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IMF Working Paper

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Abstract

How did expectations of the outcome of the United Kingdom's (UK) referendum on European Union (EU) membership in 2016 affect prices in financial markets? We study this using high frequency data from betting and financial markets. We find that a one percentage point increase in the probability of "Leave" result caused British stocks (FTSE All-Share) to decline by 0.004 percent, and the Pound to depreciate by 0.006 percent against the euro. We find negative and significant effects for most sub-sectors, and negative spill-overs to other EU member countries. We show that the differential impact across sectors and countries can be explained by differences in the trade exposures.

JEL Classification Numbers: D80, E65, G14, G18.

Keywords: Brexit, EU referendum, political uncertainty, high frequency data.

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I. INTRODUCTION

The United Kingdom's (UK) referendum on European Union (EU) membership ("the referendum") held on June 23rd 2016 provides an opportunity to study the impact of political uncertainty on asset prices. The the implications of a "Stay" result were relatively clear: the UK would remain in the EU and policies would be unchanged. The implications of a "Leave" result were more uncertain, both ex ante and ex post. As events following the referendum have shown, a "Leave" result did not give clear guidance on the specifics of an exit from the EU, for example the time for invoking Article 50 or trade policies following an exit. Thus, in expectation a "Leave" result meant much more policy uncertainty than a "Remain" result (Figure 1). There would also be spillovers to other EU countries. Therefore, a "Leave" result could have important implications for equity prices, both through the expected profitability of firms (and the UK economy more broadly) and through the added uncertainty. Using high frequency data from a political prediction market (i.e. an online betting platform), we examine how fluctuations in peoples' expectations of the outcome of the referendum affected the market value of UK and European equities in the run-up to the referendum. The results are informative for how asset prices react to fluctuations in political uncertainty. However, the uncertainty we study is specific to the EU referendum result, which reflects the chance of leaving the EU and the political uncertainty that entails.

An alternative way of assessing the effect of a political event is through event studies. Some examples of such studies are Fisman et al. [2012], Jayachandran [2006], and Auerbach and Hassett [2007]. However, this method suffers from lack of variation as a given political event rarely happens repeatedly. In contrast, betting odds on a future political event are observable

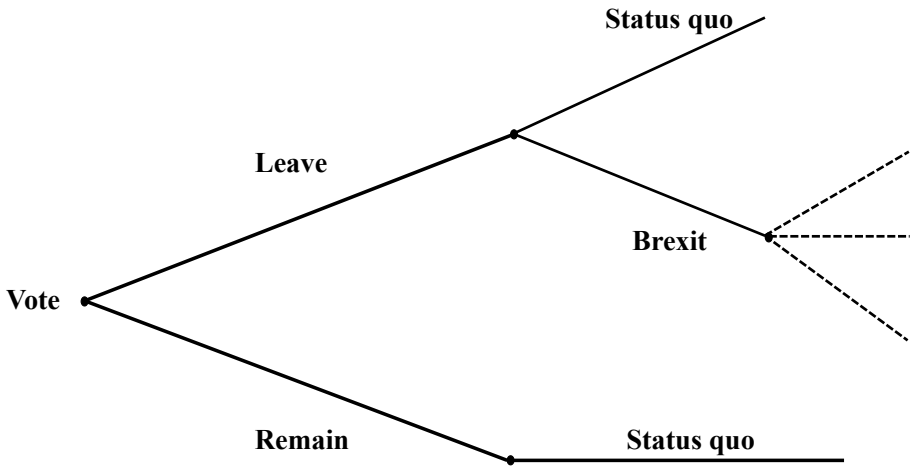


Figure 1. Policy uncertainty and the British EU Referendum in 2016

with high frequency, and can react almost instantaneously to new information as individuals place bets online. These odds thus display much more variation than the outcome of the actual political event. Our data contains prices for all trades made on Betfair (an online betting platform) during the run-up to the EU referendum, and the prices of various financial assets. By regressing the high frequency betting odds on financial market prices we get an estimate of how changes in the perceived probability of a "Leave" result, which implies substantially more policy uncertainty than a "Remain" result, affects asset prices.

We find that changes in the probabilities of a "Leave" result had a meaningful short run impact on asset prices. In the very short run (within 5 minutes), an increase in probability of a "Leave" result of one percentage point caused (i) British stocks (as measured by FTSE All-Share) to decline by 0.004 percent, and (ii) the Pound to depreciate by 0.006 percent against the Euro. Thus, a ten percentage point increase in the probability of a “Leave” result caused the stock market (FTSE all) to lose a value of around GBP 1 billion. We also find negative and significant effects for most sub-sectors in the FTSE all index. We also find evidence of negative spill-overs to other EU member countries. We show that the different impact across industries and countries can be explained by differences in the amount of trade exposures. Our results strengthen when we allow for 24 hour for adjustment. This could reflect lags in information processing of the market.

The validity of our results relies on several assumptions. First, we assume that betting odds in the run up to referendum reflected financial market participants’ view on the referendum outcome. We find this assumption plausible given the sheer volume of bets placed leading up to the referendum. This reassures us that betting on the referendum was not a niche industry for a small number of specialized participants, but rather a broader representation of market expectations. Betfair is the world’s largest online betting platform, and in 2016 its Brexit market had the largest number of transactions ever processed for a political event up to that point. Second, we assume that movements in equity prices which occur shortly after a change in the betting odds, are the price effect of a change in the expected outcome of the referendum. We test this assumption by varying the time-window we examine. Additionally, since the betting platform is easily accessible online, we believe it is reasonable to assume that the betting markets react quickly to events (such as speeches by politicians, publication of polling results, opinion pieces in major newspapers) in a similar manner as asset prices do.

Our work provides empirical support to a theoretical literature that has studied the impact of political uncertainty on financial markets [Pastor and Veronesi, 2012, 2013, Brogaard and Detzel, 2015, Kelly et al., 2016, Boutchkova et al., 2012, Beaulieu et al., 2005, Hil et al., 2019] and on economies more generally [Bloom, 2009, Baker et al., 2016]. In particular, our results are consistent with the leading theoretical model by Pastor and Veronesi [2012], whose show that asset prices should fall on the announcement of policy changes, more so when the associated political uncertainty is large, and with increasing magnitude as the probability of an event increases. In our case rather than formal policy announcements, we focus on indirect policy changes implied by changes in the probability of a "Leave" vote. We also provide empirical evidence consistent with Boutchkova et al. [2012], who find that political uncertainty in countries of trading partners and trade-dependent industries results in greater

asset price volatility. Finally, it is a member of the growing body of literature on prediction markets summarized by [Horn et al., 2014, Wolfers and Zitzewitz, 2004].

Our work also contributes to the relatively sparse literature on the EU referendum's impact on global asset prices. As far as we are aware, only two other studies use betting data to examine the implied market costs of the referendum Coleman et al. [2018] use betting data to study how the equities of US banks responded to a possible "Leave" vote in the referendum. They find that leading up to the vote, the equity prices of US banks fell by 0.003 to 0.0054 percent in response to a 1 percent change in the probability of Brexit. The US banks with more extensive UK operations were affected the most. In contrast, we do not find significant results for the UK based banks and financial firms in the short run. This is potentially attributable to the expected regulatory changes following a "Leave" vote or that investors did not expect UK banks to face the same geographic and legal organizational issues as their US counterparts. Belke et al. [2018] uses betting data in addition to policy uncertainty measures to estimate the implied cost of the referendum on equities, currencies, and sovereign debt in the UK, and some EU/OECD countries. They find that an increase in the probability of Brexit caused an depreciation in the British pound and has strong negative effects on the European stock markets, which is in line with our results. Importantly, both Coleman et al. [2018] and Belke et al. [2018] use betting data at daily frequency. In contrast, we use betting data at much higher frequency to estimate the impact of changes in expectations to the referendum result on currencies and equities across industries. Pairing high frequency betting and financial data allows us to make a more precise identification of these relationships.

Other papers have studied the impact of the referendum result on equity and currency volatility a few days after referendum [Ehler et al., 2017, Quaye et al., 2016] and over a longer horizon [Kurecic and Kokotovic, 2018, Caporale et al., 2018]. Relatedly, Hohlmeier and Fahrholz [2018] studies the consequences of the "Leave" result on on regulations governing financial activities between the UK and EU. There is also a growing literature examining how prolonged uncertainty about post-Brexit policy is impacting the broader UK economy [[Lapinska and Orak, 2020, Ries et al., 2020, 2017, Bloom et al., 2019]] and other countries around the world Hassan et al. [2019]. Unlike our work, these papers focus on the post-referendum financial or real outcomes and not on the impact of perceptions on markets before the vote.

The paper proceeds as follows. Section II provides background on the referendum and explains the mechanics of the betting platform Betfair. Section III describes our data. Section IV presents our baseline estimations. Section V contains the robustness checks of our baseline specifications and some additional analysis. Section VI concludes.

II. THE REFERENDUM AND BETTING PLATFORM

On February 20, 2016, the British government announced a referendum on the future of British membership in the European Union (EU), to be held on June 23, 2016. On the referendum day, the question posed to voters was "Should the United Kingdom remain a member of the

European Union or leave the European Union"? Voters chose from two answers, "Remain a member of the European Union", or "Leave the European Union".

The announcement of the vote was not unexpected, as Prime Minister David Cameron had pledged to hold such a vote during his re-election campaign in 2015. In response to this promise, Betfair, an online exchange where people can place bets against each other rather than a traditional bookmaker, created a market for people to bet on the outcome of the referendum. The question presented to betters was, “What will be the EU Referendum Result?" Betters could choose between two outcomes, “In favor of staying in EU" and “In favor of leaving EU". In this two-sided market, Betfair takes on no risk, it provides a platform for customers to match bets against each other and in turn takes a small commission on the winnings. Betters with a placed bet could either wait until after the referendum to cash out any winnings, or sell their bet to take advantage price movements in the bet before the election.

The exchange works in the following way. Betters can either match an existing bet placed by another person, or place a new bet with their desired odds for other betters to match. There are two types of bets a person can place, a back bet and a lay bet. A back bet pays out if the outcome occurs, while a lay bet pays out if the event does not occur. For example, a better can put in an offer to pay out 300 GBP if a certain outcome materializes, against the opportunity to receive 100 GBP if the outcome does not materialize. This is a back bet. Conversely, the better can put in an offer to payout 100 if the outcome does not materialize, against the opportunity to receive 300 if the outcome does materialize. This is a lay bet. Other betters can then buy these back/lay bets with 3:1 odds that the event materializes. Thus, every matched bet on the exchange involves both a lay bet and a back bet.

