estimated for each firm using daily data over the period between February 20, 2016 (the day the referendum was announced), and June 22, 2016 (the day before the referendum). The sample period includes 84 trading days.

In Section 4 we provide a series of additional tests to check robustness of key findings of the paper in which we extend Model (1) to include additional control variables, such as changes in the foreign exchange rate or global macro factors and general market uncertainty captured by changes in the S&P500 and VIX indices.

It is possible that the link between stock returns and changes in the probability of a Brexit vote reflects reverse causality: i.e. movements in financial markets affect revisions of bookmakers' odds. We argue that such a possibility is not very likely in our setup. First, it is difficult to claim that stock prices of any individual company would influence bookmakers,

[8] Our overall empirical approach is also similar to the methods used in the earlier literature to estimate the foreign exchange exposure of individual companies (see e.g. Jorion (1990) and He and Ng (1998)).

[9] When talking about Brexit uncertainty we refer to the policy uncertainty associated with an eventual leave vote. Goodell and Vähämaa (2013) highlight the difference between election outcome uncertainty and political uncertainty. Election outcome uncertainty increases where the probabilities of the opposing options move towards 50/50. Political uncertainty reflects the uncertainty in policy related to a particular outcome. Throughout the referendum period the leave vote probability that we employ remained below 50%, and thus an increase in the leave vote probability reflected both increased election outcome uncertainty and increased policy uncertainty.

and our estimation is at the level of the individual firm. Second, we estimate the model at the relatively high frequency of daily observations, whereas any potential reverse causality is only likely to lead to biases in estimated coefficients at lower frequencies (Snowberg *et al.*, 2007).

2.2. Probability of Brexit

The change in the probability of a leave (Brexit) vote, x_t, the explanatory variable in Model (1) is measured as:

$$x_t = \frac{prob_t^{Leave} - prob_{t-1}^{Leave}}{0.5 - prob_{t-1}^{Leave}}, \quad (2)$$

where $prob_t^{Leave}$ is the average probability of a leave vote on day *t*, calculated across the four largest fixed-odds bookmakers in the U.K.: Coral, Ladbrokes, Paddy Power and William Hill. Scaling the daily change in the probability by the distance from the 50/50 probability of the dichotomous leave/remain outcomes captures the relative significance of the change in the probability;[10] for example, a two-percentage point change (equivalent to, roughly, one standard deviation of daily changes in our sample, as reported below) is more meaningful when the gap is 10 percentage points than when it is 30 percentage points (approximately the minimum and maximum gap in our sample).

For each bookmaker *j*, the probability of a leave vote is calculated as:

$$prob_{jt}^{Leave} = \frac{1/odds_{jt}^{Leave}}{1/odds_{jt}^{Leave} + 1/odds_{jt}^{Remain}}, \quad (3)$$

where $odds_{jt}^{Leave}$ ($1/odds_{jt}^{Remain}$) is the end of day *t* decimal odds offered by bookmaker *j* on the leave (remain) outcome of the referendum. The data on odds are sourced from Oddschecker. Odds can be updated 7 days a week but for consistency with the return measures, x_t used in Model (1), it is calculated on the basis of probabilities measured on stock exchange trading days only.

[Figure 1 and Table 1 about here]

The probability of a Brexit vote over the sample period is presented in Figure 1, and Table 1 presents relevant descriptive statistics of the measure and scaled changes in the probability of Brexit, as defined in Model (2). Throughout the sample period the probability of a Brexit vote remained below 0.50, with a minimum of 0.179 on May 26 and a maximum of 0.392 on June 15. The descriptive statistics of x_t are presented in the bottom row of Table 1

[10] As shown below, the gap was positive throughout the sample period which makes the interpretation easier, and it was never close to 0.50 which would have driven the denominator of x_t to zero and hence x_t to infinity, distorting its statistical properties.

('Change in probability scaled by lagged gap'). The minimum of -1.009 indicates that the largest drop in the scaled probability of Brexit was observed when the previous day's gap between the Leave probability and 0.50 approximately doubled, while the largest change in the opposite direction was observed when the gap narrowed by roughly a third (0.323). The median daily change is zero, and the mean daily change of -0.012 reflects the overall slight decrease in the probability of a Brexit vote from 0.314 at the beginning of the sample period to 0.245 on the day before the referendum.

Ex post it is clear that the prediction based on bookmakers' odds was wrong, as on June 23 51.9% of the voters voted in favor of an exit from the European Union. The outcome brought bookmakers into the spotlight with commentators casting doubt on the usefulness of odds for predictions.[11] Below we offer several arguments to validate the use of the measure based on bookmakers' odds in our empirical tests.

Even though the prediction based on the odds proved incorrect *ex post*, there is no clear reason to argue that the odds were uninformative *ex ante*. First, given the specific nature of referendums, a parallel could be drawn between the Brexit referendum and the recent 2014 Scottish independence referendum when bookmakers' odds proved to be a good predictor of the result (Acker and Duck, 2015). Second, possibly linked to the success in predicting the Scottish referendum result, bookmakers' odds received substantial media attention in the run-up to the Brexit referendum with revisions in odds reaching news headlines.[12] An online search of the Financial Times archives for articles containing the words 'Brexit' and 'bookmakers' in the body of the text returns 42 items during our sample period of 84 trading days. Third, it is reported that the odds were tilted by larger bets placed on remain compared to leave[13] but if the larger flow of money put on remain was fairly constant throughout the sample period, it systematically biased the *level* of the implied probability of a leave vote downwards but did not directly affect the information conveyed by *changes* in the probability we use in the estimation of Model (1). Moreover, the betting market in the run-up to the referendum was quite active and deep which made it less prone to potential noise coming from individual bets. Betting on the Brexit referendum outcome broke the U.K. record for non-sporting events, with an estimated GBP 120 million wagered through betting exchanges and bookmaking firms.[14]

[11] See, e,g., 'EU Referendum: How the bookies got it so wrong over Brexit', *independent.co.uk*, June 24, 2016.
[12] See, e.g., 'Bookmakers cut Remain odds despite narrow polls', *Financial Times*, May 20, 2016; 'Betting odds tilt towards Brexit', *Fast FT* (*Financial Times*), June 6, 2016.
[13] 'Big London Bets Tilted Bookmakers' 'Brexit' Odds', *Wall Street Journal*, June 26, 2016.
[14] 'Brexit wagers set new record for non-sports bets', *Financial Times*, June 26, 2016.

[Figure 2 about here]

Furthermore, in what follows, we show how the probability of a Brexit vote moved in response to the news flow, including opinion polls, during the campaign. This indicates that it was not pure noise and contained (or aggregated) economically relevant information. In Figure 2, Panel A, the probability of a Brexit vote is plotted against the Brexit news coverage in the Financial Times. The coverage is calculated as the average number of articles containing the word 'Brexit' over the previous 7 days, searched in the online archives at FT.com. The news coverage proxies for the news flow relevant for updating expectations regarding the outcome of the referendum. After the initial spike following the announcement of the referendum on February 20, the article count went down and started picking up in April when the referendum campaign officially started on April 15. It gradually went up towards the referendum day as the campaign intensified. The behavior of the leave probability is consistent with it being a measure incorporating relevant news. The probability remained stable when the news flow was relatively small, and the daily variation in the probability increased when more news was flowing to the market.

In Panel B of Figure 2, the probability of a Brexit vote is plotted against the percentage-point lead of remain over leave in polls of voting intentions, after excluding 'don't knows'. The data are obtained from whatukthinks.org, a website run by NatCen Social Research. The measure is the so called poll-of-polls and is calculated as the average of the six most recent poll results available. The plot shows a close link between the two measures, which is particularly strong in the second part of the sample period, with the probability of leave going up (down) when the polls swing against (in favor of) a remain vote. Again, the evidence confirms that the proxy based on bookmakers' odds reflects publically available information about the prospects of a Brexit vote.

To further validate the measure of the probability of a leave vote derived from bookmakers' odds, we plot it against the USD/GBP exchange rate (Panel C of Figure 2) sourced from Datastream. *Ex post* we know that the strongest reaction to the referendum outcome was observed on the foreign exchange market. On the announcement of the referendum result on June 24, the pound lost 8.0% against the dollar, compared to a 3.8% drop in the FTSE All Share index. The plot in Panel C of Figure 2 shows a very close link between the value of the pound and the probability of a leave vote, which confirms that the calculated probability contains the same economically relevant information employed by foreign exchange market investors.

Taking all of the above arguments together, we argue that the probability of a Brexit vote calculated from bookmakers' odds is a meaningful measure that contains relevant information despite its systematically biased level and *ex post* incorrect prediction of the outcome of the vote.

2.3. Sample

The sample is constructed in the following way. First, we obtain the list of all stocks listed on the London Stock Exchange (LSE) on January 1, 2016 from the stock exchange website.[15] Only companies incorporated in the United Kingdom with a Premium Listing on the Main Market of the exchange are retained, and the sample further excludes companies in the following sectors (as classified by the LSE): Equity Investment Instruments, Non-Equity Investment Instruments, Real Estate Investment and Services, and Real Estate Investment Trusts. The exclusion is aimed at limiting the sample to operating companies (manufacturers of goods or service providers) for which comparable characteristics can be identified for the cross-sectional analysis. Finally, to be included in the sample, total return data for the stock have to be available in Datastream.

β_{Bi}, our coefficient of interest in Model (1) might be underestimated for thinly-traded companies (e.g. Dimson, 1979), therefore to avoid biased estimates, we exclude from the final sample the least liquid firms. We base our illiquidity measure on the frequency of zero returns, as proposed by Lesmond *et al.* (1999), and exclude companies with more than 8 zero returns in the sample period (approximately 10% of days). The final sample contains 331 firms.

