Brexit Premium in Corporate Bonds: Evidence from British "Yankee" Bonds

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Abstract

We study the impact of Brexit on corporate bond markets. The yield spread difference between British Yankee bonds and US corporate bonds increases dramatically when the EU-UK concluded their membership negotiation in February 2016. Our difference-in-difference analysis shows that Brexit uncertainty increases the bond yield spreads by 32%. The effect is long lasting and present in the bond market one year after the referendum. We find that Brexit primarily unfolds itself as credit risk instead of liquidity risk in the bond market, and affects bond yields predominantly through issuers' equity volatility. In addition, the term structure of bonds indicates that the medium-long-term adverse impact of Brexit on the economy is the most pronounced. Our results highlight the finance channels through which the political uncertainty affects the economy and suggest proper policies to bolster the credit markets.

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Recent years have witnessed increasing political uncertainty on issues of global financial markets, international trade and immigration. Staggering events including the withdrawal of United Kingdom from the European Union (Brexit), the election of Donald J Trump as the president of the United States and the subsequent trade disputes between US and the major trading partners, have been dubbed as landmarks of the emerging deglobalization. The measure of lowering mobility of labor, capital and goods and increasing trade friction is in sharp contrast to the extensive effort of mitigating trade barrier in the late 1990s and early 2000s. The iconic events and the underlying trend have profound economic and financial consequences. In this paper, we study the impact of Brexit on British corporate bonds, shedding light on the financial implications of rising deglobalization.

To identify the impact, we exploit the variation of yield spreads for bonds issued by firms domiciled in the United States and in the United Kingdom in the US corporate bond market, i.e., US corporate bonds and the British “Yankee” bonds, before and after the Brexit referendum. The identification strategy offers many advantages. First, while Brexit significantly affects firms in the UK and on the Continent Europe, the effect on the US companies is plausibly minimal. Hence, the US companies serve as reasonable control groups to highlight the impact of Brexit on British firms’ debt financing. Second, as our focus are bonds denominated in the US dollars that are traded in the US market, the policy interventions from Bank of England and the fluctuation in the foreign exchange market do not directly influence the bond pricings and therefore our results provide clear and large context in which Brexit affects the corporate financing of British firms. Finally, the US bond market is more transparent to the European counterpart. The availability of data such as TRACE enables us to study both cross-sectional and time-series impacts of Brexit on firms.

Despite Brexit referendum's "leave" outcome is frequently portrayed as a black swan in 2016, opinion polls of voters before the referendum in general tended to show roughly equal proportions in favor of remaining and leaving. It is highly probable that the Brexit effect shows up in the bond market long before the referendum date. In fact, there are other candidate dates on which the bond markets might start to react the potential uncertainty brought by the referendum. For example, David Cameron won the 2015 general election in May, 2015 who promised to renegotiate the terms of the UK's EU membership and to hold a referendum should a conservative majority government was elected. Hence, it is imperative to pin down the timing of the uncertainty shock to account for the impact of Brexit uncertainty accurately. Our analysis shows that the Brexit uncertainty started to rattle the corporate bond markets long before the referendum. The bond yield spreads between US and UK firms sharply diverge starting from February 2016, the same time during which the UK and EU concluded their renegotiations and the British Government announced that the referendum would be held on June 23rd, 2016, indicating the bond markets begin to price in the Brexit uncertainty.

We subsequently employ an empirical approach to quantify the impact of Brexit uncertainty on the bond yield spreads. Our base difference-in-difference estimates show that the yield spreads for British bonds increased by 22 basis points (bps) after the Brexit announcement in February 2016, approximately 32% increase in the pre-announcement standard deviation units. We further break down the average effect by measuring quarter-specific effects. The results show that the impact of Brexit on corporate bond markets reached its peak in the 2nd quarter during which the referendum took place and delivered stunning rejection to EU, increasing the yield spreads of British bonds by almost 50 bps. In addition to the significant

contemporaneous impact on the bond, the effect of Brexit uncertainty on bond markets lingers on and is present at least one year after the referendum, implying a long-lasting Brexit premium on British bonds in the US market.