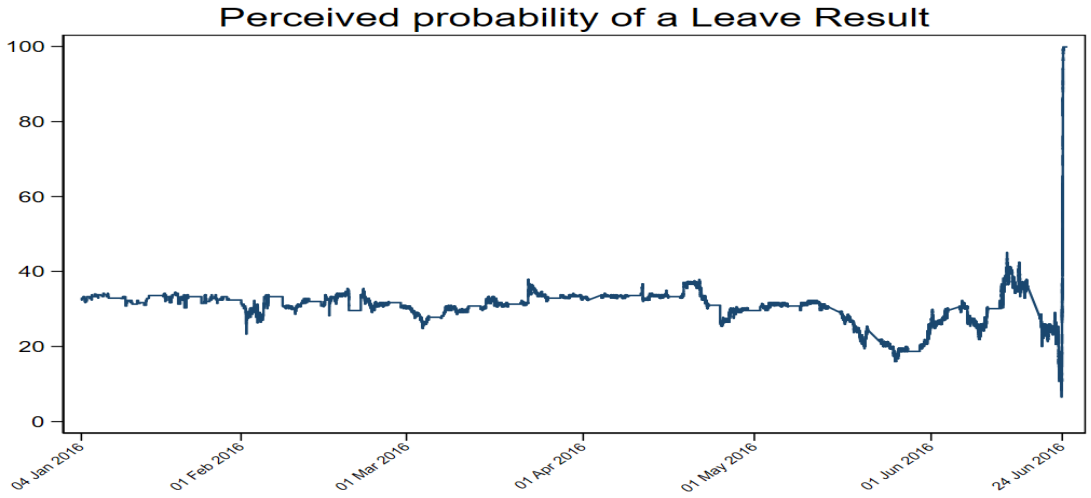
Figure 2. Betting Market Structure on the Betfair Platform

Notes: The figure shows the prevailing uncleared Referendum bets on the Betfair platform at a given point in time.

At a given point in time, a range of back/lay bets will be on sale on the Betfair platform, giving rise to a bid-ask spread (Figure 2). The going odds at every point in time is the odds of the latest bet traded. These bets can be converted into probabilities. If a bet is trading at odds of 1:3 this reflects a probability of 75 percent of this event occurring.[2] Figure 3 shows the probability odds of a “Leave” vote over the sample period and Figure 4 the cumulative distribution of trades placed on the platform leading up to the referendum day.

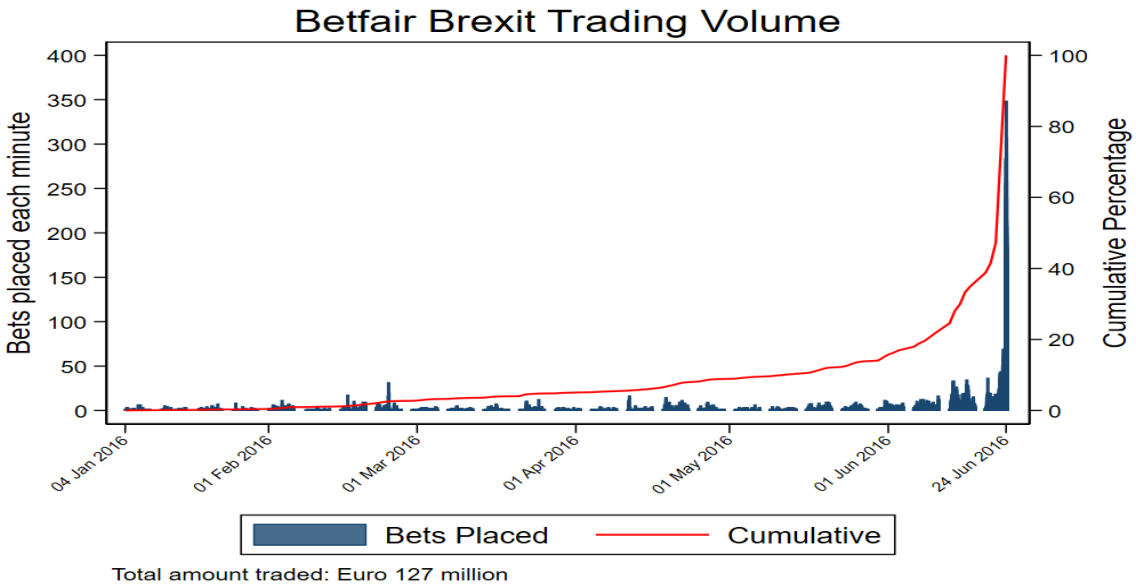
[2]This can be derived as the probability that would make a risk neutral person indifferent between placing both a bet or holding cash.

Figure 3. Market Perceived Probability of a Leave Result



Notes: The figure shows the perceived probability of a Leave result in the referendum on United Kingdom's membership of the European Union on June 23, 2016 based on betting data.
Source: Author's calculation using Betfair.com data.

Figure 4. Trade Volume and Cumulative Distribution



Notes: The figure shows the by-minute trade volume and the cumulative distribution of trades on the Betfair.com platform leading up to the referendum on June 23, 2016.
Source: Author's calculation using Betfair.com data.

III. THE DATA

Our betting data comes from Betfair, an online betting platform. The data is at the tick-level, meaning that each data point represents a trade. The implied probability that the referendum would result in a "Leave" vote is derived from the price of a trade in the Referendum Market. The betting odds associated with each trade are presented as decimals, which we convert into a probability.[3] As trades are made in the market the odds change, and simultaneously so does the implied probability. Each new implied probability is time-stamped with precision on the second. When Betfair first started taking bets, the implied probability would move only by the minute or hour. The frequency of bets increased significantly in the lead up to the referendum, and by the end of our sample probabilities were updated up to every second. The online market was open for bets 24 hours per day, seven days per week.

Financial prices are collected from Bloomberg at minute intervals. We collect price series for exchange rates and equity indices:

- The exchange rates for the British pound sterling (GBP) to Euro and GBP to Unites States Dollar (USD). The currencies are traded over the counter 24 hours day, Monday through Friday globally.
- The Financial Times Stock Exchange 100 Index (FTSE 100) index and the FTSE All-Share index. The FTSE 100 index is comprised of the 100 companies listed on the London Stock Exchange (LSE) with the highest market capitalization, which is approximately 80 percent of the total market capitalization of the LSE. The FTSE All-Share, is a capitalization-weighted index, comprising of 613 companies (as per August 31, 2020) representing 98 percent of of the UK's market capitalization. The LSE is open from 8am to 4:30pm Monday through Friday.
- The FTSE Industry Classification Benchmark (ICB) 19 sub-indices. In aggregate, these 19 sectors make up the full market capitalization of the FTSE100 and FTSE All-Share (these include, for instance, sectors as broad as construction, banking, chemicals, household and personal goods, among others).
- The major stock indices for other EU member countries. Stock markets across the EU open and close at various times throughout the day, but all markets typically stay open for about 8 hours.

All financial and betting data is harmonized to Greenwich Mean Time (GMT). The data covers the period from January 4th, 2016 to June 24th, 2016. The referendum was held on June 23rd, and the results were released gradually on the evening of June 24th. Note that the period we consider in our baseline empirical model is shorter, beginning in April 23rd and ending on June 24th, which is to focus on the period when the betting market saw a greater volume of

[3]The formulation for conversion is (1/odds) *100 = implied probability.

trades, more turnover, and increased volatility. The full sample period is used in the robustness tests which are presented in Section V.

Observations in the final data set are recorded at the minute level, so that the implied probabilities match the financial data. In the instances where multiple probabilities are recorded per minute, the last recorded probability is used. For example, if the last recorded probability between 12:15pm and 12:16pm occurred at 12:15:45pm (hh:mm:ss) at 33 percent, then this probability is assigned to 12:15pm. In instances where no probability was recorded for a minute(s), the last recorded probability is used. For example, 33 percent would be assigned to 12:16pm and 12:17pm if there was no change in probability until 12:18pm.

Our data also includes the timing of poll results leading up to the referendum. Details on 88 polls conducted by eleven companies and released from January until June were downloaded from Twitter. We describe in V.B. how variation just around the release of these poll results can be used as a robustness check of our main empirical methodology. Figure 7 indicates when these polls were released and how the implied probability of Leave responded.

Finally, trade data are taken from the OECD's Trade in Value Added (TiVA) database which provides bilateral sectoral-level trade data at an annual frequency. The sectoral classifications in TiVA are matched to the broad FTSE categories using detailed sectoral definitions.

For further details on the data we use, see Annex VII.C.

IV. ANALYSIS

A. Impact of referendum expectations on nominal exchange rates

We begin by estimating the impact of changes in the expected probability of a "Leave" vote on the value of the British pound sterling (£, GBP). To do so, we regress the log of the nominal sterling exchange rate vis-à-vis the euro and the U.S. dollar, $s_{ht,£/l}$ where $l \in \{\$, €\}$, on the perceived probability of leave derived from betting odds, P(leave)_{ht}, measuring financial market's belief of the probability of leaving the EU:

$$\Delta \ln s_{ht,£/l} = \alpha_h + \beta \Delta \text{P(leave)}_{ht} + e_{ht} \tag{1}$$

where h denotes the hour and t the exact time and date (minute, day, month, and year), α_h are hourly fixed effects that capture all other factors affecting the pound during a given hour, and e_{ht} is the residual term. We estimate the model in differences, expressed by the Δ term, which we define as either 5 or 10 minute difference of the dependent and independent variables.[4]

[4]Note that we multiple the dependent and independent variables by 100, so our coefficient of interest, β, is directly (approximately) interpreted as the percentage change in response to a one percentage point change in the probability of Brexit.

Estimating equation (1) involves a choice of time unit. This needs to be sufficiently long for news related to the referendum to be passed on to betting markets, but sufficiently short to avoid that other news influence the exchange rate during the same time period. Below we look at two possibilities, 5 and 10 minute intervals. These intervals are short, yet they allow time for market adjustment to new information. In both cases, we also include time fixed effects to allow for other possible that also could affect the exchange rate. In order for the model to be identified the fixed effects must be at a lower frequency than our variables of interest–which are at the minute frequency. We choose one hour time fixed effects, which we believe provides a reasonable window for news to be transmitted to exchange rates. In robustness exercises, we show that time fixed effects at a lower frequency do not affect the results in a substantive way (Section V).

The results are reported in Table 1 for 5 minute difference increment and in Table 2 for 10 minute. In columns (1) and (2) of both tables we include as our sample the full period for which Betfair's markets were taking bets on the probability of the referendum outcome, 00:00 (midnight) on 3 January 2016 until 16:29 on 24 June 2016. In columns (3) and (4) we restrict the sample period to start two months before the vote, at 00:00 23 April 2016. The shorter sample period gives us an indication of whether or not markets were more responsive to changes in the perceived probability of a leave vote as the date of the referendum approached. In addition, as Figure 5 shows, there was little variation in the perceived probability of leaving in the early part of the sample, making identification in the full sample possibly difficult.