2.4. Descriptive Statistics of the Brexit Exposure Measure

Table 2 presents detailed descriptive statistics for the estimated β_{Bi}s, the Brexit exposure. In the top row, the mean and median β_{Bi} in the full sample of 331 firms is negative, indicating that in line with theoretical predictions, political uncertainty associated with Brexit has a negative impact on stock returns – increases in political uncertainty lead to decreases in stock prices. The estimated Brexit exposure is negative and statistically significant at the 5 percent level in nearly a half (49.2%) of the sample stocks, and it is positive and significant for only 3 firms. To illustrate the economic significance of the results, the mean β_{Bi} of -0.025

[15] http://www.londonstockexchange.com/statistics/historic/company-files/company-files.htm

indicates that when the gap between the probability of a Brexit vote and 0.50 decreased by 13.6% (one standard deviation of x_t) stock prices fell on that day, on average, by 0.34%.[16]

[Table 2 about here]

We use the Industry Classification Benchmark (ICB) to group firms into 10 industries. The classification leaves a meaningful number of firms in the majority of industry groups. Setting aside Telecommunication firms and Utilities which are represented by only a handful of firms, the following patterns emerge. Financials and firms in the Consumer Goods and Consumer Services sectors are the most exposed to Brexit (have the most negative mean and median β_{Bi}), while Basic Materials and Healthcare firms are at the other end of the exposure spectrum.

The high exposure of financial firms reflects uncertainty about the post-Brexit status of the City of London as a major financial center. Currently, financial firms located and regulated in the U.K. benefit from passporting rights that allow them to operate freely across the whole European Economic Area, and Brexit was expected to bring major disruption in this respect, with uncertainty about future E.E.A. membership. Furthermore, the high exposure of financial firms reflects the highly-regulated nature of the financial sector which makes it particularly vulnerable to political uncertainty. Liu *et al.* (2017) draw a similar conclusion in their study of the impact of the Bo Xilai political scandal on the stock prices of Chinese firms. Political uncertainty also translates into changes to household spending and saving behavior (Giavazzi and McMahon, 2012). Therefore, we see relatively high Brexit exposure among firms in the Consumer Goods and Consumer Services sectors.

On the other hand, Basic Materials and Healthcare firms are least exposed to Brexit-related uncertainty. Many of the firms in these sectors are multinational companies with significant operations or revenues overseas. While they are also potentially negatively affected by the uncertainty of post-Brexit foreign trade agreements, their foreign operations provide diversification of domestic risks (e.g. Shapiro, 1978; Kwok and Reeb, 2000). It is also possible that they benefit from the weakening pound against other currencies which increases the pound-denominated value of foreign sales or assets. We conduct specific tests to separate diversification benefits from exchange rate benefits in Section 4.

Taken together, the results reveal that in the run-up to the referendum stock prices reacted negatively, on average, to the prospect of a Brexit vote, and there was substantial

[16] $-0.025 \times 0.136 = -0.0034$

variation in the Brexit exposure of individual sectors. Cross-sectional tests of the determinants of the exposure at the level of the individual firm are presented in Section 3 below.

3. Determinants of Brexit Exposure

3.1 Predictions and Variables

This section develops formal tests to shed light on the determinants of Brexit exposure of individual firms. Specifically, we run cross-sectional regressions with estimated β_{Bi} as the dependent variable and a set of firm-level measures as independent variables. As stated in the Introduction, to develop predictions regarding the determinants of Brexit exposure we refer to the theoretical and empirical literature on policy uncertainty and political risk and factors specific to the U.K.'s links with the E.U. and the European Single Market.

The first group of possible determinants of Brexit exposure are the firm's growth and investment opportunities. We expect that growing firms and firms with greater investment opportunities have a larger exposure to the policy uncertainty associated with Brexit. This expectation follows from the theoretical arguments (e.g., Aizenman and Marion, 1993; Bloom, 2009; Pastor and Veronesi, 2012) and empirical evidence (e.g. Baker *et al*, 2016; Hassan *et al.*, 2016) that firms cut investment and reduce employment when political uncertainty increases. Consequently, we expect that firms which are likely to require uninterrupted investment in physical and human capital to support their growth are most affected by Brexit uncertainties which could distort the investment process. We proxy for growth and investment opportunities with the market-to-book (MB) ratio[17] and three-year sales growth. In the subsample of non-financial firms we additionally use capital expenditures (Capex) and research and development (R&D) expenses as direct measures of investment and development.

The second group of factors captures the firm's international exposure. Previous literature provides contradictory evidence on the effect of foreign activities on the exposure to political uncertainty in the domestic market; for example, Boutchkova *et al.* (2012) find that higher political risk leads to greater return volatility for industries more dependent on foreign trade, contract enforcement and labor. Beaulieu *et al.* (2005) find that firms with international exposure are less affected by political risk than firms without international exposure. On the one hand, companies can diversify domestic risks by operating internationally, assuming that risks are not perfectly correlated across countries (e.g. Shapiro, 1978; Kwok and Reeb, 2000).

[17] Beaulieu *et al.* (2005) argue that firms with low assets in place (high MB) are less affected by political risks because they can more easily relocate to a lower risk environment. Such an interpretation of the MB ratio gives the opposite prediction regarding the link between Brexit exposure and MB ratio.

Even though Brexit implications are expected to spread globally, they are most severe locally in the U.K., with the effect being more muted elsewhere, particularly beyond Europe. Therefore we expect U.K. firms with larger foreign activities to be less exposed to Brexit-related uncertainty in the run-up to the referendum (this argument is supported by Beaulieu *et al.* (2005)). Moreover, the weakening of the pound (GBP) in response to higher probabilities of a Brexit vote increased the GBP-denominated value of foreign sales or assets. On the other hand, uncertainty regarding post-Brexit foreign trade agreements adversely affects firms operating internationally. The expected disruption to the access to the European Single Market and uncertain future bilateral trade agreements with the European Union and non-European countries can be expected to lead to firms with greater export activities having larger Brexit exposure. Similar arguments are provided by Boutchkova *et al.* (2012) and Handley and Limao (2015).

We quantify foreign activities using three different variables. First, we use foreign sales measured as the fraction of total sales generated from foreign operations. Second, we use foreign assets defined as assets of foreign operations divided by total assets. The third variable follows the approach in Garcia and Norli (2012) and is defined as (the natural logarithm of one plus) the number of foreign countries mentioned in the firm's last annual report. This measure picks up, *inter alia*, information on suppliers, new contracts or joint ventures in addition to foreign sales and assets and thereby provides a more complete picture of geographical exposure than the other measures. Wherever data permits we additionally disaggregate foreign sales into European and non-European foreign sales,[18] and we also calculate separately the European Single Market country count and other country count.[19] The split into European and non-European foreign activities allows us to better test the mechanism through which foreign activities affect firms' Brexit exposure. Brexit is expected to impact to some degree the whole European economy and thus firms' foreign activities in Europe are expected to provide weaker diversification benefits than operations beyond Europe. Second, uncertainty about post-Brexit access to the European Single Market, is expected to most severely affect companies with substantial activities in Europe. However, U.K. firms with existing operations in Europe are able to more easily relocate their headquarters to an alternative E.U. country escaping domestic

[18] We are unable to identify clean data on sales within the European Single Market but we believe that the broadly defined European foreign sales are a good proxy for the single market exposure. Also, firms report the geographical breakdown of sales with varying levels of detail, reporting either individual countries or broad regions and we are able to perform a reliable split for only a subset of 215 firms in the sample.
[19] We are not able to perform a similar split of foreign assets because of limited data availability.

policy uncertainties, including uncertainties related to access to the European Single Market.[20] Nonetheless, we expect that non-European foreign activities have a stronger moderating effect than European activities.

We also test the link between Brexit exposure and foreign ownership, defined as the percentage of shares outstanding held by investors located outside of the U.K. Share ownership data is obtained from Thomson One. We argue that international investors are less exposed to risks in a specific country as they diversify across countries and hence we expect U.K. firms with a larger fraction of outstanding shares held by foreign investors to be less exposed to Brexit. However, less-than-perfect market integration is required to achieve benefits of international portfolio diversification and Bekaert *et al.* (2011) show that developed equity markets have been effectively integrated over the last two decades. Still, they document that market integration is time-varying and it decreases in periods of market uncertainty, offering potential benefits given that Brexit raises market uncertainty.

In all regressions we control for firm size, measured as the natural logarithm of the firm's stock market capitalization. The expected effect of firm size on Brexit exposure is ambiguous. On the one hand, the literature on political uncertainty and political connections suggests greater exposure for large firms. Pastor and Veronesi (2012) show that larger firms command a higher government policy uncertainty risk premium because their capital covaries more closely with aggregate capital. According to the political cost hypothesis (Zimmerman, 1983), larger firms are subject to greater government scrutiny and hence we expect that they are more likely to be exposed to uncertainty about future government actions. The greater sensitivity of large firms to uncertainties in the political environment is also reflected in the evidence that larger firms more often than small firms have a politically connected board (Goldman *et al.,* 2009), and they lobby more (Borisov *et al.,* 2016).[21] On the other hand, large firms are more stable and less likely to get into financial distress which is expected to make them more immune in the period of increased uncertainty associated with Brexit. This last argument predicts a negative correlation between firm size and Brexit exposure.

A further group of factors that are potentially linked with Brexit exposure reflect the firm's financial strength. We argue that firms in a weaker financial position are more exposed to uncertainty about future government policy based on the evidence that uncertainty about

[20] In the wake of the Brexit vote, some U.K. companies started considering relocating their headquarters to the continent. See, e.g. 'EasyJet Opens Talks Over Post-Brexit HQ Move', *Sky News*, July 1, 2016, or the news on Vodafone in 'Javid: Single Market Access 'Number One Priority'', *Sky News*, June 27, 2016.

[21] It is also possible that firms appoint politicians to their boards or intensify lobbying in response to higher political uncertainty to manage, or reduce their exposure (Hassan *et al.,* 2016).

economic policies leads to weaker future overall economic conditions (e.g. Fernandez-Villaverde *et al.*, 2015; Baker *et al.*, 2016). As mentioned above, size is one of the measures of the firm's financial strength. Additionally, for all firms, we measure financial strength using return on equity (ROE). For the subsample of non-financial firms we also use leverage and cash holdings, based on the notion that firms with higher leverage and lower liquidity (lower cash holdings) are expected to be more affected in more turbulent times.