The increase of yield spreads can arise from either worsened credit conditions or deterioration in bond liquidity. We study how Brexit affects the bonds' credit risk and/or liquidity conditions to understand how bond investors perceive the uncertainty associated with Brexit. We collect CDS spreads of the bonds and calculate the Amihud (2002)'s bond illiquidity measure to gauge the credit risk and liquidity condition, respectively. We find that the yield spread increase is mostly driven by credit risk rather than illiquidity. Our test shows that the CDS spreads significantly increase upon Brexit announcement. In particular, the magnitude of CDS spread increase is around 20 bps, similar to our estimates from bond markets. On the other hand, the liquidity of British bonds does not change substantially upon Brexit announcement.

Having established that credit risk mostly drives the widened yield spreads, we further examine which determinants of the credit risk play critical roles affecting the yield spreads. Motivated by Merton (1974), we primarily consider three variables: bond issuer's leverage, equity volatility and risk-free rate. We find that equity volatility is the key determinant driving the yields of British bonds to increase. One percentage point increase in issuers' equity volatility approximately leads to 19 bps increase in bond yield spreads. Similar to bond yield spreads, the equity volatility of British issuers starts to increase upon Brexit announcement and spikes around the referendum day. In contrast, the bond issuer's leverage and risk-free rate have little influence over the yield spreads. The result is robust to different measures of issuer's leverage and possible nonlinear effect of risk-free rate.

Most bonds have finite maturities and the term structure of the yields carry valuable expectations of the bond markets. We strive to shed light on the term structure of Brexit's effect. Most economists and policy makers including those who support Brexit, agree that Brexit will take a toll on the British economy. They disagree, however, on how soon the adverse effect wanes and the uncertainty resolves. We categorize sample bonds into short-term and long-term groups and estimate the Brexit's impact within each group. We find that although Brexit uncertainty increases yield spreads of British bonds along the maturity spectrum, the effect is not homogenous. The effect is strong for short-medium term bonds with time to maturity less than 8 years, suggesting that the bond markets anticipate that the medium-long-term adverse impact of Brexit on the economy is the most pronounced.

Our empirical results are robust to different model specifications. We account for other confounding variables that might affect the bond yield spreads, including credit ratings, time to maturities and transaction amount, in addition to bond-issue fixed effect and month fixed effect. For most of our analysis, we also introduce non-parametric propensity score matching estimations and all our results continue to hold, if not stronger.

Throughout our analysis, our focus is secondary market bond transactions and associated bond yield spreads. The multitude of data enables us to control for bond-level and monthly fixed effects and clearly identify Brexit's impact. Nevertheless, we also study the primary market and offering yields of the bonds, which is directly linked to debt financing cost of the firms. Despite less frequent new bond issuance by British firms and the consequent smaller sample, the results are largely consistent with our findings from the secondary market. Brexit premium is also present in the offering

yields of British “Yankee” bonds. In addition, both equity volatility and the issuer’s market leverage contribute to the increased offering yield spreads in the primary market upon Brexit announcement.

Our paper builds on the literature of uncertainty and corporate investment and financing. Bloom (2009) and Bloom et al. (2007) study the real effects of macroeconomic uncertainty. Julio and Yook (2012), Gulen and Ion (2016) and Bonaime et al. (2016) show the impacts of firm-level uncertainty on their investments. In particular, Bloom et al. (2019) use survey data of decision makers in UK firms and specifically quantify the negative impact of Brexit-related uncertainty on investment and productivity. Uncertainty can affect corporate investment through many channels. We show that uncertainty raises firm-level debt financing cost and hence potentially hinders real investment by firms, suggesting the real effects of debt financing. Our study also highlights that Brexit mostly affects the credit risk of corporate bonds through equity volatility, offering a deeper understanding of how Brexit risk unwind itself in the bond markets. Different from the findings of Bloom et al. (2019) and Hassan et al. (2019) based on survey data and textual analysis, our market based analysis indicates that the Brexit’s adverse impacts and uncertainty is expected to be medium-long term.