Table 1. Impact of Perceived Probability of Leave on Exchange Rate (5 Minutes)

	(1)	(2)	(3)	(4)
Dependent Variable	$s_{t,£/€}$	$s_{t,£/\$}$	$s_{t,£/€}$	$s_{t,£/\$}$
P(Leave)	0.004***	0.006***	0.006***	0.008***
	(0.0011)	(0.0016)	(0.0015)	(0.0021)
Time FE (hour)	Yes	Yes	Yes	Yes
Sample period start date	03 Jan 16	03 Jan 16	23 Apr 16	23 Apr 16
R2	0.08	0.09	0.08	0.09
N	175,956	176,733	63,371	63,675

Notes: Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. Variables are differenced over 5 minute intervals.

As expected, we observe a larger impact on exchange rates in the period leading up to the referendum and we see that when we allow more time for information process there is a larger effect on the exchange rate (compare Table 1 to Table 2). The explanatory power of changes in the perceived probability of leave of exchange rates almost double with a longer time window (compare (1) to (3) and (2) to (4), respectively, in Table 1 and Table 2). While the impact

Table 2. Impact of Perceived Probability of "Leave" on Exchange Rates (10 Minutes)

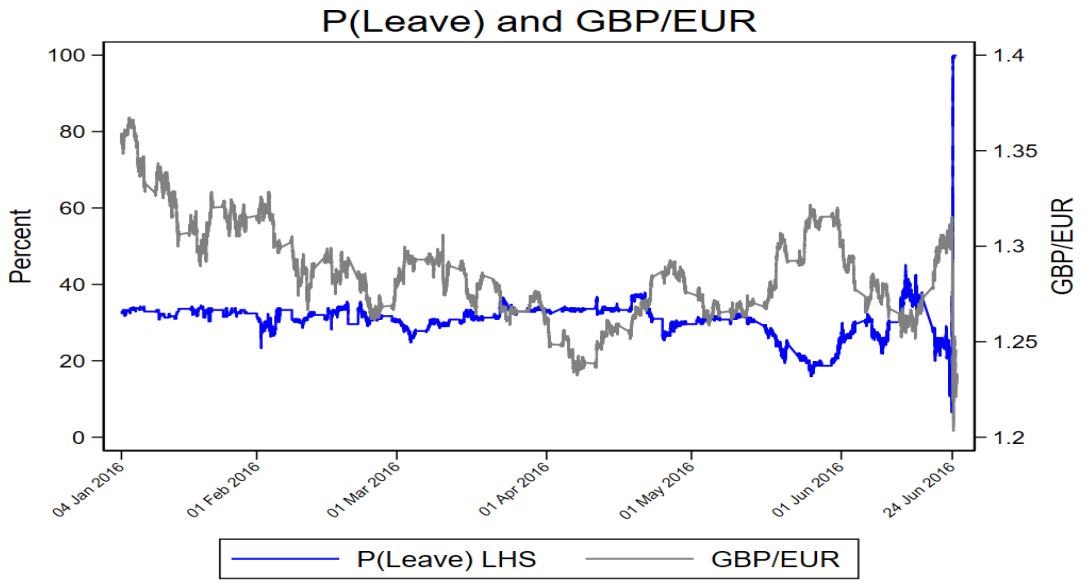
	(1)	(2)	(3)	(4)
Dependent Variable	$s_{t,£/€}$	$s_{t,£/\$}$	$s_{t,£/€}$	$s_{t,£/\$}$
P(Leave)	0.007***	0.010***	0.009***	0.014***
	(0.0016)	(0.0022)	(0.0022)	(0.0030)
Time FE (hour)	Yes	Yes	Yes	Yes
Sample period start date	03 Jan 16	03 Jan 16	23 Apr 16	23 Apr 16
R2	0.15	0.17	0.16	0.18
N	175,827	176,608	63,326	63,630

Notes: Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. Variables are differenced over 10 minute intervals.

of a one percentage point increase in the probability of leaving the EU lead to a 0.004-0.007 percent decline in the value of the pound sterling against the euro (column (1)) and a 0.006-0.100 percent decline against the U.S. dollar (column (2)) over the full sample, during the shorter period leading up to the vote the impact of changes in the perceived probability of leaving were about 0.002-0.003 percentage points higher against both.[5] This suggests that while market participants negatively priced in the event of a Leave vote throughout the period leading up to the referendum, they became considerably more sensitive as the date approached.

[5]The magnitude of these coefficient can be compared to the average hourly standard deviation of changes in the sterling exchange rate, which was 0.036 vis-a-vis the euro and 0.04 against the dollar.

Figure 5. Probability of Leave Result and GBP/EUR



Notes: The figure shows the high frequency (by minute) changes in the perceived probability of a Leave result in the referendum and the GBP/EUR exchange rate.
Source: Author's calculations using data from Betfair.com and Bloomberg.

B. Impact of the referendum on UK equity markets

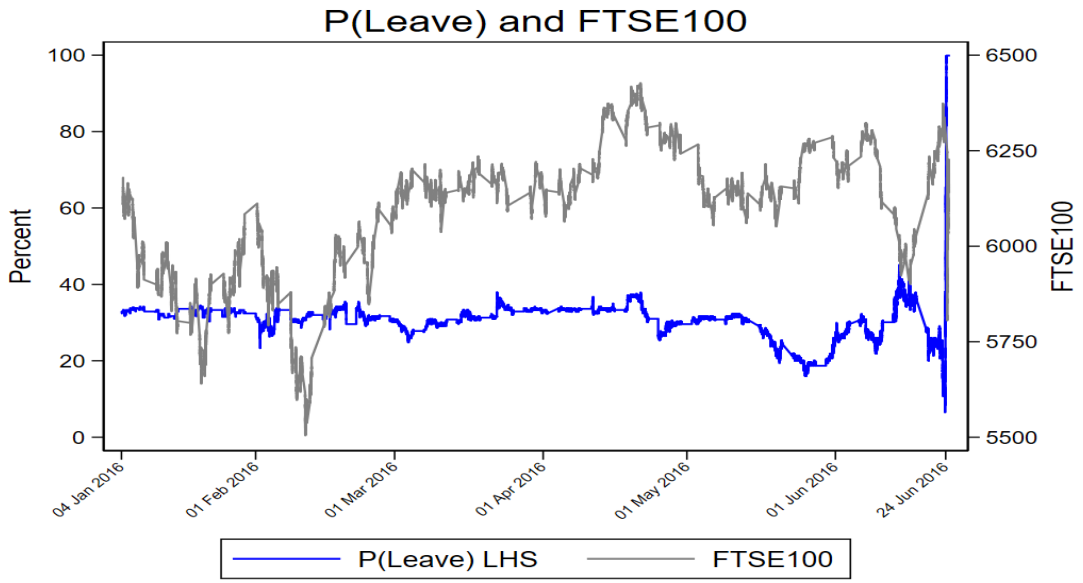
Next, we examine the impact of the perceived probability of a "Leave" result on the Financial Times and Stock Exchange index (FTSE), $\text{FTSE}_{All,ht}$, which comprises the most highly capitalized companies in the UK listed on the London Stock Exchange. We also look separately at each of the sub-sectors of the index, $\text{FTSE}_{i,ht}$. We estimate an analogous regression in 5-minute and 10-minute differences to (1) for these equities:

$$\Delta \ln \text{FTSE}_{i,ht} = \alpha_h + \beta \Delta \text{P(leave)}_{i,ht} + e_{i,ht} \tag{2}$$

More specifically, we start with the entire FTSE market, $\text{FTSE}_{All,ht}$, which represents the performance of all eligible companies listed on the London Stock Exchange main market, which pass screening for size and liquidity, and captures 98% of the UK's market capitalization.[6] We then narrow the sample to the FTSE 100, $\text{FTSE}_{100,ht}$, which consists of the 100 companies with the highest market capitalization listed on the London Stock Exchange, see Figure 6. Finally, we look separate at the FTSE's specific sectors, $\text{FTSE}_{i,t}$, which include: (i) real estate, (ii) industrial, (iii) utilities, (iv) banks, (v) oil and gas, (vi) insurance, (vii) technology, (viii) construction, (ix) housing, (x) media, (xi) finance, (xii) retail, (xiii) chemistry, (xiv) telecommunications, (xv) travel, (xvi) food and beverages, (xvii) health care, (xviii) basic resources, and (xix) automotive. The sector-level analysis allows us to investigate which sec-

[6]See https://www.ftse.com/Analytics/FactSheets/Home/DownloadSingleIssue?issueName=ASX&IsManual=Falsefordetails.

Figure 6. Probability of Leave Result and FTSE100



Notes: The figure shows the high frequency (by minute) changes in the perceived probability of a Leave result in the referendum and the FTSE100 stock index.
Source: Author's calculations using data from Betfair.com and Bloomberg.

tors market participants expected to be most affected by losing free access to EU markets. For example, by breaking down equity markets in this way, our estimate will provide insight to whether UK sectors whose firms are more dependent on the EU market upstream (sectors whose customers are individuals or firms in the EU) or downstream (firms whose suppliers are in the EU) are expected to be most affected by leaving.

We will also be able to test whether those sectors that were more strictly regulated by EU law (for e.g. food and beverage, telecommunications) were more affected than those that fell more under domestic regulation (for e.g. construction and healthcare), since there was more uncertainty in EU regulated markets.

Our results are reported in Tables 3 and 4 for the 5 minute differencing specification and 10 minute differencing specification, respectively.[7] Comparing Table 3 and 4 we see that the impact from changes in in the probability of a "Leave" result on equity markets in the UK is substantially larger for the specification with 10 minute differencing. This is likely because the longer time window allows markets to better process the information. For the total market the impact of a one percentage point increase in the "Leave" probability is -0.0039 percent for 5 minute differencing, and -0.0073 percent for 10 differencing. For the 100 largest firms the impact is -0.0045 and -0.0083 percent, respectively. This result is likely driven by an expected fall in future earnings resulting from a "Leave" result. On the other hand, some firms in the indices have substantial earnings from abroad, and will thus get an offset from the associated sterling depreciation (Section IV.A).

The impact of the perceived probability of "Leave" is mixed across industry indices, with some indication that more EU-exposed industries take greater hit than domestic industries. For instance, the impact of chemicals, basic resources and construction are not statistically significant (in the 5 minute difference specification), while the impact on other sectors is highly significant and large. It is noteworthy that the results are not significant for either banks nor finance, which potentially could be explained by the intangible, and thus mobile, nature of capital in these sectors. The results could also be driven by expected regulatory changes following a "Leave" vote.