We also look at firm level political activity. In the context of Brexit we examine the firm's lobbying activities in E.U. institutions (European Parliament and European Commission) to determine the extent to which a firm is connected to the existing E.U. political setup. Liu *et al.* (2017) show that Chinese firms with greater connections to the current political setup are more affected by a disturbance to the Chinese political system. However, Akey (2015) concludes that U.S. firms contribute to political campaigns or engage in lobbying in an attempt to benefit from government policy, and lobbying can be used to actively manage political uncertainty exposure (Hassan *et al.*, 2016). Following our preceding arguments, on the one hand E.U. lobbying indicates the firm's reliance on the E.U., for example its legislation or funding. Therefore, firms which lobby more are expected to be more affected by Brexit uncertainty. On the other hand, since lobbying can also be used to actively manage political uncertainty exposure, firms which lobby more are less exposed to political uncertainty. The link between our β_{Bi} and E.U. lobbying remains therefore an open question to be tested empirically. We proxy the extent of lobbying activities with declared E.U. lobbying budgets scaled by total sales. We collect data on lobbying budgets from LobbyFacts.eu.

We also examine a factor which is potentially linked with political uncertainty exposure in the specific context of Brexit. The political discussion in the run-up to the Brexit referendum revolved around immigration; the European Single Market is associated with the freedom of movement of people. The Brexit vote is therefore linked with uncertainty about future government immigration policies and in particular the access of E.E.A. and Swiss citizens to the U.K. labor market. Therefore we expect that firms reliant on the single market workforce, and, more generally, labor intensive firms, have higher political uncertainty exposure in the context of Brexit. The composition of the U.K. workforce by nationality is not available at the firm level but we construct the variable at the sector level (2-digit British SIC code level) based on the 2016 Labour Market Surveys (LFS), available from the Office of National Statistics. Labor intensity is measured as the natural logarithm of the ratio of total assets to the number of employees. Higher values of the measure reflect lower labor intensity.

Unless stated otherwise, all variables are sourced from Worldscope and are measured at the end of 2015 to avoid the firms' characteristics being influenced by the referendum which means that at the same time we avoid the possibility of reverse causality in our empirical setting. The summary of definitions and descriptive statistics of explanatory variables are presented in Table 3 and Table 4, respectively. In Table 4 and in subsequent regressions, all variables, both dependent and explanatory, are winsorized at the 1st and 99th percentiles to limit the impact of outliers on estimated coefficients. After excluding firms with missing observations, the largest sample on which regressions are run consists of 297 firms. There is reduced availability of data on foreign sales and foreign assets, and the sample of non-financial firms contains up to 251 firms.

[Tables 3 and 4 about here]

It is worth noting the high international exposure of U.K. firms. The average sample firm generates 46.4% of its sales abroad, holds 28.0% of assets overseas, 30.8% of its shares are owned by international investors, and it mentions 25 different foreign countries in its annual report. The three measures of foreign activities (foreign sales, assets and country count) are highly correlated (pairwise correlation coefficients of between 0.52 to 0.72), therefore to avoid the multicollinearity problem they are included separately in subsequent regressions.

3.2 Regression Results

The results of the regression tests are reported in Table 5 (all firms) and Table 6 (non-financial firms). As explained in Section 2, β_{Bi} is more negative for firms with higher Brexit exposure, hence variables with a positive (negative) coefficient reduce (increase) the exposure. We run alternative cross-sectional regressions explaining Brexit exposure without and with controlling for industry fixed effects to take into account possible unobservable industry-level factors. Regressions for non-financial firms include additional independent variables which are not directly comparable (for example, leverage and cash holdings) or are meaningless (for example, labor intensity) for financial firms due to their fundamentally different nature and different reporting requirements. All models are estimated via OLS with heteroskedasticity-consistent standard errors.

[Tables 5 and 6 about here]

We find that larger firms are more affected by Brexit as the coefficients of firm size are all negative and highly significant. This result is consistent with theoretical predictions in

Pastor and Veronesi (2012) and with the political cost hypothesis of Zimmerman (1983). The result is potentially important for the stock market as a whole, given the significance of large-cap firms for broad stock market indices which not only reflect but also shape overall investor sentiment. Also, in line with our predictions discussed above, we find that growth firms (high MB firms) and less profitable firms are more affected by Brexit-related uncertainties.

Across all regressions we find strong evidence that international exposure measured with foreign sales, foreign assets or foreign country count has a moderating effect on Brexit exposure. Except for foreign assets in specifications with industry fixed effects (model (4) in Tables 5 and 6), the coefficients of the three variables are positive and highly statistically significant indicating that, compared with other companies, stock prices of firms with larger international exposure decreased less (or even increased) when the probability of a Brexit vote went up. The result is consistent with the diversification benefit of international operations. As previously discussed, the effect could also be driven by the weakening of the GBP. We explore these two alternative explanations in detail in the following section.

The results of the estimation with foreign sales and foreign country count split into European and non-European are reported in columns (7) to (10) of Tables 5 and 6. We find that the coefficient of non-European foreign sales and non-European country count is larger in magnitude and has higher statistical significance than the coefficient of European foreign sales or country count, consistent with our prediction. However, the F-test for differences between the two coefficients lacks statistical significance, which shows that the evidence is only suggestive. Nevertheless, the evidence suggests that the diversifying effect of foreign activities is driven by global activities beyond Europe.

We do not find any consistent and robust, statistically significant relation between exposure to Brexit-related uncertainty and other factors considered. Leverage and cash holdings, designed to indicate the financial strength of the firm, are not important determinants of political uncertainty exposure, unlike profitability. We also find no effect of capital or research and development expenditure. The lack of significance of these factors might indicate that the market does not see them as relevant in pricing the impact of Brexit.

Assets per employee measure the (inverse of) labor intensity of firms in our sample and it is not significant. Labor intensity may again reflect competing effects in that labor-intensive firms are likely to face a shortage of their key input in the event of Brexit but they are also more flexible than capital intensive firms. We also investigate the impact of reliance on employees from the single market, and again we find that this does not impact firms' sensitivities to the probability of Brexit. We also find no evidence that the extent of E.U.

lobbying is related to Brexit exposure. As discussed, Liu *et al.* (2017) find evidence that Chinese firms with more politically connected boards are more exposed to political risk. It is possible that the different setting accounts for these different results, suggesting that political connections play a more important role in determining political uncertainty exposure in China.

The results change little between specifications with and without industry fixed effects which indicates that the link between Brexit exposure and firm-specific characteristics identified in the tests is not driven by unobserved industry-specific characteristics.

To summarize, the regression analysis reveals that, *ceteris paribus*, larger firms, less profitable firms and growth firms are more exposed to Brexit-related political uncertainty. Firms with larger foreign operations are less exposed.

4. Further Tests and Robustness Checks

4.1 Alternative Estimation of Brexit Exposure

In this subsection we explore alternative methods of estimating Brexit exposure. We start by re-running Model (1), explicitly controlling for changes in the GBP/USD exchange rate, in the spirit of Jorion (1990). Specifically, we run the following regression model:

$$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{xi} r_t^{GBPUSD} + \varepsilon_{it}, \quad (4)$$

where r_t^{GBPUSD} is the percentage change in the GBP/USD exchange rate on day *t*, and all other notation is as before. In this extended model, β_{xi} captures the effect of foreign exchange rate movements on stock returns, leaving β_{Bi} to capture the effect of Brexit net of the exchange rate effect. As mentioned in Section 3.2 above, we find that foreign activities have a moderating impact on Brexit exposure. Estimating the Brexit exposure with an explicit control for foreign exchange rate movements allows us to assess if the effect only captures the benefits of a weaker pound or whether foreign activities determine Brexit exposure after allowing for exchange rate effects.

Second, we re-estimate Brexit exposure controlling for global macro factors, including general economic uncertainty, proxied by the S&P500 and VIX indices in the following model:

$$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{m1i} r_t^{S\&P500} + \beta_{m2i} r_{t-1}^{S\&P500} + \beta_{v1i} \Delta VIX_t + \beta_{v2i} \Delta VIX_{t-1} + \varepsilon_{it}, \quad (5)$$

where $r_t^{S\&P500}$ is the return on the S&P500 index on day *t* and ΔVIX_t is the change in the value of the VIX index on day *t*. All other notation is as before. Because of non-overlapping trading hours between the U.K. and the U.S. – markets in the U.S. close later than in the U.K. – the model includes both day *t*'s and *t-1*'s S&P500 returns and changes in VIX. The model allows

us to isolate the effect of Brexit over and above other market-wide factors, which is particularly important in case they drive Brexit probability.

Third, we re-run Model (1) with the stock return, r_{it}, calculated in U.S. dollars (USD). In this approach, β_{Bi} quantifies the firm-level exposure to Brexit uncertainty from the perspective of international investors holding shares in U.K. companies. Given that the value of the British pound decreased (increased) when the probability of a Brexit vote increased (decreased), as illustrated in Panel C of Figure 2, we expect the mean β_{Bi} to be more negative than in the baseline tests reported above. Changes in the value of the GBP would amplify the effect of changes in Brexit probability on the GBP value of British firms.

Fourth, we re-estimate Model (1) changing the definition of x_t. In the revised estimation we define x_t as a raw (not scaled) change in the probability of Brexit (*Change in probability* reported in Table 1):

$$x_t = prob_t^{Leave} - prob_{t-1}^{Leave}. \quad (6)$$

This approach makes a simplifying assumption, that the market reaction to the change in the probability of a leave vote does not depend on how close the probability is to the 50/50 split, but at the same time it makes the interpretation of β_{Bi} more straightforward. In the revised approach β_{Bi} directly measures the market assessment of the value effect of Brexit, defined as the stock return associated with a hypothetical change in the probability of a leave vote from 0 to 1.

Finally, we re-run Model (1) by adding a lagged change in the probability of a Brexit vote, x_{t-1}:

$$r_{it} = \beta_{0i} + \beta_{B1i}x_t + \beta_{B2i}x_{t-1} + \varepsilon_{it}, \quad (7)$$

with x_t defined as in baseline tests (Equation (2)). Brexit exposure is then calculated as the sum of the coefficients of the contemporaneous and lagged x ($\beta_{B1i} + \beta_{B2i}$). This approach takes into account a possibility of Brexit related news arriving late in the day, moving bookmakers' odds after stock exchange trading hours[22] and being incorporated in stock prices the following day.

Descriptive statistics of the Brexit exposure measures estimated using the alternative methods are presented in Table 7. For comparison, row (1) of the table replicates the full sample results of the baseline method, as reported in Table 2.