The remainder of the paper proceeds as follows. Section 2 describes our data sources and sample construction. Section 3 discusses the timing of Brexit uncertainty shock and presents results from our baseline difference-in-difference regression results. Section 4 studies the term structure of Brexit’s effect. Section 5 measures quarter-specific impact of Brexit uncertainty. Section 6 discusses whether credit or liquidity

conditions give rise to the increased yield spreads. Section 7 investigates primary markets and bond offering yields, and Section 8 concludes.

2. Data and Sample

Our main dependent variable is bond yield spreads, measured as the difference between bond yields and treasury yields with matching time to maturities. The data on secondary bond market transactions and yields are from TRACE, created by the Financial Regulatory Authority (FINRA). We use a sample of corporate bonds which have some trade reports in TRACE during the period January 1, 2015 to Dec 31, 2017. Following Dick-Nielsen (2014), we exclude trades that are cancelled or corrected and remove reversal trades. For each bond, we choose the market yield and trading quantity taking place on the last active trading day in a given month. To determine the yield spreads, we choose the daily constant maturity treasury rates from Federal Reserve Board for maturities 0.25, 1, 2, 3, 5, 7, 10, 20 and 30 years, and use linear interpolation to obtain the entire yield curve. The yield spreads are calculated as the difference between the bond yield and the treasury yield at the same maturity on the same trading day.

We merge the TRACE data with the data from Mergent Fixed Income Security Database (FISD) by CUSIP identifier to obtain bond characteristics, including offering date, maturity date, credit ratings and a range of indicators on the type of each bond, such as Yankee bond indicator. We denote bonds as British bonds based on two criteria:

1. The bonds are designated as Yankee Bonds in FISD
2. The issuers' country of domicile is Great Britain.

Similarly, we define the US bonds as non-Yankee bonds whose issuers' country of domicile is US. For both groups, we only include bonds denominated in US dollars. Moreover, we exclude from the sample all bonds that are convertible, puttable, callable, asset-backed. We also exclude equity-like securities including preferred stocks and preferred securities, pass-through securities and US/foreign agency debt. We combine ratings by S&P, Moody's or Fitch into standard notches. As there are no AAA-rated, B-rated and C-rated British Yankee bonds in the sample, we also exclude AAA-rated, B-rated and C-rated US corporate bonds. Consequently, our standard notches include AA, A, BBB and BB.

Our credit default swap (CDS) spreads data are from Markit. We focus on CDS reference entities covered in our corporate bond data. Similar to the bond transactions, for each CDS contract, we choose the spread on the last active trading day in a given month. As the majority of the CDS on British issuers have doc/restructuring clauses of Modified Modified Restructuring, we focus CDS contracts with currency in US dollars and 'doc clause' of MM/MM14.

When studying the determinants of the yield spreads change, we employ firm-level accounting data from Compustat and equity return data from CRSP. The book leverage is defined as the book value of debt over total asset value. The market leverage is calculated as the book value of debt over the total market capitalization. The historical volatility is based on 180 days of stock returns. The summary statistics of our main variables are reported in Table 1.

3. Brexit Timing and Baseline Regressions [Table 2]

To analyze the impact of political uncertainty associated with Brexit on corporate bond yields, we need to account for the timing of Brexit accurately. Although the referendum occurred and the result was announced on June 23rd, 2016, several Brexit-related events predate the official referendum. In fact, the European Union Referendum Act 2015, which legislated for the referendum, received the Royal Assent on Dec 17th, 2015. And then British prime minister David Cameron did not announce the in-out referendum date until after the UK-EU renegotiation on the membership, declaring the referendum to be hold on June 23rd, 2016. Therefore, it is possible that bond investors had priced the uncertainty long before the referendum. If that is the case and we mistakenly take that the Brexit treatment transpired on June 23rd, 2016, we may underestimate the effects of Brexit on corporate bond yields. To determine the time at which the bond markets start to price in the Brexit risk, we turned to the bond yield data.