[7]For the remainder of the paper we report results only for the sample period April 23, 2016 onwards, given the results from the exchange rate analysis suggests markets didn't react to changes in the probability of Leave prior to that. Results for the full sample (from January 3, 2016) are provided in Appendix VII.A.

Table 3. Impact of Perceived Probability of “Leave" on FSTE Sectors, (5 Minutes)

	ALL	**100**	**Real Estate**	**Industrial**	**Utilities**
P(Leave)	-0.0039***	-0.0045***	-0.0023*	-0.0034***	-0.0038***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.05	0.05	0.02	0.04	0.06
N	21,629	21,629	21,304	21,607	20,870
	Banks	**Oil& Gas**	**Insurance**	**Tech**	**Construction**
P(Leave)	-0.0033	-0.0090***	-0.0052***	-0.0041**	-0.0032
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.04	0.07	0.02	0.08	0.01
N	21,551	21,529	21,531	18,403	14,970
	Housing	**Media**	**Finance**	**Retail**	**Chem**
P(Leave)	-0.0034**	-0.0053***	-0.0015	-0.0033**	-0.0008
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.06	0.05	0.06	0.04	0.07
N	21,567	21,146	21,593	21,593	17,256
	Telecom	**Travel**	**Food & Bev**	**Health Care**	**Resources**
P(Leave)	-0.0041**	-0.0028**	-0.0025**	-0.0028*	-0.0049
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.08	0.04	0.05	0.10	0.07
N	18,403	21,573	21,086	21,539	21,565
	Automotive				
P(Leave)	-0.0051				
	(0.00)				
R2	0.08				
N	10,601				

Robust standard errors in parentheses, $^{*}p < 0.1,^{**}p < 0.05,^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. Variables are differenced over 5 minute intervals. All regressions include time fixed effects (hourly frequency).

Table 4. Impact of Perceived Probability of "Leave" on FSTE Sectors, (10 Minutes)

	ALL	**100**	**Real Estate**	**Industrial**	**Utilities**
P(Leave)	-0.0073***	-0.0083***	-0.0053***	-0.0049***	-0.0079***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.08	0.09	0.02	0.06	0.12
N	21,432	21,432	21,108	21,410	20,675
	Banks	**Oil& Gas**	**Insurance**	**Tech**	**Construction**
P(Leave)	-0.0077***	-0.0156***	-0.0079***	-0.0051***	-0.0066***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.08	0.13	0.05	0.16	0.04
N	21,354	21,332	21,334	18,212	14,756
	Housing	**Media**	**Finance**	**Retail**	**Chem**
P(Leave)	-0.0076***	-0.0087***	-0.0028***	-0.0046***	-0.0005
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.12	0.08	0.07	0.03	0.13
N	21,370	20,949	21,396	21,396	17,027
	Telecom	**Travel**	**Food & Bev**	**Health Care**	**Resources**
P(Leave)	-0.0051***	-0.0050***	-0.0047***	-0.0056***	-0.0108***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.16	0.05	0.12	0.21	0.15
N	18,212	21,376	20,887	21,342	21,368
	Automotive				
P(Leave)	-0.0100**				
	(0.00)				
R2	0.16				
N	10,343				

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly frequency). Variables are differenced over 10 minute intervals.

C. Impact of the referendum on European equity markets

The UK market is highly integrated with European markets through trade in goods and services and movement of people. As such, the impact of a "Leave" vote should not only affect UK listed companies but also those firms based in other EU countries who do business in the UK, with UK customers or UK based-businesses, or conduct transactions in pound sterling. In order to determine the extent to which businesses based in other EU countries were affected by the perceived probability of a "Leave" result, we estimate the country-specific impact of changes in the probability on other EU equity markets:[8]

$$\Delta \text{ln Equity}_{j,ht} = \alpha_{j,h} + \beta \Delta \text{P(leave)}_{ht} + e_{ht} \tag{3}$$

where $\text{Equity}_{j,t}$ is country j's aggregate equity market index. Results for the 5 and 10 minute differencing specifications are reported in Tables 5 and 6.[9] Not surprisingly, the impact of changes in the perceived probability of a Leave result in the referendum is much smaller in foreign equity markets than in the UK market, particularly when we look at the 5 minute differencing specification. Yet, a number of countries did see their equity markets fall significantly in response to a one percentage point rise in the probability of a "Leave" result. In particular, the French and Irish equity markets, whose economies are two of the most highly integrated with the UK are estimated to have fallen by about 0.004 percent in response to a one percentage point increase in the perceived probability of a "Leave" result (allowing for the longer, 10 minute, information processing time). The Netherlands and Belgium are also estimated to have been significantly affected by changes in the perceived probability of "Leave", which could be related to fears of disruption in import activities between the UK, Netherlands (Rotterdam, Amsterdam), and Belgian (Antwerp) ports, which are the some of the principal points of entry for foreign imports into the EU. [10] We investigate the role of trade exposures in the following section (IV.D).

[8] Note we do not include Malta, Slovakia and Luxembourg in our analysis because we do not have sufficient data on their equity market prices to identify the the model parameters.

[9] Results for the full sample period are provided in Appendix VII.A.

[10] The positive coefficients for Hungary and Bulgaria could be explained by pre-vote EU council agreement which allowed countries to limit in-work benefits for workers from other EU countries. Under the agreement EU countries would be allowed to lengthen the period required to qualify for in-work benefits up to 4 years for workers from other EU countries, and index child benefits to the cost of living conditions in workers' home country. The implementation of this agreement was contingent on a "Stay" result in the UK referendum.

Table 5. Impact of Perceived Probability of "Leave" on EU Equities, (5 Minutes)

	Germany	**France**	**Spain**	**Italy**	**Portugal**
P(Leave)	-0.0027	-0.0030*	-0.0027	-0.0030	-0.0029*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.09	0.09	0.09	0.21	0.07
N	21,063.00	21,629.00	21,063.00	21,628.00	21,629
	Ireland	**Netherlands**	**Belgium**	**Denmark**	
P(Leave)	-0.0011	-0.0038**	-0.0037**	-0.0012	
	(0.00)	(0.00)	(0.00)	(0.00)	
R2	0.02	0.07	0.07	0.12	
N	21,126.00	21,629.00	21,629.00	19,120	
	Finland	**Sweden**	**Austria**	**Greece**	**Poland**
P(Leave)	-0.0016	-0.0016	-0.0021	-0.0012	-0.0028
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.08	0.08	0.04	0.10	0.11
N	20,623.00	20,120.00	19,853.00	16,090.00	19,839
	Czech	**Hungary**	**Romainia**	**Cyprus**	
P(Leave)	-0.0034	0.0041**	0.0014	0.0043	
	(0.00)	(0.00)	(0.01)	(0.00)	
R2	0.04	0.05	0.24	0.07	
N	14,003.00	16,707.00	2,800.00	15,361	
	Slovenia	**Estonia**	**Latvia**	**Lithuania**	**Bulgaria**
P(Leave)	0.0055	0.0028	0.0023	0.0012	0.0056***
	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.37	0.08	0.07	0.12	0.11
N	771.00	14,320.00	13,962.00	14,678.00	16,690

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly). Variables are differenced over 5 minute intervals.

Table 6. Impact of Perceived Probability of “Leave" on EU Equities, (10 Minutes)

	Germany	**France**	**Spain**	**Italy**	**Portugal**
P(Leave)	-0.0033	-0.0042**	-0.0033	-0.0058**	-0.0055***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.18	0.15	0.18	0.36	0.10
N	20,871	21,432	20,871	21,431	21,414
	Ireland	**Netherlands**	**Belgium**	**Denmark**	
P(Leave)	-0.0042**	-0.0053***	-0.0051***	-0.0037*	
	(0.00)	(0.00)	(0.00)	(0.00)	
R2	0.05	0.13	0.11	0.22	
N	20,916	21,414	21,414	18,920	
	Finland	**Sweden**	**Austria**	**Greece**	**Poland**
P(Leave)	-0.0033**	-0.0063***	-0.0050**	-0.0021	-0.0026
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.15	0.16	0.11	0.13	0.20
N	20,436	19,920	19,657	15,885	19,634
	Czech	**Hungary**	**Romainia**	**Cyprus**	
P(Leave)	-0.0048**	0.0061***	0.0102*	0.0003	
	(0.00)	(0.00)	(0.01)	(0.00)	
R2	0.06	0.09	0.37	0.12	
N	13,847	16,569	2,713	15,156	
	Slovenia	**Estonia**	**Latvia**	**Lithuania**	**Bulgaria**
P(Leave)	-0.0036	-0.0007	0.0025	0.0009	0.0101***
	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.30	0.13	0.13	0.17	0.20
N	754	14,120	13,767	14,473	16,495

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly). Variables are differenced over 10 minute intervals.

D. Role of Trade Exposure

Does trade exposure explain the sensitivity of equity prices to changes in the probability of a "Leave" vote across UK industries (Section IV.B) and across other European equity markets (Section IV.C)? To investigate this connection further, we augment our model specification to include foreign trade exposure by industry (for the regressions using UK industry-level data) and trade exposure by EU country (for the regressions using EU country-level data).

We define industry-level trade exposure as the sum of industry i exports UK trading partner j (including all trading partners globally), over total UK exports in 2016:

$$EX_i^{Industry} = \frac{\sum_j Exports_{ij,2016}}{\sum_j \sum_i Exports_{ij,2016}} \tag{4}$$

We define EU-country level trade exposure, $EX_j^{Country}$ in a similar fashion, summing the UK's exports to country j across all industries in 2016:

$$EX_j^{Country} = \frac{\sum_i Exports_{ij,2016}}{\sum_j \sum_i Exports_{ij,2016}} \tag{5}$$

We then, in turn, interact each of these trade exposure variables with our perceived probability of "Leave" variable. This allows us to include sector (or country) fixed effects, and thus control for time-invariant sector (or country) specific characteristics. Specifically, we estimate the following equations which correspond to our FTSE industry and EU baseline specifications, respectively:

$$\begin{aligned} \Delta\ln \text{FTSE}_{i,t} &= \alpha_i + \alpha_t + \beta_1 \Delta\text{P(leave)}_t \cdot EX_i^{Industry} + \beta_2 \Delta\text{P(leave)}_t \\ &\quad + \beta_3 EX_i^{Industry} + e_t \end{aligned} \tag{6}$$

$$\begin{aligned} \Delta\ln \text{Equity}_{j,t} &= \alpha_j + \alpha_t + \beta_1 \Delta\text{P(leave)}_t \cdot EX_j^{Country} + \beta_2 \Delta\text{P(leave)}_t \\ &\quad + \beta_3 EX_j^{Country} + e_t \end{aligned} \tag{7}$$

Table 7 reports our estimation results. Columns 1-2 report the estimated equation (6) with 5 and 10 minute differencing, respectively, and columns 3-4 report the estimated equation (7). All columns includes fixed time and industry/country fixed effects, and robust standard errors.[11] The results suggest that trade linkages are an important determinant of the extent to which asset prices were affected by changes in the perceived probability of a leave vote. Specifically, for each one percent increase in a sector's share of total UK exports, the price of that sector's equity index would decline by 0.01 percent more relative to other sectors. Our results are consistent with Hil et al. [2019] who find policy uncertainty has a differentiated impact on industries in the UK. We also find similar results at the EU country level. For each

[11] We also tried to estimate the same equations using Driscoll-Kraay standard errors and country fixed effects. This did not alter our conclusions (see Appendix Table 28-29).