[Table 7 about here]

[22] We do not have time-stamped changes in odds, we only have data on end-of-day (11:59pm) prevailing odds.

Compared with the results for baseline Model (1), β_{Bi}s estimated from Model (4) that explicitly controls for the exchange rate effect on stock returns, are smaller in magnitude with fewer individual coefficients which are statistically significant. Specifically, as presented in row (2) of Table 7, the magnitude of the mean coefficient goes down from -0.025 (Model (1)) to -0.015 (Model (4)), with the number of significantly negative estimates down from 163 to 101. However, the results clearly show that firm exposure to changes in the probability of a Brexit vote is not subsumed by exposure to changes in the exchange rate and hence, Brexit uncertainty sensitivities reported earlier in the paper are not a pure manifestation of the currency effects on firm values in the run-up to the referendum. Similarly, the magnitude of estimated Brexit exposures from Model (5), which controls for global economic factors captured by S&P500 and VIX, are smaller compared with the baseline model, with the mean β_{Bi} of -0.017 and 111 statistically significant negative coefficients (see, row (3) of Table 7).

In line with our expectations, the exposures based on returns calculated in U.S. dollars (row (4) of Table 7) are larger in magnitude (the average of -0.048 versus -0.025 in the baseline tests) and more coefficients are significantly negative (248 versus 163). The calculation based on the raw change in the probability of a leave vote (row (5)) yields a similar number of positive coefficients to the baseline model (164), and the mean coefficient of -0.164 indicates that the market priced the impact of Brexit, on average, as a reduction in value of 16.4%. When we estimate Brexit exposure including the lagged change in the probability of a Brexit vote (Model (7) above, with the estimates presented in row (6) of Table 7) the magnitude of the mean exposure measure goes up slightly from -0.025 in baseline tests to -0.030 in the revised tests, but the number of significantly negative estimates decreases from 163 to 141. Overall however, we find that the potential problems of non-synchronous measurement of returns and changes in bookmakers' odds is limited; the coefficient of the lagged change in Brexit probability, β_{B2i} in Model (7), is significant at the 5 percent level for only 15 firms (there are 11 negative and 4 positive coefficients; results are not tabulated).

4.2 Source of Benefits of Foreign Exposure

As reported in Section 3.2, we find strong and robust evidence that firms with larger international exposure are less affected by Brexit uncertainty. The result is consistent with the diversification benefits of internationalization but also could be driven by exchange rate effects. In this subsection, we develop supplementary tests to shed more light on these two alternative interpretations. We re-run baseline regressions using β_{Bi}'s estimated from Model (4), which explicitly control for exchange rate effects, as the dependent variable. If the moderating effect

of foreign sales and foreign assets reported in Tables 5 and 6 in Section 3.2 is purely driven by the currency effect, we should see no link between the scope of foreign activities and Brexit exposure net of currency effects. The results of the estimation are reported in Table 8 (all firms) and Table 9 (non-financial firms).

[Tables 8 and 9 about here]

The results clearly confirm the strong and robust link between sensitivities to the probability of a Brexit vote and foreign exposure, measured alternatively by foreign sales, foreign assets and foreign country count. The respective coefficients across all specifications are positive and highly significant, with even larger magnitudes compared to the baseline tests reported in Tables 5 and 6. Therefore we conclude that the moderating impact of foreign activities on Brexit exposure is not driven by currency movements and is consistent with the diversification benefits of internationalization which makes firms less exposed to domestic political uncertainties.

4.3 Cross-Sectional Results for Alternative Brexit Exposure Estimates

In this subsection we provide further cross-sectional results for alternative Brexit exposure measures presented in Section 4.1 to verify the robustness of key findings of this paper. To save space we tabulate results for only selected model specifications (equivalent to specifications in column (6) of Tables 5 and 6) but full results are available from the authors upon request.

[Table 10 about here]

The results in Table 10 show that the main results of the paper, presented in Tables 5 and 6 above, hold for different empirical models used to estimate Brexit exposure. Across all tests we find strong evidence of larger exposures for larger, less profitable and less internationally-oriented firms. The results for market-to-book ratios weaken for selected specifications, however in the specification in column (10), where Brexit exposure is estimated from Model (7), we additionally find that firms with stronger past sales growth are more affected by Brexit uncertainty confirming that growth is an important determinant of sensitivities to political uncertainty. In the test presented in column (10) we also find that, contrary to our expectations, firms with larger R&D expenditures and firms with smaller cash holdings have lower Brexit exposure. We are unable to confirm this result for any other specification.

In sum, despite the different magnitudes of the Brexit exposure measures presented in Table 7 above, the results of tests in Table 10 show the robustness of the cross-sectional determinants of exposure to political uncertainty associated with Brexit, the key focus of this paper.

4.4 Brexit Exposure and Result Day Stock Price Reaction

To provide further verification of our measure of Brexit exposure, we analyze the extent to which this exposure, measured during the pre-referendum period, captures stock returns on the referendum result announcement day (June 24, 2016) and the two trading days either side (June 23 and 27). Specifically, we divide the sample firms into five portfolios (each with 66 or 67 stocks) based upon their estimated β_{Bi} from baseline tests reported in Table 2 and we examine the (equally-weighted) returns to each portfolio as a result of the Brexit vote.

It has been widely reported that the vote for Brexit came as a surprise, both within and outside the U.K. We demonstrate that this is the case by examining returns to each portfolio on Thursday, June 23, 2016 (the referendum day), the day before the result of the Brexit vote was known. In Panel A of Table 11, we show that the one-day return to the portfolio of the firms most exposed to Brexit is 2.03% and this declines monotonically with Brexit exposure to 1.01% for the portfolio of the least exposed firms. The difference in returns across the most and least exposed firms is significant at a 1 percent level or greater. 92.4% (74.2%) of firms in the portfolio of the most (least) exposed firms had positive returns on June 23. Panel A is commensurate with the market expectation that the vote would be for the U.K. to remain in the E.U.,[23] with firms with the most to gain from this result having the most positive returns.

[Table 11 about here]

The result of the vote for Brexit was known on Friday, June 24. In Panel B of Table 11 we show that the one-day return to the portfolio of the most exposed firms is -13.33%. This compares with a return of -3.40% for the portfolio of the least exposed firms. The difference in returns across the most and least exposed firms is significant at a 1 percent level or greater. Returns for all portfolios are negative and significantly less than zero and tend to decline with measured Brexit exposure (the returns to the two least exposed portfolios have similar returns).

[23] Even Nigel Farage, the leader of the UK Independence Party and one of the key figures of the leave campaign admitted defeat shortly after polling stations closed in the evening of June 23; see 'EU referendum: Nigel Farage says it 'looks like Remain will edge it' as polls close', *independent.co.uk*, June 23, 2016.

1.5% of firms in the portfolio of the most exposed firms had positive returns on June 24, versus 15.2% of firms in the portfolio of the least exposed firms.

In Panel C of Table 11 we show that the market had not finished fully incorporating the news of Brexit on June 24, and the portfolio of the firms most exposed to Brexit fell another 10.39% on Monday, June 27.[24] This compares with a return of -4.90% for the portfolio of the least exposed firms. This difference in returns across the most and least exposed firms is again significant at a 1 percent level or greater.

In summary, these results provide strong support for the fact that our measurement of Brexit exposure during the referendum campaign period, from February 20, 2016 through June 22, 2016, does indeed capture the relative exposure to Brexit across our sample firms.

5. Conclusions

This paper examines the firm-level determinants of British public companies' exposure to Brexit, an unprecedented political event which substantially increased political uncertainty. On June 23, 2016 the U.K. voted to leave the E.U. with far-reaching consequences affecting virtually all government policies. We estimate each firm's Brexit exposure as sensitivity of its stock returns to changes in the probability of a Brexit vote calculated from bookmakers' odds during the referendum campaign.

At the industry level, we find that Financials and companies in the Consumer Goods and Consumer Services sectors are most affected. Firm-level cross-sectional regressions reveal that, *ceteris paribus*, firms with larger foreign operations have lower Brexit exposure. We show that the effect of foreign operations is not a pure exchange rate effect (due to the weakening of the British pound) and we suggest that the moderating impact of foreign operations on the exposure to political uncertainty associated with Brexit results from multinational firms being able to diversify domestic policy risks. We also find that larger, high growth and less profitable companies are more affected by Brexit uncertainty. These findings are consistent with our predictions based on the existing literature on policy and political uncertainty.

This paper contributes to the literature by providing a comprehensive analysis of the determinants of exposure to uncertainty associated with a major political event at the firm level. As such, it provides important evidence relevant to the current situation around the globe where

[24] This stock market reaction may have been exacerbated by the actions of the credit rating agencies with Moody's amending its outlook on the U.K. rating to negative on Friday, June 24. However, the markets had been forewarned of the likelihood of negative actions by the rating agencies in the event of a Brexit vote. S&P and Fitch downgraded the U.K. rating after the markets had closed for trading on Monday, June 27.

policy uncertainty is at a record high (Davis, 2016) and the findings of this study can inform corporate managers, investors and policymakers. In the U.K. alone, the surprising result of the Brexit referendum opened a period of prolonged uncertainty about the outcome of negotiations of the E.U. exit terms which will impact U.K. companies for years to come.

This paper leaves some issues unanswered. While theories predict a link between Brexit exposure and corporate characteristics such as leverage, liquidity, capital and R&D expenditures, we do not find them significant determinants of exposure to Brexit-related uncertainty in our empirical tests. The result may suggest that, in contrast to theoretical predictions, those factors do not matter in practice, but due to inherent limitations of the availability of financial data we are yet not able to examine the extent to which changes to these variables were made prior to, during and after the referendum period, albeit changes will be apparent as financial reports become available in the post Brexit window.