Figure 1 plots average yield spreads of US and British bonds for each month over our sample period. It clearly shows that British bonds have higher yield spreads than their US counterparts. The yield spread difference between the two countries' bonds is visibly constant over time up to January 2016. The difference, nonetheless, substantially increases in February in which the European Union Referendum Act 2015 came into full legal force and Prime Minister David Cameron announced the referendum. The heightened yield spread difference persisted to the end of our sample period. Based on the evidence, therefore, we choose February 2016 as the time when Brexit treatment occurred. In the subsequent section, we will also demonstrate that yield spread difference between British bonds and US bonds is indeed statistically

constant before Fe bruary 2016, ruling out the possibility that the increased yield spread difference post February 2016 may be driven by a pre-existing trend towards higher yields for British bonds in the US bond markets.

Adopting a difference-in-differences approach, we test the hypothesis that bond investors demand a higher yield for bonds issued by British issuers post the Brexit announcement. The first difference in the difference-in-difference strategy is between bonds issued by US corporations and the "Yankee Bonds" issued by British firms, measured using a dummy variable (country_GBR). The second difference is between the period before the Brexit announcement and the period after the announcement, measured using another dummy variable (Brexit) with Brexit being 1 for each bond transaction post Brexit announcement on Feb 20th, 2016. Specifically, the difference-in-difference strategy is implemented using the following specification:

$$Yield\ Spread_{bt} = \alpha_b^1 + \alpha_t^2 + \beta^y \text{country\_GBR} \times \text{brexit} + \widetilde{\mathbf{X}_{\boldsymbol{bt}}}\tilde{\boldsymbol{\gamma}} + \boldsymbol{\epsilon_{bt}} \quad \textbf{(1)}$$

where $\widetilde{\mathbf{X}_{\boldsymbol{bt}}}$ represents other covariates, α_b^1 indicates bond fixed effects and α_t^2 indicates month fixed effects. The coefficient on the interaction terms allow us to trace the difference-in-difference effect of the Brexit on the cost of debt financing of British firms.

Table 2 shows the results of our regressions and indicate that the effect of Brexit uncertainty on bond yield spreads is substantial and statistically significant. Model 1 shows the basic regression specification. We include bond fixed effects to control for time-invariant bond issue-specific omitted variables, and include month fixed effects

to minimize potential issues related to time-varying common shocks to bond market, including shocks to investor' or dealer' bond demand and liquidity shocks. Model 2, Model 3 and Model 4 control for bond credit ratings, time to maturity (ttm) and bond trade quantity in dollar amount (log(quant)). The results are consistent with the basic regression of Model 1 and are robust to different specifications of fixed effects. With the exception of OLS regression of Model 2 that does not control for bond-issue fixed effects, the estimated coefficients of the interaction term are almost the same. On average, the bond yield spreads increase by 21.6 basis points (bps) after the Brexit announcement, approximately 32% increase in the pre-announcement standard deviation units.

We also construct a propensity score matched (PSM) sample, and carry out our DiD analysis on this PSM sample. We first restrict the potential control bonds, i.e. US bonds, to those in the same rating category as the target British bonds. We then match the British bonds in the consideration to control bonds using the Mahalanobis distance and then find the closest bond in terms of time to maturity and yield spread in the pre-announcement periods. For the matched sample, we estimate the same regressions as those in Models 1 and 4 of Table 2. The results are reported in Model 5 and 6 of Table 2.

Model 5 and Model 6 shows that the coefficient of $\mathrm{country\_GBR} \times \mathrm{brexit}$ is positive and statistically significant at 1% level. Using matched sample increases the coefficient estimate and model explanatory power, but the results are largely consistent with Model 1 and Model 4.