Table 7. Estimated Impact of Perceived Probability of on UK and European Equities, Controlling for Trade

Dependent Var:	$\Delta ln(Equity_{it})$		$\Delta ln(Equity_{jt})$	
	(1)	(2)	(3)	(4)
$\Delta P(Leave_t) \cdot EX_j$	-0.009***	-0.011***		
	(0.00)	(0.00)		
$\Delta P(Leave_t) \cdot EX_j$			-0.010***	-0.013***
			(0.00)	(0.00)
Differencing (minutes)	5	10	5	10
R2	0.46	0.51	0.42	0.51
N	966313.00	965788.00	1.15e+06	1.14e+06

Notes: Standard errors in parentheses, $^{*}p < 0.1,^{**}p < 0.05,^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. Standard errors robust. All regressions include time fixed effects. Exports are defined as total exports in sector (country) i (j) as a share of total global exports from the U.K. in 2016.

one percent greater an EU country's trade was with the UK, they equity prices would decline by 0.02 percent more relative to other countries.

V. ROBUSTNESS

A. Alternative fixed effects

The previous section provided evidence that foreign exchange and equity markets (in the UK and EU) were significantly affected by changes in the perceived probability of a "Leave" vote in the EU referendum, under the assumption that events triggering changes in the perceived probability were unique in the hour that they occurred and no other news during that hour would affect financial markets. We now test whether that is a reasonable assumption.

First we estimate the model with shorter time fixed effects, setting them to half hour intervals. That is, we shorten the time period during which we absorb any variation in the data that could affect financial markets. Results for the estimation of equations (1) - (3) are reported in Tables 12, 13, and 14. Results for the nominal exchange rate and UK equity regressions are highly robust to our baseline results, both in terms of the magnitude of the estimated coefficients and their statistical significance. The results on European equity markets are also broadly robust, except for on French equities which is no longer statistically significant. The robustness of these results suggests there was indeed little additional information during the second half of each hour on financial markets.

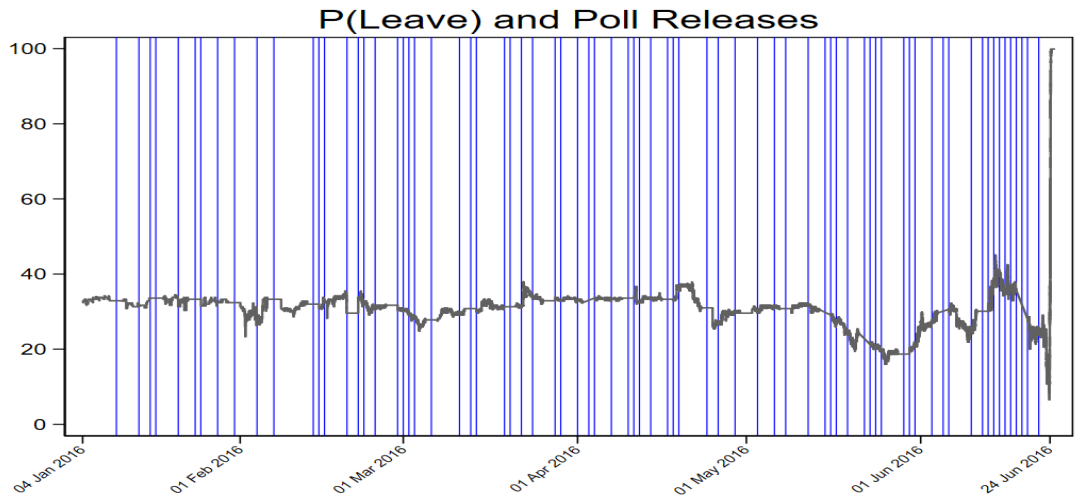
Next we extend the fixed effects to daily intervals. This is a less strict specification, which absorbs daily news and allows the coefficient estimate to capture more variation within days. The results, reported in Tables 15, 16, and 17, are highly robust for the exchange rate and UK equity market regressions. Results on European Equity markets tend to be more statistically significant, not surprisingly because we allow for more variation in our perceived probability of "Leave" variable. The results of both exercises broadly suggest our choice of hour-fixed effects in our baseline regressions are reasonable, but that the results are not sensitive to that choice.

B. Restricted sample

A final test of the degree to which we are capturing the correct news regarding the transmission of information about the probability of a "Leave" result rather than other news that may have moved markets in the same direction is to restrict our sample to those 5-minute intervals when news regarding polling results was released. We assume that it is during these intervals when individuals are more likely to place informed bets on the probability of a "Leave" result, and is a truer proxy for the actual probability of the UK voting in favor of leaving the EU. Wall et al. [2017] provides evidence for this assumption. They find that betting market prices were quite sensitive to key events leading up to the 2014 Scottish Independence Referendum, and were particular responsive to poll releases. Results are reported in Tables 18 – 20. We show that by restricting the sample to those short intervals where concrete news about the public's preference for leaving the EU, in the form of poll results, the estimated impact of changes in the perceived probability of a "Leave" result had a much stronger impact on

exchange rates. The impact on equities is more mixed, with only those sub-sectors that had the largest effect in our baseline regression that show a statistically significant effect in this restricted sample.

Figure 7. Poll Result Releases



Notes: The figure presents the perceived probability of a Leave result, and release date-times for 88 polls conducted about the public's support/opposition for the Brexit Referendum leading up to the vote on June 23, 2016.
Source: Author's calculation using Betfair and Twitter data.

C. Non-linearities

Given the important differences between the result of a "Stay" vote in the referendum–that the UK would enter a regime of almost absolute certainty with regards to it's relationship to the EU–and the result of a "Leave" vote–that the UK would enter a regime of high uncertainty–it's possible that the impact of an increase in the perceived probability of a "Leave" result has a significantly different effect on markets than the impact of a decrease in the perceived probability of a "Leave" result. We test whether this is the case and report the results for our exchange rate model specification in Tables 21, for the FTSE index in Tables 22 and 23, and for European equities in Tables 24 and 25. The impact of a rise in the probability of a leave vote appears to be much more important for the UK than the impact of a fall in the probability–given the certainty surrounding the effects of staying relative to leaving the EU, it's natural that the impact on the exchange rate would be greater. Yet the asymmetries are much less apparent in equity markets.

D. Effects beyond immediate impact

So far, we have been investigating the immediate impact of changes in the perceived referendum result. How does the impact change over time? To investigate this, we re-run the regressions for equity (1) and exchange rates (2) while we increase the time window over which the estimated impact on exchange rates and equity prices (the left hand side variable) is calculated. The change in probability (on the right hand side) remains calculated over 10 minutes. The results from this exercise is show in Table 26 for exchange rates and Table 27 for equity prices. For exchange rates, Table 26 shows that the estimated impact is persistent up to 15 minutes after the the change in probability. The estimated effect falls from 0.009 percent after 10 minutes to 0.008 after 15 minutes. After 15 minutes the estimated effect turns insignificant.[12] For equity prices, Table 27 the estimated effect is more persistent. The estimated impact increases from 0.008 percent after 10 minutes to 0.013 percent after 30 minutes. Even after 1440 minutes (24 hours) the estimated effect is 0.011 percent and significant.

VI. Conclusion

In this paper we study how expectations of the outcome of the UK's referendum on EU membership in 2016 affected exchange rates and equity prices in the UK and EU, and in doing so provide empirical support for the leading theoretical predictions of the impact of political uncertainty on asset prices (see Pastor and Veronesi [2012]). Since equity prices are a reflection of expected future profits of cash flows from firms, the impact should be heterogeneous across sectors based on their exposure to EU-based regulations, to the EU-single market, to foreign competition, and to trade. We use high frequency betting data to assess the revealed expectations of market participants, and show that expectations did indeed affect asset prices. In the very short run (within 5 minutes), we find that an increase in probability of a "Leave" result of one percentage points caused (i) British stocks (as measured by FTSE all) to decline by 0.004 percent–the equivalent of a GBP 1 billion loss for a ten percentage point increase in the probability of "Leave"–and (ii) the Pound to depreciate by 0.006 percent against the Euro. We find negative and significant effects for most sub-sectors in the FTSE aindex, and more so the more exposed each industry is to international markets. We also find evidence of negative spill-overs to other EU member countries, and more so the more exposed each country is to the UK market.

[12] It is however negative and significant after 1 hours. However, we do not attach much weight on this as the effect again is insignificant after 24 hours.

VII. ANNEXES

A. Equity regressions, full sample period

Table 8. Impact of Perceived Probability of "Leave" on FSTE Sectors, (5 Minutes, Full Sample)

	ALL	100	Real Estate	Industrial	Utilities
P(Leave)	-0.0017*	-0.0018	-0.0022**	-0.0023**	-0.0011
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.07	0.07	0.03	0.07	0.07
N	60,973.00	60,973	60,122	60,937	59,363
	Banks	**Oil& Gas**	**Insurance**	**Tech**	**Construction**
P(Leave)	-0.0017	-0.0007	-0.0021	-0.0039**	-0.0002
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.06	0.08	0.05	0.09	0.03
N	60,847	60,829	60,806	50,979	41,167
	Housing	**Media**	**Finance**	**Retail**	**Chem**
P(Leave)	-0.0018	-0.0048***	-0.0012	-0.0026**	-0.0004
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.07	0.07	0.09	0.05	0.09
N	60,881	59,745	60,913	60,903	50,353
	Telecom	**Travel**	**Food & Bev**	**Health Care**	**Resources**
P(Leave)	-0.0039**	-0.0017	-0.0014	-0.0021	0.0015
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.09	0.05	0.07	0.10	0.08
N	50,979	60,877	59,542	60,799	60,875
	Automotive				
P(Leave)	-0.0073*				
	(0.00)				
R2	0.09				
N	35,447				

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 03 January 2016 until 16:29 24 June 2016. Variables are differenced over 5 minute intervals. All regressions include time fixed effects (hourly frequency).