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Appendix A. Glossary of Terms Relating to Political and Economic Arrangements in Europe

Name / Organization	Member countries
European Union (E.U.)	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom
European Economic Area (E.E.A.)	E.U. plus Iceland, Liechtenstein and Norway
European Single Market	E.E.A. plus Switzerland

Table 1. Descriptive Statistics of Measures of Probability of Brexit

	Mean	Std dev	Min	Q1	Median	Q3	Max
Probability of leave (Brexit) vote	0.293	0.043	0.179	0.271	0.294	0.325	0.392
Gap between probability and 0.50	0.207	0.043	0.108	0.175	0.206	0.229	0.321
Change in probability	-0.001	0.022	-0.134	-0.006	0.000	0.004	0.073
Change in probability scaled by lagged gap	-0.012	0.136	-1.009	-0.030	0.000	0.021	0.323

Probability of leave (Brexit) vote is the average implied probability from odds by Coral, Ladbrokes, Paddy Power and William Hill, and probabilities for individual bookmakers are calculated as:

$$prob_{jt}^{Leave} = \frac{1/odds_{jt}^{Leave}}{1/odds_{jt}^{Leave}+1/odds_{jt}^{Remain}},$$

where $odds_{jt}^{Leave}$ ($odds_{jt}^{Remain}$) is the end of day *t* decimal odds offered by bookmaker *j* on the leave (remain) outcome of the referendum. *Change in probability scaled by lagged gap* is the variable x_t in subsequent tests, unless stated otherwise, and is calculated as:

$$x_t = \frac{prob_t^{Leave}-prob_{t-1}^{Leave}}{0.5-prob_{t-1}^{Leave}},$$

where $prob_t^{Leave}$ is the *Probability of leave vote* defined above. All variables are measured for 84 trading days between February 20, 2016, when the EU membership referendum was announced and June 22, 2016, one day before the referendum. Data on odds are sourced from Oddschecker.

Table 2. Brexit Exposure across Industries

	Mean	Min	Q1	Median	Q3	Max	N^- [% of all]	N^+ [% of all]
Full sample [331]	-0.025	-0.120	-0.040	-0.027	-0.014	0.431	163 [49.2]	3 [0.9]
Basic materials [22]	-0.010	-0.100	-0.021	-0.014	0.001	0.094	2 [9.1]	0 [0.0]
Consumer goods [34]	-0.033	-0.072	-0.052	-0.029	-0.019	0.001	21 [61.8]	0 [0.0]
Consumer services [82]	-0.028	-0.080	-0.044	-0.029	-0.016	0.040	45 [54.9]	1 [1.2]
Financials [49]	-0.040	-0.120	-0.050	-0.040	-0.029	0.014	34 [69.4]	0 [0.0]
Healthcare [16]	0.012	-0.036	-0.026	-0.016	-0.005	0.431	4 [25.0]	1 [6.3]
Industrials [90]	-0.020	-0.059	-0.034	-0.021	-0.010	0.085	38 [42.2]	1 [1.1]
Oil & gas [11]	-0.026	-0.099	-0.033	-0.015	-0.011	-0.006	2 [18.2]	0 [0.0]
Technology [15]	-0.024	-0.062	-0.040	-0.026	0.005	0.009	7 [46.7]	0 [0.0]
Telecommunication [5]	-0.036	-0.055	-0.041	-0.039	-0.028	-0.018	4 [80.0]	0 [0.0]
Utilities [7]	-0.033	-0.048	-0.040	-0.034	-0.025	-0.018	6 [85.7]	0 [0.0]

This table presents descriptive statistics of β_{Bi}, the Brexit exposure of individual firms, estimated from the model:

$$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \varepsilon_{it},$$

where r_{it} is stock i's return on day t and x_t is the scaled change in the probability of a Brexit vote on day t implied by bookmakers' odds and is calculated as in Table 1. β_{Bi} is negative where firm returns fall in response to an increase in the probability of a Brexit vote. N^- (N^+) is the number of negative (positive) coefficients significant at the 5 percent level. The model is estimated over 84 trading days between February 20, 2016 and June 22, 2016. The full sample includes 331 stocks, and the number of firms in each industry is reported in square brackets. Data on stock and index returns are from Datastream.

Table 3. Definitions of Independent Variables

Variable	Definition
Firm size	The natural logarithm of the firm's stock market capitalization. Source: Datastream.
Sales growth	Three-year change in revenues. Source: Worldscope.
MB ratio	The ratio of the year-end share price to book value per share. Source: Worldscope.
ROE	Return on equity, calculated as net income less preferred dividends divided by the average of current year's and previous year's common equity. Source: Worldscope.
Foreign sales	The fraction of total sales generated from foreign operations. Source: Worldscope.
Foreign sales - Europe	The fraction of total sales generated from foreign operations in Europe. Calculated based on geographical segment data from Worldscope.
Foreign sales - other	The fraction of total sales generated from foreign operations outside of Europe. Calculated based on geographical segment data from Worldscope.
Foreign assets	Assets of foreign operations divided by total assets. Source: Worldscope.
Foreign country count	The natural logarithm of 1 plus the number of foreign countries mentioned in the firm's most recent (2015/2016) annual report published before the Brexit referendum. Annual reports are sourced from Thomson One and firms' websites.
Foreign country count – Europe	The natural logarithm of 1 plus the number of the European Single Market foreign countries mentioned in the firm's most recent (2015/2016) annual report published before the Brexit referendum. Annual reports are sourced from Thomson One and firms' websites.
Foreign country count – other	The natural logarithm of 1 plus the number of foreign countries other than the European Single Market countries mentioned in the firm's most recent (2015/2016) annual report published before the Brexit referendum. Annual reports are sourced from Thomson One and firms' websites.
Foreign ownership	The percentage of shares outstanding held by investors located outside of the U.K. Source: Thomson One.
E.U. lobbying	The midpoint of the range of the declared E.U. lobbying costs (converted to GBP) scaled by total sales and multiplied by 100. Source: LobbyFacts.eu, Worldscope.
Single market workforce	The fraction of the workforce in the sector the firm belongs to (defined by the 2-digit British SIC code) born in a European Single Market country other than the U.K. Calculated based on data pooled from 4 quarterly Labour Force Surveys (LFS) conducted in 2016 available from the Office for National Statistics.
Leverage	The ratio of total debt to total assets. Source: Worldscope.
Capex	Capital expenditures scaled by the previous year's total assets. Source: Worldscope.
R&D	Research and development expense scaled by total sales. Source: Worldscope.
Cash holdings	Cash scaled by total assets. Source: Worldscope
Assets per employee	The natural logarithm of the ratio of total assets to the number of employees. Source: Worldscope.

This table presents definitions of independent variables used in regressions. Unless stated otherwise, the variables are measured at December 31, 2015.

Table 4. Descriptive Statistics of Independent Variables

	N	Mean	Std dev	Min	Q1	Median	Q3	Max
Firm size	297	7.362	1.509	3.781	6.370	7.198	8.327	11.096
Firm size (GBP mil)	297	5,550	12,337	44	584	1,337	4,135	65,930
MB ratio	297	3.959	4.521	0.090	1.590	2.670	4.370	33.950
Sales growth	297	0.052	0.161	-0.288	-0.027	0.030	0.096	0.910
ROE	297	0.153	0.372	-0.852	0.043	0.130	0.213	2.245
Foreign sales	277	0.464	0.363	0.000	0.037	0.504	0.811	1.000
Europe	215	0.089	0.146	0.000	0.000	0.000	0.133	0.630
Other	215	0.360	0.339	0.000	0.000	0.336	0.668	1.000
Foreign assets	231	0.280	0.286	0.000	0.000	0.199	0.542	0.992
Foreign country count	297	2.901	0.857	1.099	2.197	2.996	3.497	4.736
Europe	297	2.004	0.794	0.000	1.386	2.079	2.639	3.367
Other	297	2.420	0.904	0.693	1.792	2.485	2.996	4.431
Foreign country count (raw)	297	25	22	2	8	19	32	113
Europe (raw)	297	9	7	0	3	7	13	28
Other (raw)	297	16	16	1	5	11	19	83
Foreign ownership	297	0.308	0.185	0.021	0.175	0.286	0.424	0.841
E.U. lobbying	297	0.001	0.002	0.000	0.000	0.000	0.000	0.013
Single market workforce	297	0.076	0.044	0.019	0.051	0.064	0.100	0.314
Leverage	251	0.229	0.172	0.000	0.091	0.217	0.332	0.855
Capex	251	0.049	0.043	0.000	0.017	0.037	0.064	0.185
R&D	251	0.023	0.084	0.000	0.000	0.000	0.008	0.700
Cash holdings	251	0.082	0.082	0.000	0.028	0.059	0.100	0.492
Assets per employee	251	-1.524	1.165	-4.075	-2.293	-1.630	-0.936	3.719
Assets per employee (GBP mil)	251	0.604	2.698	0.017	0.101	0.196	0.392	41.235

The table presents descriptive statistics of independent variables used in cross-sectional regressions explaining firms' Brexit exposure. All variables are winsorized at the 1st and 99th percentile. The sample is limited to companies with all data available (297 for all firms including financial firms, and 251 for non-financial firms), except for *Foreign sales* and *Foreign assets* for which the coverage is lower. All variables are defined in Table 3.