4. The term structure of Brexit's effect [Table 3]

Most of economists and policy makers including those who support Brexit, have reached a consensus that Brexit will take a toll on the British economy. They argue, however, how long the adverse impacts will persist. Furthermore, they disagree over the short-term and long-term impacts of Brexit. In the short term, the UK still enjoys free movement of goods, services, capital and persons provided by the EU single internal market without borders. However, the firms in the UK will possibly halt capital expenditures in the short term until the uncertainty caused by Brexit completely resolves. On the other hand, in the long term, the UK will lose the frictionless access to the European market once it leaves the EU. The UK, nevertheless, can offset the loss with entering new free trade agreement with rest of the world including Commonwealth countries. In addition, once the Brexit uncertainty resolves, firms in the UK might start to increase their investments.

Although providing definitive answers to these questions is hard, since most of corporate bonds have finite maturities, the bond market can shed a light. To this end, based on the time to maturities, we categorize the bonds in our sample into short-term and long-term groups and estimate the same regression as Model 4 of Table 3. We try two different cut-off thresholds for time to maturities: 4 years and 8 years, corresponding to 2nd quartile and 3rd quartile of time to maturities for US and British bonds in our sample. The results are reported in Table 3.

Model 1 and Model 2 show the results for short-term and long-term subsamples when the short term/long term cut-off is 4 years. The coefficients of $\mathrm{country}_{\mathrm{GBR}} \times \mathrm{brxt}_{\mathrm{flag}}$ across two groups are both positive and significant. In addition, the magnitude of the

coefficients are close, indicating the impacts of Brexit uncertainty on the two groups of bonds are similar. However, when the cut-off increases to 8 years in Model 3 and Model 4, the results appear different. For short-term group of bonds, since the Brexit announcement, the yield spreads increase by 28 bps. The result is significant at 1% level. But when it comes to the long-term group of bonds, the coefficient becomes statistically insignificant and much smaller (10 bps), despite being positive.

We also carry out the DiD analysis by groups on the PSM sample. Model 5 and Model 6 show the results when the cut-off is 4 years, while Model 7 and Model 8 exhibit the results when the threshold is 8 years. The DiD analysis based on the matched sample delivers very similar results to those in the full sample tests. When the cut-off is 4 years, the impacts of Brexit announcements are similar across two groups of bonds, with the yield spreads increasing by 21-26 bps. When the cut-off becomes 8 years, the results are still positive and significant across two groups. However, the magnitude of the coefficient of the long-term group is almost half of that of the short-term group.

Overall, the results of Table 3 show that although Brexit uncertainty increases yield spreads of British bonds along the maturity spectrum, the effect is not homogenous. The effect is strong for short-medium term bonds with time to maturity less than 8 years, suggesting the short-medium-term adverse impact of Brexit on the economy is most pronounced from bond investors' perspective.

5. Measuring Month-Specific Treatment Effects [Table 4]

In addition to average effects, we also estimate quarter-specific treatment effects. Although Brexit announcement began to rattle bond markets in February, the

referendum took place in June and delivered “stunning rejection to EU” (Wall Street Journal, 2016). Therefore, we anticipate the effect of Brexit on bond yield spreads will be particularly strong in the 2nd quarter of 2016. In addition, quarter-specific treatment will also reveal whether Brexit has long-term impacts on the yield spreads. Specifically, using the last quarter in 2015 as a benchmark, we repeat the baseline specifications replacing the Brexit dummy variable with quarterly dummy variables,

$$Yield\ Spread_{bt} = \alpha_b^1 + \alpha_t^2 + \sum_{q=2015Q1}^{q=2016Q2} \beta^q \text{country}_{\text{GBR}} \times Quarter_t^q + \theta\ \text{country}_{\text{GBR}} \times \text{Post2016Q2} + \widetilde{\mathbf{X}_{bt}}\tilde{\boldsymbol{\gamma}} + \boldsymbol{\epsilon_{bt}} \quad \textbf{(2)}$$

where $Quarter_t^q$ is a dummy variable that takes the value 1 in quarter q and 0 otherwise. Similarly, Post2016Q2 is a dummy variable that takes the value 1 in the months after 2016Q2 and 0 otherwise. The coefficient estimate of θ measures the long-term change in bond yield spreads due to Brexit.