Table 9. Impact of Perceived Probability of "Leave" on FSTE Sectors, (10 Minutes, Full Sample)

	ALL	**100**	**Real Estate**	**Industrial**	**Utilities**
P(Leave)	-0.0031***	-0.0033***	-0.0029**	-0.0035***	-0.0024*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.13	0.14	0.05	0.12	0.14
N	60,419	60,419	59,566	60,383	58,800
	Banks	**Oil& Gas**	**Insurance**	**Tech**	**Construction**
P(Leave)	-0.0018	-0.0009	-0.0034*	-0.0052***	0.0014
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.12	0.15	0.10	0.17	0.10
N	60,293	60,275	60,251	50,411	40,591
	Housing	**Media**	**Finance**	**Retail**	**Chem**
P(Leave)	-0.0052***	-0.0075***	-0.0018*	-0.0043***	0.0001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.15	0.13	0.13	0.07	0.18
N	60,327	59,193	60,359	60,349	49,747
	Telecom	**Travel**	**Food & Bev**	**Health Care**	**Resources**
P(Leave)	-0.0052***	-0.0028**	-0.0024**	-0.0021	-0.0042
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.17	0.10	0.15	0.19	0.16
N	50,411	60,323	58,980	60,245	60,321
	Automotive				
P(Leave)	-0.0147***				
	(0.00)				
R2	0.17				
N	34,868				

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 03 January 2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly frequency). Variables are differenced over 10 minute intervals.

Table 10. Impact of Perceived Probability of "Leave" on EU Equities, (5 Minutes, Full Sample)

	Germany	**France**	**Spain**	**Italy**	**Portugal**
P(Leave)	-0.0004	-0.0001	-0.0004	-0.0017	-0.0017
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.09	0.09	0.09	0.12	0.08
N	60,318	60,973	60,318	60,972	60,973
	Ireland	**Netherlands**	**Belgium**	**Denmark**	
P(Leave)	-0.0005	-0.0014	-0.0021	-0.0028*	
	(0.00)	(0.00)	(0.00)	(0.00)	
R2	0.05	0.08	0.09	0.11	
N	60,464	60,973	60,973	55,558	
	Finland	**Sweden**	**Austria**	**Greece**	**Poland**
P(Leave)	-0.0007	-0.0003	-0.0001	-0.0103***	-0.0030*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.10	0.09	0.09	0.11	0.11
N	59,462	58,724	58,190	46,802	57,173
	Czech	**Hungary**	**Romainia**	**Cyprus**	
P(Leave)	-0.0009	0.0013	-0.0015	0.0035*	
	(0.00)	(0.00)	(0.00)	(0.00)	
R2	0.06	0.07	0.19	0.06	
N	40,578	48,867	8,591	43,831	
	Slovenia	**Estonia**	**Latvia**	**Lithuania**	**Bulgaria**
P(Leave)	0.0092	0.0032*	0.0056**	-0.0003	0.0022
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.33	0.08	0.09	0.09	0.10
N	2,046	41,994	41,996	41,992	49,322

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 03 January 2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly). Variables are differenced over 5 minute intervals.

Table 11. Impact of Perceived Probability of "Leave" on EU Equities, (10 Minutes, Full Sample)

	Germany	**France**	**Spain**	**Italy**	**Portugal**
P(Leave)	-0.0015	-0.0013	-0.0015	-0.0046**	-0.0037**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.18	0.17	0.18	0.22	0.15
N	59,769	60,419	59,769	60,416	60,368
	Ireland	**Netherlands**	**Belgium**	**Denmark**	
P(Leave)	-0.0023	-0.0033**	-0.0037**	-0.0065***	
	(0.00)	(0.00)	(0.00)	(0.00)	
R2	0.11	0.16	0.16	0.21	
N	59,864	60,368	60,368	54,978	
	Finland	**Sweden**	**Austria**	**Greece**	**Poland**
P(Leave)	-0.0022*	-0.0040**	-0.0022	-0.0188***	-0.0040**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.19	0.18	0.18	0.19	0.22
N	58,922	58,139	57,616	46,212	56,577
	Czech	**Hungary**	**Romainia**	**Cyprus**	
P(Leave)	-0.0018	0.0040***	0.0077*	0.0014	
	(0.00)	(0.00)	(0.00)	(0.00)	
R2	0.11	0.16	0.34	0.12	
N	40,226	48,472	8,392	43,246	
	Slovenia	**Estonia**	**Latvia**	**Lithuania**	**Bulgaria**
P(Leave)	0.0144	0.0021	0.0090***	-0.0003	0.0022
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.31	0.13	0.15	0.14	0.18
N	2,004	41,409	41,411	41,407	48,747

Robust standard errors in parentheses, $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$. The sample period is from 00:00 03 January 2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly). Variables are differenced over 10 minute intervals.

B. Robustness tables

Table 12. Impact of Perceived Probability of “Leave" on Exchange Rate, half hour FE

	(1)	(2)	(3)	(4)
Dep. Var.	$s_{t,£/€}$	$s_{t,£/\$}$	$s_{t,£/€}$	$s_{t,£/\$}$
P(Leave)	0.005***	0.007***	0.007***	0.009***
	(0.0012)	(0.0017)	(0.0016)	(0.0023)
Sample period start date	03 Jan 16	03 Jan 16	23 Apr 16	23 Apr 16
R2	0.15	0.15	0.15	0.15
N	175,956	176,733	63,371	63,675

Notes: Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. All regressions include time fixed effects (half hour frequency). Variables are differenced over 5 minute intervals.

Table 13. Impact of Perceived Probability of “Leave" on FSTE Sectors, Half Hour FE

	ALL	**100**	**Real Estate**	**Industrial**	**Utilities**
P(Leave)	-0.0030***	-0.0036***	-0.0014	-0.0027**	-0.0029**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.16	0.15	0.07	0.15	0.12
N	21,629	21,629	21,304	21,607	20,870
	Banks	**Oil& Gas**	**Insurance**	**Tech**	**Construction**
P(Leave)	-0.0012	-0.0083***	-0.0042**	-0.0030*	-0.0019
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.15	0.16	0.11	0.18	0.05
N	21,551	21,529	21,531	18,403	14,970
	Housing	**Media**	**Finance**	**Retail**	**Chem**
P(Leave)	-0.0024*	-0.0049***	-0.0008	-0.0030**	-0.0006
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.14	0.16	0.18	0.12	0.16
N	21,567	21,146	21,593	21,593	17,256
	Telecom	**Travel**	**Food & Bev**	**Health Care**	**Resources**
P(Leave)	-0.0030*	-0.0016	-0.0018*	-0.0026	-0.0032
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.18	0.13	0.10	0.17	0.15
N	18,403	21,573	21,086	21,539	21,565
	Automotive				
P(Leave)	-0.0037				
	(0.00)				
R2	0.17				
N	10,601				

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. Variables are differenced over 5 minute intervals. All regressions include time fixed effects (half hour frequency).

Table 14. Impact of Perceived Probability of “Leave" on EU Equities, Half Hour FE

	Germany	**France**	**Spain**	**Italy**	**Portugal**
P(Leave)	-0.0014	-0.0019	-0.0014	-0.0023	-0.0018
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.17	0.26	0.17	0.28	0.19
N	21,063.00	21,629.00	21,063.00	21,628.00	21,629.00
	Ireland	**Netherlands**	**Belgium**	**Denmark**	
P(Leave)	0.0003	-0.0030*	-0.0030**	-0.0010	
	(0.00)	(0.00)	(0.00)	(0.00)	
R2	0.04	0.19	0.23	0.19	
N	21,126.00	21,629.00	21,629.00	19,120.00	
	Finland	**Sweden**	**Austria**	**Greece**	**Poland**
P(Leave)	-0.0008	-0.0000	-0.0008	-0.0024	-0.0015
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.17	0.17	0.16	0.11	0.17
N	20,623.00	20,120.00	19,853.00	16,090.00	19,839.00
	Czech	**Hungary**	**Romainia**	**Cyprus**	
P(Leave)	-0.0036*	0.0038**	0.0019	0.0039	
	(0.00)	(0.00)	(0.01)	(0.00)	
R2	0.14	0.13	0.32	0.12	
N	14,003.00	16,707.00	2,800.00	15,361.00	
	Slovenia	**Estonia**	**Latvia**	**Lithuania**	**Bulgaria**
P(Leave)	0.0028	0.0030	0.0019	0.0009	0.0047**
	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.47	0.14	0.16	0.18	0.20
N	771.00	14,320.00	13,962.00	14,678.00	16,690.00

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. All regressions include time fixed effects (half hour frequency). Variables are differenced over 5 minute intervals.

Table 15. Impact of Perceived Probability of “Leave" on Exchange Rate, Daily FE

	(1)	(2)	(3)	(4)
Dep. Var.	$s_{t,£/€}$	$s_{t,£/\$}$	$s_{t,£/€}$	$s_{t,£/\$}$
P(Leave)	0.003*	0.004*	0.004**	0.005*
	(0.0014)	(0.0020)	(0.0019)	(0.0027)
Sample period start date	03 Jan 16	03 Jan 16	23 Apr 16	23 Apr 16
R2	0.00	0.00	0.01	0.01
N	175,956	176,733	63,371	63,675

Notes: Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. All regressions include time fixed effects (daily frequency). Variables are differenced over 5 minute intervals.

Table 16. Impact of Perceived Probability of “Leave" on FSTE Sectors, Daily FE

	ALL	**100**	**Real Estate**	**Industrial**	**Utilities**
P(Leave)	-0.0040***	-0.0047***	-0.0022*	-0.0031**	-0.0044***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0	0	0	0	0.01
N	21,629	21,629	21,304	21,607	20,870
	Banks	**Oil& Gas**	**Insurance**	**Tech**	**Construction**
P(Leave)	-0.0037	-0.0088***	-0.0051***	-0.0052***	-0.0037*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0	0.01	0	0.01	0
N	21,551	21,529	21,531	18,403	14,970
	Housing	**Media**	**Finance**	**Retail**	**Chem**
P(Leave)	-0.0041***	-0.0050***	-0.0020**	-0.0031**	-0.0004
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0	0	0.01	0	0.01
N	21,567	21,146	21,593	21,593	17,256
	Telecom	**Travel**	**Food & Bev**	**Health Care**	**Resources**
P(Leave)	-0.0052***	-0.0029**	-0.0027**	-0.0029*	-0.0057
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.01	0	0.01	0.02	0.01
N	18,403	21,573	21,086	21,539	21,565
	Automotive				
P(Leave)	-0.0052				
	(0.00)				
R2	0.01				
N	10,601				

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016.Variables are differenced over 5 minute intervals. All regressions include time fixed effects (daily frequency).