Table 5. Determinants of Brexit Exposure – All Firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	-0.0002	0.0043	0.0031	0.0075	-0.0033	0.0016	0.0031	0.0090	-0.0001	0.0047
	(-0.02)	(0.49)	(0.36)	(0.75)	(-0.41)	(0.19)	(0.32)	(0.93)	(-0.01)	(0.55)
Firm size	-0.0048***	-0.0043***	-0.0049***	-0.0044***	-0.0061***	-0.0052***	-0.0052***	-0.0053***	-0.0062***	-0.0052***
	(-4.81)	(-4.42)	(-4.33)	(-3.97)	(-5.99)	(-5.08)	(-4.25)	(-4.53)	(-5.96)	(-5.08)
MB ratio	-0.0006*	-0.0008**	-0.0010*	-0.0011**	-0.0006*	-0.0008**	-0.0008**	-0.0009**	-0.0006	-0.0008**
	(-1.66)	(-2.15)	(-1.92)	(-2.04)	(-1.66)	(-2.22)	(-2.14)	(-2.39)	(-1.60)	(-2.19)
Sales growth	-0.0133	-0.0102	-0.0225**	-0.0176*	-0.0058	-0.0015	-0.0054	-0.0011	-0.0047	-0.0006
	(-1.64)	(-1.22)	(-2.39)	(-1.86)	(-0.60)	(-0.15)	(-0.53)	(-0.11)	(-0.49)	(-0.06)
ROE	0.0135***	0.0159***	0.0182***	0.0212***	0.0125***	0.0152***	0.0164***	0.0181***	0.0127***	0.0152***
	(2.98)	(3.44)	(2.61)	(2.78)	(2.82)	(3.41)	(3.46)	(3.65)	(2.85)	(3.38)
Foreign sales	0.0135***	0.0086**								
	(3.84)	(2.13)								
Foreign assets			0.0115**	0.0061						
			(2.46)	(1.16)						
Foreign country count					0.0065***	0.0049***				
					(3.85)	(2.74)				
Foreign sales – Europe							0.0144*	0.0105		
							(1.72)	(1.17)		
Foreign sales – other							0.0184***	0.0145***		
							(4.59)	(3.44)		
Foreign country count - Europe									0.0002	-0.0001
									(0.08)	(-0.06)
Foreign country count - other									0.0064***	0.0052***
									(3.22)	(2.65)
Foreign ownership	0.0085	0.0043	0.0140*	0.0104	0.0052	0.0014	0.0052	0.0045	0.0050	0.0013
	(1.14)	(0.61)	(1.69)	(1.26)	(0.71)	(0.19)	(0.57)	(0.50)	(0.68)	(0.18)
E.U. lobbying	-0.3736	0.2386	-0.0591	0.3658	-0.3568	0.2283	0.0922	0.4215	-0.3574	0.2269
	(-0.71)	(0.44)	(-0.09)	(0.58)	(-0.67)	(0.42)	(0.13)	(0.50)	(-0.69)	(0.43)

(continued)

Table 5. – *continued*

Single market workforce	0.0264	0.0281	0.0230	0.0394	0.0386*	0.0373	0.0064	0.0408	0.0364*	0.0348
	(1.22)	(1.07)	(1.02)	(1.32)	(1.88)	(1.39)	(0.30)	(1.45)	(1.77)	(1.30)
Industry dummies	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Number of observations	277	277	231	231	297	297	215	215	297	297
Adjusted R-squared	0.1620	0.1881	0.1265	0.1496	0.1373	0.1717	0.1938	0.1973	0.1397	0.1733
Europe = other (F-test)							0.19	0.16	2.42	1.95

This table presents estimated coefficients from regressions of Brexit exposure (dependent variable) on a set of firm characteristics. The sample includes all firms. The dependent variable, β_{Bi}, is defined in Table 2, and all independent variables are defined in Table 3. Since β_{Bi} is more negative for firms with higher Brexit exposure, variables with a positive (negative) coefficient reduce (increase) Brexit exposure. All dependent and independent variables are winsorized at the 1st and 99th percentile. *t*-statistics based on heteroskedasticity-consistent standard errors of the coefficients are reported in parentheses. ***, **and * denote significance at the 1, 5, and 10 percent level, respectively.

Table 6. Determinants of Brexit Exposure – Non-Financial Firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	0.0074	0.0131	0.0076	0.0132	0.0063	0.0106	0.0002	0.0107	0.0086	0.0136
	(0.74)	(1.29)	(0.72)	(1.12)	(0.66)	(1.01)	(0.02)	(0.95)	(0.91)	(1.30)
Firm size	-0.0052***	-0.0051***	-0.0052***	-0.0049***	-0.0064***	-0.0060***	-0.0050***	-0.0052***	-0.0063***	-0.0060***
	(-4.82)	(-4.53)	(-4.27)	(-3.98)	(-5.30)	(-4.93)	(-4.12)	(-4.23)	(-5.19)	(-4.89)
MB ratio	-0.0009**	-0.0009**	-0.0013**	-0.0013**	-0.0008**	-0.0007*	-0.0012***	-0.0012***	-0.0008*	-0.0007*
	(-2.23)	(-2.04)	(-2.19)	(-2.07)	(-2.01)	(-1.74)	(-2.74)	(-2.59)	(-1.95)	(-1.68)
Sales growth	-0.0199**	-0.0165*	-0.0301***	-0.0268***	-0.0140*	-0.0119	-0.0136	-0.0094	-0.0125	-0.0106
	(-2.07)	(-1.67)	(-3.08)	(-2.67)	(-1.73)	(-1.44)	(-1.21)	(-0.81)	(-1.60)	(-1.32)
ROE	0.0169***	0.0174***	0.0219***	0.0248***	0.0156***	0.0158***	0.0200***	0.0204***	0.0156***	0.0157***
	(3.54)	(3.49)	(2.87)	(2.93)	(3.26)	(3.24)	(3.90)	(3.71)	(3.24)	(3.20)
Foreign sales	0.0118***	0.0093**								
	(2.95)	(2.05)								
Foreign assets			0.0128**	0.0088						
			(2.55)	(1.47)						
Foreign country count					0.0054***	0.0046**				
					(2.78)	(2.21)				
Foreign sales – Europe							0.0106	0.0091		
							(1.24)	(0.99)		
Foreign sales – other							0.0166***	0.0150***		
							(3.91)	(3.29)		
Foreign country count - Europe									0.0002	0.0000
									(0.06)	(0.01)
Foreign country count - other									0.0052***	0.0060**
									(2.58)	(2.22)
Foreign ownership	0.0080	0.0060	0.0148*	0.0138	0.0074	0.0057	0.0049	0.0050	0.0075	0.0060
	(1.01)	(0.78)	(1.68)	(1.51)	(1.00)	(0.78)	(0.53)	(0.54)	(1.01)	(0.81)
E.U. lobbying	0.7405	1.2126	1.1890	1.5370**	0.6133	1.0655	0.4532	0.8448	0.5966	1.0336
	(1.08)	(1.60)	(1.62)	(2.00)	(0.92)	(1.43)	(0.58)	(0.91)	(0.92)	(1.44)

(continued)

Table 6. – *continued*

Single market workforce	-0.0018	0.0218	0.0050	0.0335	0.0179	0.0382	-0.0054	0.0318	0.0157	0.0367
	(-0.08)	(0.76)	(0.20)	(1.05)	(0.76)	(1.30)	(-0.22)	(1.05)	(0.67)	(1.25)
Leverage	-0.0036	-0.0080	-0.0019	-0.0051	-0.0043	-0.0094	0.0041	-0.0001	-0.0047	-0.0101
	(-0.36)	(-0.74)	(-0.15)	(-0.38)	(-0.43)	(-0.89)	(0.34)	(-0.01)	(-0.47)	(-0.94)
Capex	0.0395	0.0268	0.0335	0.0187	0.0469	0.0423	0.0504	0.0327	0.0445	0.0413
	(0.97)	(0.65)	(0.69)	(0.39)	(1.10)	(0.95)	(1.18)	(0.76)	(1.05)	(0.94)
R&D	0.0228**	0.0147	-0.0010	-0.0411*	0.0204*	0.0126	0.0219**	0.0161	0.0200*	0.0125
	(2.27)	(1.11)	(-0.04)	(-1.70)	(1.91)	(0.89)	(2.03)	(1.17)	(1.84)	(0.88)
Cash holdings	-0.0224	-0.0207	-0.0078	-0.0047	-0.0267	-0.0265	-0.0091	-0.0080	-0.0260	-0.0261
	(-1.31)	(-1.16)	(-0.39)	(-0.22)	(-1.55)	(-1.48)	(-0.48)	(-0.41)	(-1.51)	(-1.46)
Assets per employee	-0.0003	-0.0004	-0.0001	-0.0002	0.0006	0.0009	-0.0010	-0.0011	0.0004	0.0008
	(-0.21)	(-0.26)	(-0.07)	(-0.12)	(0.48)	(0.63)	(-0.64)	(-0.64)	(0.31)	(0.57)
Industry dummies	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Number of observations	239	239	201	201	251	251	203	203	251	251
Adjusted R-squared	0.1527	0.1517	0.1245	0.1311	0.1386	0.1431	0.1818	0.1748	0.1376	0.1421
Europe = other (F-test)							0.41	0.33	1.51	1.22

This table presents estimated coefficients from regressions of Brexit exposure (dependent variable) on a set of firm characteristics. The sample includes non-financial firms. The dependent variable, β_{Bi}, is defined in Table 2, and all independent variables are defined in Table 3. Since β_{Bi} is more negative for firms with higher Brexit exposure, variables with a positive (negative) coefficient reduce (increase) Brexit exposure. All dependent and independent variables are winsorized at the 1st and 99th percentile. *t*-statistics based on heteroskedasticity-consistent standard errors of the coefficients are reported in parentheses. ***, **and * denote significance at the 1, 5, and 10 percent level, respectively.

Table 7. Brexit Exposure – Alternative Estimation Methods

		Mean	Min	Q1	Median	Q3	Max	N^- [% of all]	N^+ [% of all]
(1)	Baseline model	-0.025	-0.120	-0.040	-0.027	-0.014	0.431	163 [49.2]	3 [0.9]
(2)	Brexit exposure controlling for FX exposure	-0.015	-0.099	-0.032	-0.018	-0.005	0.420	101 [30.5]	6 [1.8]
(3)	Brexit exposure controlling for changes in S&P500 and VIX	-0.017	-0.112	-0.033	-0.020	-0.006	0.464	111 [33.5]	6 [1.8]
(4)	Stock returns in USD	-0.048	-0.145	-0.064	-0.050	-0.037	0.421	248 [74.9]	1 [0.3]
(5)	Change in leave probability not scaled	-0.164	-0.737	-0.270	-0.170	-0.091	2.263	164 [49.5]	2 [0.6]
(6)	Current and lagged change in leave probability	-0.030	0.158	-0.053	-0.030	-0.015	0.341	141 [42.6]	2 [0.6]

This table presents descriptive statistics of alternative Brexit exposure measures of individual firms. Row (1) replicates the full sample results reported in Table 2. In row (2) the exposure is defined as β_{Bi} estimated from the model:

$$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{xi} r_t^{GBPUSD} + \varepsilon_{it},$$

where r_{it} is stock i's return on day t, r_t^{GBPUSD} is the percentage change in the GBP/USD exchange rate on day t, and x_t is the scaled change in the probability of a leave (Brexit) vote on day t implied by bookmakers' odds and is calculated as in Table 1.

In row (3) the exposure is defined as β_{Bi} estimated from the model:

$$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{m1i} r_t^{S\&P500} + \beta_{m2i} r_{t-1}^{S\&P500} + \beta_{v1i} \Delta VIX_t + \beta_{v2i} \Delta VIX_{t-1} + \varepsilon_{it},$$

where r_{it} and x_t are defined as above, $r_t^{S\&P500}$ is the return on the S&P500 index on day t, and ΔVIX_t is the change in the value of the VIX index on day t.

In rows (4) and (5) the exposure is defined as β_{Bi} estimated from the model:

$$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \varepsilon_{it},$$

where r_{it} is stock i's return on day t. In row (4) the returns are measured in USD while in row (5) they are measured in GBP, as in other tests unless stated otherwise. x_t is the scaled (row (4)) or not scaled (row (5)) change in the probability of a leave vote on day t implied by bookmakers' odds and is calculated as in Table 1.

In row (6) Brexit exposure is calculated as $(\beta_{B1i} + \beta_{B2i})$, estimated from the model:

$$r_{it} = \beta_{0i} + \beta_{B1i} x_t + \beta_{B2i} x_{t-1} + \varepsilon_{it},$$

where r_{it} is stock i's return on day t and x_t is the scaled change in the probability of a leave (Brexit) vote on day t implied by bookmakers' odds and is calculated as in Table 1. N^- (N^+) is the number of negative (positive) exposure measures significant at the 5 percent level.

The models are estimated over 84 trading days between February 20, 2016 and June 22, 2016.

Table 8. Determinants of Brexit Exposure Controlling for Foreign Exchange Rate – All Firms

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.0087	0.0158*	0.0104	0.0190*	0.0055	0.0133
	(1.02)	(1.67)	(1.22)	(1.81)	(0.69)	(1.62)
Firm size	-0.0050***	-0.0046***	-0.0047***	-0.0043***	-0.0066***	-0.0057***
	(-4.75)	(-4.64)	(-4.22)	(-3.97)	(-6.37)	(-5.71)
MB ratio	-0.0008*	-0.0010**	-0.0012**	-0.0015***	-0.0008**	-0.0010**
	(-1.88)	(-2.32)	(-2.53)	(-2.72)	(-2.13)	(-2.54)
Sales growth	-0.0129	-0.0036	-0.0226**	-0.0106	-0.0060	0.0038
	(-1.39)	(-0.42)	(-2.18)	(-1.16)	(-0.65)	(0.41)
ROE	0.0100*	0.0147***	0.0137*	0.0203***	0.0093*	0.0145***
	(1.70)	(2.70)	(1.91)	(2.69)	(1.65)	(2.74)
Foreign sales	0.0152***	0.0091**				
	(4.03)	(2.28)				
Foreign assets			0.0191***	0.0101**		
			(4.03)	(2.06)		
Foreign country count					0.0079***	0.0062***
					(4.67)	(3.67)
Foreign ownership	0.0174**	0.0117	0.0197**	0.0161*	0.0131	0.0069
	(2.04)	(1.49)	(2.07)	(1.75)	(1.61)	(0.88)
E.U. lobbying	-0.1823	0.3593	0.0999	0.4724	-0.2295	0.3443
	(-0.47)	(0.76)	(0.20)	(0.89)	(-0.57)	(0.77)
Single market workforce	0.0181	0.0574**	0.0015	0.0438	0.0258	0.0596**
	(0.74)	(2.25)	(0.07)	(1.65)	(1.17)	(2.44)
Industry dummies	No	Yes	No	Yes	No	Yes
Number of observations	277	277	231	231	297	297
Adjusted R-squared	0.1763	0.2430	0.1530	0.2232	0.1633	0.2483

This table presents estimated coefficients from regressions of Brexit exposure after controlling for the exchange rate exposure (dependent variable) on a set of firm characteristics. The sample includes all firms. The dependent variable, β_{Bi}, is defined as in row (2) of Table 7, and all independent variables are defined in Table 3. Since β_{Bi} is more negative for firms with higher Brexit exposure, variables with a positive (negative) coefficient reduce (increase) Brexit exposure. All dependent and independent variables are winsorized at the 1st and 99th percentile. *t*-statistics based on heteroskedasticity-consistent standard errors of the coefficients are reported in parentheses. ***, **and * denote significance at the 1, 5, and 10 percent level, respectively.

Table 9. Determinants of Brexit Exposure Controlling for Foreign Exchange Rate – Non-Financial Firms

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.0153	0.0216	0.0130	0.0217*	0.0125	0.0181*
	(1.45)	(1.93)	(1.15)	(1.71)	(1.25)	(1.78)
Firm size	-0.0056***	-0.0053***	-0.0051***	-0.0047***	-0.0072***	-0.0064***
	(-5.05)	(-4.62)	(-4.04)	(-3.76)	(-5.86)	(-5.40)
MB ratio	-0.0011**	-0.0011***	-0.0015***	-0.0017***	-0.0012***	-0.0011***
	(-2.56)	(-2.59)	(-2.73)	(-2.70)	(-2.74)	(-2.64)
Sales growth	-0.0194*	-0.0085	-0.0311***	-0.0188**	-0.0131	-0.0024
	(-1.88)	(-0.86)	(-3.07)	(-2.06)	(-1.46)	(-0.27)
ROE	0.0138**	0.0164***	0.0170**	0.0232***	0.0134**	0.0156***
	(2.55)	(3.15)	(2.24)	(2.79)	(2.55)	(3.10)
Foreign sales	0.0147***	0.0100**				
	(3.54)	(2.25)				
Foreign assets			0.0201***	0.0122**		
			(3.89)	(2.14)		
Foreign country count					0.0078***	0.0063***
					(3.96)	(3.13)
Foreign ownership	0.0152*	0.0118	0.0208**	0.0193**	0.0130	0.0098
	(1.74)	(1.37)	(2.14)	(1.91)	(1.61)	(1.22)
E.U. lobbying	0.4355	1.4080	1.1751	1.9003**	0.1528	1.0756
	(0.47)	(1.58)	(1.19)	(2.12)	(0.17)	(1.23)
Single market workforce	0.0009	0.0486*	-0.0079	0.0396	0.0116	0.0575**
	(0.03)	(1.72)	(-0.30)	(1.37)	(0.44)	(2.08)
Leverage	-0.0001	-0.0054	-0.0032	-0.0060	0.0001	-0.0069
	(-0.01)	(-0.54)	(-0.26)	(-0.48)	(0.01)	(-0.70)
Capex	0.0865**	0.0482	0.0806	0.0375	0.0998**	0.0673
	(2.04)	(1.12)	(1.55)	(0.75)	(2.24)	(1.43)
R&D	0.0187	0.0226	-0.0230	-0.0569***	0.0184	0.0222
	(1.40)	(1.31)	(-0.97)	(-2.81)	(1.47)	(1.35)
Cash holdings	-0.0129	-0.0081	0.0067	0.0116	-0.0164	-0.0134
	(-0.68)	(-0.42)	(0.30)	(0.49)	(-0.87)	(-0.68)
Assets per employee	0.0011	-0.0001	0.0008	-0.0001	0.0021	0.0013
	(0.79)	(-0.07)	(0.52)	(-0.04)	(1.49)	(0.82)
Industry dummies	No	Yes	No	Yes	No	Yes
Number of observations	239	239	201	201	251	251
Adjusted R-squared	0.1940	0.2448	0.1694	0.2344	0.1961	0.2534

This table presents estimated coefficients from regressions of Brexit exposure after controlling for the exchange rate exposure (dependent variable) on a set of firm characteristics. The sample includes non-financial firms. The dependent variable, β_{Bi}, is defined as in row (2) of Table 7, and all independent variables are defined in Table 3. Since β_{Bi} is more negative for firms with higher Brexit exposure, variables with a positive (negative) coefficient reduce (increase) Brexit exposure. All dependent and independent variables are winsorized at the 1st and 99th percentile. *t*-statistics based on heteroskedasticity-consistent standard errors of the coefficients are reported in parentheses. ***, **and * denote significance at the 1, 5, and 10 percent level, respectively.

Table 10. Determinants of Brexit Exposure – Robustness Checks

	Baseline model		Brexit exposure controlling for changes in S&P500 and VIX		Stock returns in USD		Change in leave probability not scaled		Current and lagged change in leave probability	
	All firms	Non-financial firms	All firms	Non-financial firms	All firms	Non-financial firms	All firms	Non-financial firms	All firms	Non-financial firms
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	0.0016	0.0106	0.0082	0.0148	-0.0206**	-0.0116	-0.0129	0.0452	-0.0011	0.0053
	(0.19)	(1.01)	(0.94)	(1.39)	(-2.33)	(-1.08)	(-0.23)	(0.67)	(-0.10)	(0.40)
Firm size	-0.0052***	-0.0060***	-0.0052***	-0.0061***	-0.0053***	-0.0062***	-0.0297***	-0.0352***	-0.0065***	-0.0072***
	(-5.08)	(-4.93)	(-4.94)	(-4.70)	(-5.12)	(-4.96)	(-4.49)	(-4.44)	(-5.03)	(-4.55)
MB ratio	-0.0008**	-0.0007*	-0.0007*	-0.0007*	-0.0008**	-0.0007*	-0.0050**	-0.0042	-0.0007	-0.0008*
	(-2.22)	(-1.74)	(-1.84)	(-1.74)	(-2.21)	(-1.73)	(-2.34)	(-1.62)	(-1.50)	(-1.75)
Sales growth	-0.0015	-0.0119	0.0003	-0.0099	-0.0016	-0.0122	-0.0152	-0.0773	-0.0092	-0.0264**
	(-0.15)	(-1.44)	(0.03)	(-1.07)	(-0.15)	(-1.46)	(-0.24)	(-1.41)	(-0.77)	(-2.23)
ROE	0.0152***	0.0158***	0.0136***	0.0150***	0.0154***	0.0159***	0.1025***	0.1016***	0.0153***	0.0163***
	(3.41)	(3.24)	(2.93)	(3.21)	(3.41)	(3.25)	(3.66)	(3.24)	(2.68)	(2.72)
Foreign country count	0.0049***	0.0046**	0.0057***	0.0057***	0.0049***	0.0046**	0.0340***	0.0332**	0.0092***	0.0094***
	(2.74)	(2.21)	(3.13)	(2.69)	(2.73)	(2.19)	(2.95)	(2.45)	(4.14)	(3.60)
Foreign ownership	0.0014	0.0057	-0.0012	0.0024	0.0015	0.0059	0.0025	0.0288	0.0038	0.0081
	(0.19)	(0.78)	(-0.16)	(0.31)	(0.20)	(0.78)	(0.05)	(0.61)	(0.41)	(0.85)
E.U. lobbying	0.2283	1.0655	0.2299	0.9380	0.2337	1.0868	0.9854	6.7300	-0.4187	0.6948
	(0.42)	(1.43)	(0.45)	(1.14)	(0.42)	(1.43)	(0.28)	(1.41)	(-0.64)	(0.73)
Single market workforce	0.0373	0.0382	0.0435	0.0421	0.0382	0.0389	0.2450	0.2707	0.0171	0.0104
	(1.39)	(1.30)	(1.60)	(1.39)	(1.40)	(1.30)	(1.41)	(1.44)	(0.48)	(0.28)
Leverage		-0.0094		-0.0061		-0.0094		-0.0659		-0.0123
		(-0.89)		(-0.64)		(-0.88)		(-0.96)		(-0.86)
Capex		0.0423		0.0475		0.0435		0.2112		0.0898
		(0.95)		(1.04)		(0.97)		(0.75)		(1.61)
R&D		0.0126		0.0190		0.0129		0.0301		0.0414**
		(0.89)		(1.10)		(0.90)		(0.33)		(2.47)