Table 17. Impact of Perceived Probability of “Leave" on EU Equities, Daily FE

	Germany	**France**	**Spain**	**Italy**	**Portugal**
P(Leave)	-0.0035*	-0.0033**	-0.0035*	-0.0043*	-0.0037**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Time FE (hour)	Yes	Yes	Yes	Yes	Yes
R2	0.01	0.01	0.01	0.02	0.01
N	21,063	21,629	21,063	21,628	21,629.00
	Ireland	**Netherlands**	**Belgium**	**Denmark**	
P(Leave)	-0.0019	-0.0041***	-0.0040***	-0.0012	
	(0.00)	(0.00)	(0.00)	(0.00)	
Time FE (hour)	Yes	Yes	Yes	Yes	
R2	0	0.01	0.01	0.01	
N	21,126	21,629	21,629	19,120.00	
	Finland	**Sweden**	**Austria**	**Greece**	**Poland**
P(Leave)	-0.0013	-0.0010	-0.0029	-0.0006	-0.0015
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Time FE (hour)	Yes	Yes	Yes	Yes	Yes
R2	0.01	0.01	0.01	0.01	0.02
N	20,623	20,120	19,853	16,090	19,839.00
	Czech	**Hungary**	**Romainia**	**Cyprus**	
P(Leave)	-0.0047**	0.0035*	0.0001	0.0045	
	(0.00)	(0.00)	(0.01)	(0.00)	
Time FE (hour)	Yes	Yes	Yes	Yes	
R2	0.01	0.01	0.07	0.01	
N	14,003	16,707	2,800	15,361.00	
	Slovenia	**Estonia**	**Latvia**	**Lithuania**	**Bulgaria**
P(Leave)	-0.0172	0.0035	0.0026	0.0008	0.0072***
	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)
Time FE (hour)	Yes				
R2	0.06	0.01	0.01	0.01	0.01
N	771	14,320	13,962	14,678	16,690.00

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. Variables are differenced over 5 minute intervals.

Table 18. Impact of Percevied Probability of “Leave" on Exchange Rates, Restricted Sample

Dep. Var.	Baseline $s_{t,£/€}$ (1)	Restricted Sample $s_{t,£/€}$ (2)	Baseline $s_{t,£/\$}$ (3)	Restricted Sample $s_{t,£/\$}$ (4)
P(Leave)	0.006***	0.017***	0.008***	0.019**
	(0.002)	(0.005)	(0.002)	(0.007)
R2	0.08	0.14	0.09	0.16
N	63,371	563.00	63,675.00	564.00

Robust standard errors in parentheses, $^{*}p < 0.1,^{**}p < 0.05,^{***}p < 0.01$. Sample period start data is 23 April 2016. All regressions include time fixed effects (hourly frequency).

Table 19. Estimated Impact of Perceived Probability of Leave on FSTE, by Sector, Restricted Sample

	ALL	**100**	**Real Estate**	**Industrial**	**Utilities**
P(Leave)	-0.0014	0.0027	-0.0233	-0.0043	-0.0167
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)
R2	0.80	0.80	0.88	0.81	0.64
N	90	90	90	90	85
	Banks	**Oil& Gas**	**Insurance**	**Tech**	**Construction**
P(Leave)	-0.0045	0.0253	0.0108	-0.0197	-0.0540*
	(0.05)	(0.03)	(0.03)	(0.02)	(0.03)
R2	0.78	0.52	0.97	0.55	0.98
N	89	90	89	74	70
	Housing	**Media**	**Finance**	**Retail**	**Chem**
P(Leave)	-0.0016	-0.0001	-0.0138	-0.0625*	0.0182
	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)
R2	0.75	0.90	0.73	0.78	0.86
N	90	89	90	90	74
	Telecom	**Travel**	**Food & Bev**	**Health Care**	**Resources**
P(Leave)	-0.0197	0.0151	0.0032	-0.0098	0.0671
	(0.02)	(0.02)	(0.02)	(0.02)	(0.05)
R2	0.55	0.93	0.70	0.88	0.84
N	74	90	86	90	89
	Automotive				
P(Leave)	-0.1439				
	(0.08)				
R2	0.85				
N	40				

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 23apr2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly frequency).

Table 20. Impact of Perceived Probability of “Leave" on EU Equities, Restricted Sample

	Germany	**France**	**Spain**	**Italy**	**Portugal**
P(Leave)	-0.0208	0.0233	-0.0208	0.0292	0.0353
	(0.03)	(0.04)	(0.03)	(0.04)	(0.02)
R2	0.89	0.07	0.89	0.71	0.06
N	88	89	88	89	89

	Ireland	**Netherlands**	**Belgium**	**Denmark**
P(Leave)	-0.0052	-0.0116	-0.0049	-0.0075
	(0.02)	(0.03)	(0.02)	(0.03)
R2	0.06	0.06	0.07	0.38
N	84	89	89	89

	Finland	**Sweden**	**Austria**	**Greece**	**Poland**
P(Leave)	0.0164	0.0033	0.0094	0.0078	0.0245
	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
R2	0.54	0.67	0.87	0.85	0.49
N	73	68	85	83	88

	Czech	**Hungary**	**Romainia**	**Cyprus**
P(Leave)	0.0073	0.0022	.	0.0201
	(0.02)	(0.02)	.	(0.03)
R2	0.24	0.14	0.55	0.36
N	70	75	19	78

	Slovenia	**Estonia**	**Latvia**	**Lithuania**	**Bulgaria**
P(Leave)	0.1073***	-0.0203	-0.0590	0.0107	-0.0124
	(0.00)	(0.01)	(0.06)	(0.01)	(0.02)
R2	0.83	0.86	0.67	0.74	0.79
N	6	54	54	58	83

Robust standard errors in parentheses, $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly frequency).

Table 21. Impact of Percevied Probability of “Leave" on Exchange Rates, Asymmetries

Dep. Var.	Baseline $s_{t,£/€}$	$\Delta P(L)>0$ $s_{t,£/€}$	$\Delta P(L)<0$ $s_{t,£/€}$	Baseline $s_{t,£/\$}$	$\Delta P(L)>0$ $s_{t,£/\$}$	$\Delta P(L)<0$ $s_{t,£/\$}$
	(1)	(2)	(3)	(4)	(5)	(6)
P(Leave)	0.006***	0.016**	0.002	0.008***	0.023**	0.003
	(0.002)	(0.005)	(0.004)	(0.002)	(0.007)	(0.005)
Constant	-0.000	-0.009***	0.000	-0.000	-0.012***	0.000
	(0.000)	(0.003)	(0.002)	(0.000)	(0.004)	(0.002)
R2	0.08	0.15	0.16	0.09	0.17	0.15
N	63,371	13,457	13,516	63,675	13,465	13,517

Robust standard errors in parentheses, $^{*}p<0.1$,$^{**}p<0.05$,$^{***}p<0.01$. P(L) is shorthand for P(Leave). Sample period state date is 23 April 2016. All regressions include time fixed effects (hourly frequency).

Table 22. Impact of Perceived Probability of "Leave" on FSTE Sectors, P(Leave)<0

	ALL	**100**	**Real Estate**	**Industrial**	**Utilities**
P(Leave)	-0.0093***	-0.0105***	-0.0076***	-0.0085**	-0.0086**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.33	0.33	0.33	0.31	0.31
N	5,392	5,392	5,321	5,385	5,214
	Banks	**Oil& Gas**	**Insurance**	**Tech**	**Construction**
P(Leave)	-0.0154***	-0.0121**	-0.0160***	-0.0083**	-0.0054
	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)
R2	0.31	0.29	0.33	0.30	0.26
N	5,374	5,367	5,365	4,636	3,790
	Housing	**Media**	**Finance**	**Retail**	**Chem**
P(Leave)	-0.0070**	-0.0138***	-0.0061***	-0.0068*	-0.0002
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.29	0.30	0.38	0.29	0.31
N	5,371	5,279	5,381	5,381	4,291
	Telecom	**Travel**	**Food & Bev**	**Health Care**	**Resources**
P(Leave)	-0.0083**	-0.0110***	-0.0064**	-0.0086**	0.0006
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
R2	0.30	0.30	0.29	0.35	0.31
N	4,636	5,378	5,262	5,369	5,371
	Automotive				
P(Leave)	-0.0107				
	(0.01)				
R2	0.30				
N	2,609				

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 23apr2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly frequency).

Table 23. Impact of Perceived Probability of "Leave" on FSTE Sectors, P(Leave)>0

	ALL	**100**	**Real Estate**	**Industrial**	**Utilities**
P(Leave)	-0.0061**	-0.0064**	-0.0100***	-0.0066**	0.0006
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.30	0.31	0.31	0.27	0.32
N	5,261	5,261	5,189	5,257	5,095
	Banks	**Oil& Gas**	**Insurance**	**Tech**	**Construction**
P(Leave)	-0.0019	-0.0149***	-0.0049	0.0002	-0.0118***
	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
R2	0.28	0.30	0.29	0.27	0.28
N	5,242	5,237	5,235	4,460	3,676
	Housing	**Media**	**Finance**	**Retail**	**Chem**
P(Leave)	-0.0084***	-0.0039	-0.0036*	-0.0064**	-0.0048
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.32	0.29	0.32	0.27	0.24
N	5,249	5,153	5,253	5,258	4,212
	Telecom	**Travel**	**Food & Bev**	**Health Care**	**Resources**
P(Leave)	0.0002	-0.0042	-0.0030	-0.0019	-0.0115
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
R2	0.27	0.30	0.31	0.34	0.30
N	4,460	5,251	5,132	5,244	5,251
	Automotive				
P(Leave)	-0.0190*				
	(0.01)				
R2	0.27				
N	2,479				

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 23apr2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly frequency).

Table 24. Impact of Perceived Probability of "Leave" on EU Equities, P(leave)<0

	Germany	**France**	**Spain**	**Italy**	**Portugal**
P(Leave)	-0.0031	-0.0041	-0.0031	-0.0041	-0.0005
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
R2	0.19	0.20	0.19	0.20	0.20
N	5,311	5,448	5,311	5,448	5,448
	Ireland	**Netherlands**	**Belgium**	**Denmark**	
P(Leave)	-0.0010	-0.0019	-0.0071	-0.0011	
	(0.01)	(0.00)	(0.00)	(0.00)	
R2	0.24	0.20	0.19	0.21	
N	5,282	5,448	5,448	4,957	
	Finland	**Sweden**	**Austria**	**Greece**	**Poland**
P(Leave)	-0.0030	-0.0058	-0.0093**	-0.0025	0.0128**
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
R2	0.18	0.21	0.20	0.31	0.21
N	5,403	5,237	5,071	4,076	4,997
	Czech	**Hungary**	**Romainia**	**Cyprus**	
P(Leave)	-0.0198***	0.0124**	0.0094	0.0013	
	(0.01)	(0.01)	(0.02)	(0.01)	
R2	0.20	0.22	0.35	0.21	
N	3,577	4,158	695	3,872	
	Slovenia	**Estonia**	**Latvia**	**Lithuania**	**Bulgaria**
P(Leave)	-0.0525	-0.0087	0.0079	0.0026	0.0164***
	(0.06)	(0.01)	(0.01)	(0.00)	(0.00)
R2	0.49	0.16	0.15	0.22	0.20
N	212	3,668	3,605	3,815	4,362

Robust standard errors in parentheses, $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly frequency).

Table 25. Impact of Perceived Probability of "Leave" on EU Equities, P(leave) >0

	Germany	**France**	**Spain**	**Italy**	**Portugal**
P(Leave) e	-0.0039	0.0019	-0.0039	0.0050	-0.0012
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
R2	0.22	0.21	0.22	0.19	0.19
N	5,188	5,307	5,188	5,307	5,307
	Ireland	**Netherlands**	**Belgium**	**Denmark**	
P(Leave)	0.0036	0.0018	0.0029	-0.0012	
	(0.01)	(0.00)	(0.00)	(0.01)	
R2	0.18	0.20	0.21	0.21	
N	5,148	5,307	5,307	4,857	
	Finland	**Sweden**	**Austria**	**Greece**	**Poland**
P(Leave)	0.0068*	0.0045	0.0036	-0.0011	0.0029
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
R2	0.18	0.19	0.16	0.23	0.16
N	5,258	5,099	4,919	3,933	4,874
	Czech	**Hungary**	**Romainia**	**Cyprus**	
P(Leave)	0.0007	-0.0058	-0.0167	0.0143*	
	(0.01)	(0.01)	(0.02)	(0.01)	
R2	0.19	0.18	0.32	0.18	
N	3,435	4,106	735	3,727	
	Slovenia	**Estonia**	**Latvia**	**Lithuania**	**Bulgaria**
P(Leave)	0.0036	0.0029	0.0052	0.0018	0.0068
	(0.07)	(0.01)	(0.01)	(0.00)	(0.01)
R2	0.73	0.18	0.13	0.22	0.24
N	202	3,515	3,452	3,652	4,225

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. All regressions include time fixed effects (hourly frequency).

Table 26. Effects beyond Immediate Impact of Perceived Probability of “Leave" on GBP/€

	(1)	(2)	(3)	(4)	(5)
Differencing horizon:	10 min	15 min	30 min	60 min	1440 min
P(Leave)	0.009***	0.008***	-0.003	-0.015***	0.002
	(0.0022)	(0.0026)	(0.0027)	(0.0038)	(0.0024)
Time FE (hour)	Yes	Yes	Yes	Yes	Yes
R2	0.16	0.22	0.41	0.64	0.99
N	63,326	63,281	63,146	62,876	50,457

Notes: Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$. Variables are differenced over 10 minute intervals.

Table 27. Effects beyond Immediate Impact of Perceived Probability of “Leave" on FTSE 100

	(1)	(2)	(3)	(4)	(5)
Differencing horizon:	10 min	15 min	30 min	60 min	1440 min
P(Leave)	-0.008***	-0.011***	-0.013***	-0.011***	-0.011***
	(0.0015)	(0.0017)	(0.0021)	(0.0025)	(0.0026)
Time FE (hour)	Yes	Yes	Yes	Yes	Yes
R2	0.09	0.17	0.34	0.61	0.97
N	21,432	21,217	20,574	19,284	17,313

Robust standard errors in parentheses, $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$.

Table 28. Impact of Perceived Probability of "Leave" on FTSE Index, Controlling for Trade Exposure

Dependent Var:	$\Delta ln(Equity_{it})$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta P(Leave_t) \cdot EX_i^{Industry}$	-0.010*	-0.010*	-0.009***	-0.012*	-0.012*	-0.011***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
$\Delta P(Leave_t)$	-0.005*	-0.005*	.	-0.007**	-0.007**	.
	(0.00)	(0.00)	.	(0.00)	(0.00)	.
$EX_{it}^{Industry}$	0.001	.	.	0.002	.	.
	(0.00)	.	.	(0.01)	.	.
Standard Errors	DK	DK	Robust	DK	DK	Robust
Fixed effects	No	Industry	Time, Industry	No	Industry	Time Industry
Differencing (minutes)	5	5	5	10	10	10
N	966,344	966,344	966,313	965,819	965,819	965,788

Standard errors in parentheses, $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. DK is Driscoll-Kraay standard errors. Exports are defined as total exports in sector i as a share of total global exports from the U.K. in 2016.

Table 29. Impact of Perceived Probability of "Leave" on EU Equities, Controlling for Trade Exposure

Dependent Var:	$\Delta ln(Equity_{jt})$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta P(Leave_t) \cdot EX_j^{Country}$	-0.022**	-0.022**	-0.010***	-0.044**	-0.044**	-0.013***
	(0.01)	(0.01)	(0.00)	(0.02)	(0.02)	(0.00)
$\Delta P(Leave_t)$	-0.002*	-0.002*	.	-0.003**	-0.003**	.
	(0.00)	(0.00)	.	(0.00)	(0.00)	.
$EX_j^{Country}$	-0.001	.	.	-0.005	.	.
	(0.01)	.	.	(0.01)	.	.
Standard Errors	DK	DK	Robust	DK	DK	Robust
Fixed effects	No	Country	Time, Country	No	Country	Time Country
Differencing (minutes)	5	5	5	10	10	10
N	1,148,266	1,148,266	1,148,266	1,142,427	1,142,427	1,142,427

Standard errors in parentheses, $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$. The sample period is from 00:00 23 April 2016 until 16:29 24 June 2016. DK is Driscoll-Kraay standard errors. Exports are defined as total exports to country j as a share of total global exports from the U.K. in 2016.

C. Data description

Brexit Probability Data:
Description: Tick-level data, meaning each data point represents a trade. The implied probability that the referendum would result in a "Leave" vote is derived from the price of a trade in the Referendum Market. The betting odds associated with each trade are presented as decimals, which we convert into a probability.
Source: Betfair

Poll Results and Brexit Referendum District Level Results: Results of 88 polls about the public's stance on the Brexit referendum, conducted by eleven companies and released from January until June.
Description:
Source: Twitter

Currencies:
Description: USD/Euro and GBP/Euro exchange rates.
Source: Bloomberg LLP

FTSE 100 Index:
Description: A share index of the 100 companies listed on the London Stock Exchange with the highest market capitalization.
Source: Bloomberg LLP

FTSEAll-Share Index:
Description: A capitalization-weighted index, that comprises of about 600 of more than 2,000 companies listed on the London Stock Exchange. It is aggregation of the FTSE 100, FTSE 250, and FTSE Small Cap Indexes, and represents 98-99 percent of UK market capitalization.
Source: Bloomberg LLP

FTSE 350 Supersector Indices:
Description: Real-time industry sector indexes derived from companies in the FTSE 100 and FTSE 250 indexes. Companies are classified according to the Industry Classification Benchmark (ICB) classification taxonomy. It is used to segregate markets into sectors within the macroeconomy.
Source: Bloomberg LLP

European Union Stock Market Indices:
Description: The benchmark stock market indices for 26 of the 27 countries in the EU. Malta's stock exchange is calculated on a daily basis, and therefore was not at a high enough frequency for our analysis.
Source: Bloomberg LLP

Bilateral trade data at sectoral level
Description: EU trade data are taken from the OECD's Trade in Value Added (TiVA) database which provides bilateral sectoral-level trade data at an annual frequency.

Source: OECD's Trade in Value Added (TiVA) database

Table 30. FTSE 350 Supersector Indices

Variable Name	Ticker	Description
Real Estate	F3REAE	Real Estate Investment and Services, Real Estate Investment Trusts
Industrial Goods and Services	F3IGSS	Aerospace and Defense, General Industrials, Electronic and Electrical Equipment, Industrial Engineering, Industrial Transportation, Support Services
Utilities	F3UTLOS	Electricity, Gas, Water and Multiutilities
Health Care	F3HLTHS	Health Care Equipment and Services, Pharmaceuticals and Biotechnology
Basic Resources	F3BASRS	Industrial Metals and Mining, Mining
Banks	F3BANKS	Banks
Oil and Gas	F3OILGS	Oil and Gas Producers, Oil Equipment, Services and Distribution, Alternative Energy
Insurance	F3INSUS	Nonlife Insurance, Life Insurance
Technology	F3TECHS	Software and Computer Services, Technology Hardware and Equipment
Construction and Materials	F3CNMATS	Construction and Materials
Telecommunications	F3TELES	Fixed Line Telecommunications, Mobile Telecommunications
Travel and Leisure	F3TRLES	Travel and Leisure
Food and Beverage	F3FDBVS	Beverages, Food Producers
Personal and Household Goods	F3PHSGS	Household Goods and Home Construction, Leisure Goods, Personal Goods, Tobacco
Media	F3MEDAS	Media
Financial Services	F3FINS	Financial Services (assset management, consumer finance, investment and mortgage services)
Retail	F3RETLS	Food and Drug Retailers, General Retailers
Chemicals	F3CHEMS	Chemicals, Forestry and Paper
Automobiles and Parts	F3AUTOS	Automobiles and Parts

Source: Bloomberg LLP and FTSE Russell

Table 31. Euro Area Stock Market Indices

Variable Name	Ticker	Name
Germany	DAX	DAX
France	CAC	CAC 40
Spain	IBEX	IBEX35
Italy	FTSEMIB	FTSE MIB
Portugal	PSI20	PSI General
Ireland	ISEQ	ISEQ Overall
Netherlands	AEX	AEX
Belgium	BEL 20	BEL 20
Luxembourg	LUXXX	LuXX
Denmark	KFX	OMX Copen 20
Finland	HEX	OMX Helsinski
Sweden	OMX	OMX Stock 30
Austria	ATX	ATX Austria Trd
Greece	ASE	ASE Athens SE
Poland	WIG20	MSE WIG
Czech	PX	Prague SE
Hungary	BUX	Budapest SE
Romania	BET	Bucharest BET
Slovakia	SKSM	Slovak Share
Croatia	CRO	Zagreb CROBEX
Slovenia	SBITOP	Slovenia Blue C
Estonia	TALSE	OMX Tallinn
Latvia	RIGSE	OMX Riga
Lithuania	VILSE	OMX Vilnius
Bulgaria	SOFIX	BSE Sofix
Cyprus	CYMMAPA	CSE Cyprus
Malta	MALTEX	Malta SE

Source: Bloomberg LLP and FTSE Russell

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