(continued)

Table 10. – *continued*

Cash holdings		-0.0265		-0.0182		-0.0267		-0.1688		-0.0447**
		(-1.48)		(0.96)		(-1.46)		(-1.50)		(-2.15)
Assets per employee		0.0009		0.0012		0.0010		0.0075		0.0007
		(0.63)		(0.76)		(0.64)		(0.83)		(0.36)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	297	251	297	251	297	251	297	251	297	251
Adjusted R-squared	0.1717	0.1431	0.1641	0.1570	0.1729	0.1444	0.1713	0.1392	0.1973	0.1552

This table presents estimated coefficients from regressions of Brexit exposure (dependent variable) on a set of firm characteristics. Brexit exposure is estimated using alternative methods, as presented in Table 7. Columns (1) and (2) replicate baseline tests presented in column (6) of Tables 5 and 6, respectively. In columns (3) and (4) Brexit exposure is estimated controlling for S&P500 returns and changes in VIX, as in row (3) of Table 7. In columns (5) and (6) the exposure is calculated for USD-denominated stock returns, as in row (4) of Table 7. In columns (7) and (8) the exposure is calculated as sensitivity of stock returns to raw (not-scaled) changes in the probability of a Brexit vote, as in row (5) of Table 7. In columns (9) and (10) the model to estimate Brexit exposure includes a lagged change in Brexit probability, as in row (6) of Table 7. All independent variables are defined in Table 3. Since β_{Bi} is more negative for firms with higher Brexit exposure, variables with a positive (negative) coefficient reduce (increase) Brexit exposure. All dependent and independent variables are winsorized at the 1st and 99th percentile. *t*-statistics based on heteroskedasticity-consistent standard errors of the coefficients are reported in parentheses. ***, **and * denote significance at the 1, 5, and 10 percent level, respectively.

Table 11. Performance of Portfolios Sorted by Brexit Exposure around Referendum Result Date

Portfolio	N	Mean Brexit exposure	Mean return	% positive	*t*-stat (i) (cross-section)	t-stat (ii) (BMP)	t-stat (iii) (K&P)	*t*-stat (sign)
Panel A: Day -1 = June 23, 2016								
High exposure	66	-0.058	2.032%	92.4	10.36	10.54	1.81	6.89
2	66	-0.038	1.695%	90.9	12.32	12.98	2.54	6.65
3	67	-0.027	1.565%	82.1	7.51	8.06	1.77	5.25
4	66	-0.017	1.457%	90.9	7.23	7.34	1.79	6.65
Low exposure	66	0.013	1.011%	74.2	4.55	4.75	1.98	3.94
Panel B: Day 0 = June 24, 2016								
High exposure	66	-0.058	-13.327%	1.5	-14.32	-13.48	-2.31	-7.88
2	66	-0.038	-7.386%	1.5	-11.81	-11.32	-2.21	-7.88
3	67	-0.027	-5.337%	14.9	-8.38	-7.96	-1.74	-5.74
4	66	-0.017	-3.348%	24.2	-5.58	-4.97	-1.22	-4.19
Low exposure	66	0.013	-3.401%	15.2	-5.01	-5.78	-2.41	-5.66
Panel C: Day +1 = June 27, 2016								
High exposure	66	-0.058	-10.391%	3.0	-13.25	-12.94	-2.22	-7.63
2	66	-0.038	-8.786%	3.0	-12.39	-12.67	-2.48	-7.63
3	67	-0.027	-7.121%	4.5	-10.97	-11.24	-2.46	-7.45
4	66	-0.017	-4.771%	15.2	-7.97	-7.94	-1.94	-5.66
Low exposure	66	0.013	-4.901%	12.1	-6.42	-7.32	-3.05	-6.16

In this table we divide the sample of 331 firms into five portfolios based on our measure of Brexit exposure presented in Table 2. In Panel A we examine returns on the referendum day, June 23, to show that the vote for Brexit was unexpected. Panels B and C show returns to portfolios on June 24 and 27, respectively, which are subsequent to the vote for Brexit. The reported *t*-statistics against zero are based on (i) the event day (i.e. June 23 for Panel A etc.) cross-sectional variance (ii) the Boehmer *et al.* (1991) adjustment for event induced variance changes (iii) the Kolari and Pynnonen (2010) adjustment to the BMP statistic to allow for (within portfolio) cross sectional correlation. A non-parametric sign test (Corrado, 1989) is employed to determine the influence of outliers.

Figure 1. Probability of Leave (Brexit) Vote Implied by Bookmakers' Odds

This figure presents the probability of a leave (i.e. Brexit) vote between February 22, 2016, the first trading day after the EU membership referendum was announced and June 22, 2016, one day before the referendum. The probability is calculated as in Table 1.

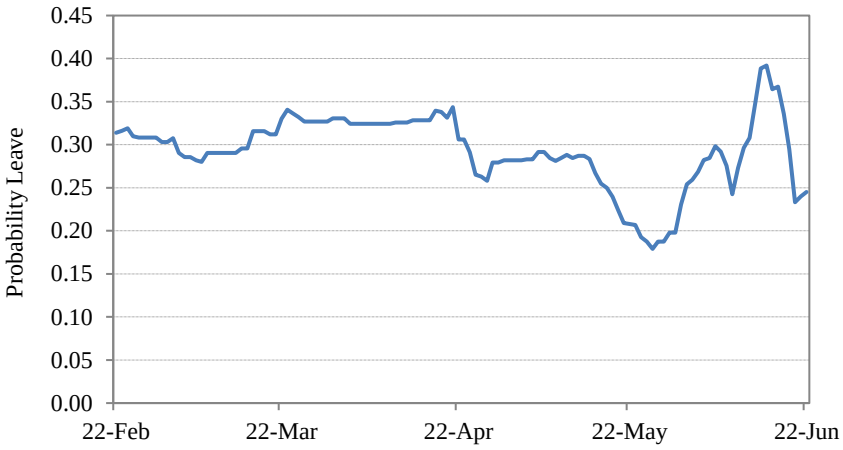
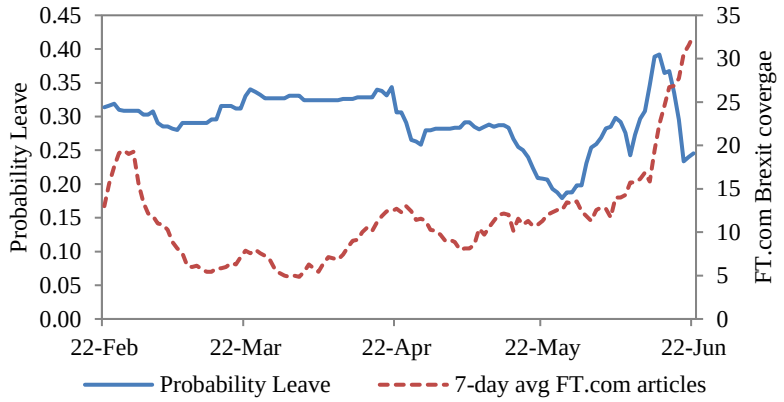


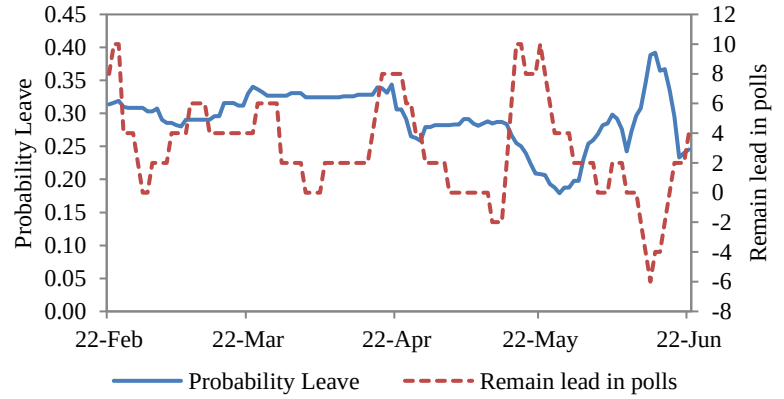
Figure 2. Probability of Leave (Brexit) Vote and Brexit News Coverage, Opinion Polls and GBP/USD Exchange Rate

This figure presents the probability of a leave (i.e. Brexit) vote plotted against the 7-day average of Financial Times (FT.com) articles with the word 'Brexit' (Panel A), the percentage point lead of the Remain vote (over the Leave vote) in opinion polls (Panel B) and the GBP/USD exchange rate (Panel C). The probability is calculated as in Table 1. The opinion polls series is based on the average of the 6 most recent polls and the Leave/Remain support is calculated excluding 'don't knows'.

Panel A. Probability Leave vs. Brexit News Coverage



Panel B. Probability Leave vs. Remain lead in polls



Panel C. Probability Leave vs. GBP/USD exchange rate