Estimation of Specification (2) also checks for parallel trends in the period before the Brexit announcement in February. It is a critical test for the validity of our DiD analysis to identify the effect of Brexit on bond yield spreads. We need to show that the yield spreads of US and British “Yankee” bonds during the pre-shock periods are not statistically different.

Table 4 shows the results from estimating specification (2). Both Model 1 and Model 2 use the full sample, and Model 3 uses the PSM sample. The results show that the coefficients of β^q *(*q=$\text{2015Q1, 2015Q2 and 2015Q3}$*)* are not statistically significant, indicating that there is no significant difference between US and British bonds before Brexit announcement and supporting the parallel trend condition of our DiD analysis. Also, consistent with our hypothesis, the result shows that the Brexit effect reached its peak in the 2nd quarter of 2016, increasing the yield spreads of British bonds by almost 50 bps. In addition, although the coefficient estimate of θ for $Post\ 2016Q2$ is smaller compared to first two quarters of 2016, it is still positive and significant .

6. Sources of the yield spread increase [Table 5]

The yield spreads increase could result from worsened credit or illiquidity conditions. Consequently, to understand how bond investors perceive the uncertainty associated with Brexit, it is useful to assess how Brexit affects the bonds' credit risk and liquidity conditions. To measure the credit risk, we use CDS spreads of the bonds. To gauge the liquidity condition of the bonds, we calculate the Amihud (2002) illiquidity measure $ILLIQ$, which is based on the theoretical model of Kyle (1995), to estimate the price impact of trades. Specifically,

$$ILLIQ = \frac{1}{N_t}\sum_{j=1}^{N_t}\frac{\left|\frac{P_j - P_{j-1}}{P_{j-1}}\right|}{Q_j}$$

where N_t is the number of returns on day t, Q_j is the trade size (in million US dollars) of j-th trade and P_j is the quoted price of j-th trade on day t. We use daily bond trading data from TRACE to calculate the *ILLIQ* measure for each bond and take the median of daily measure within the month as the monthly measure.

If heightened yield spreads are driven by worsened credit or liquidity conditions, we anticipate CDS spreads or liquidity measures to increase for British bonds relative to their US counterparts. Therefore, we apply specification (1), but change the dependent variable to CDS spreads and *ILLIQ* measure.

Table 5 presents the results. Model 1 demonstrates that the CDS spreads significantly increase upon Brexit announcement. In particular, the magnitude of CDS spread increase (around 20 bps) is similar to our estimates from bond markets in Table 2. Model 2 controls for bond ratings, time to maturities and trading quantity and the result remains the same. Model 3 and 4 show the results on *ILLIQ*. British bonds appear to

become less liquid upon Brexit announcement, but the results are not statistically significant.

Similar to our analysis of bond yield spreads, we also construct a propensity score matched (PSM) sample, and carry out our DiD analysis on this PSM sample. We first restrict the potential control bonds, i.e. US bonds, to those in the same rating category as the target British bonds. We then match the British bonds in the consideration to control bonds using the Mahalanobis distance and then find the closest bond in terms of time to maturity and CDS spreads/ *ILLIQ* measure in the pre-announcement periods. For the matched sample, we estimate the same regressions as those in Models 2 and 4 of Table 5. The results are reported in Model 5 and 6.

Model 5 shows the effect of Brexit on CDS spreads is more significant, both statistically and economically. With the matched sample, the CDS spreads increase by 40 bps upon Brexit announcement and the result is significant at 1% level. The similar occurs to liquidity result in Model 6. The coefficient estimate increases to 0.086 and is significant at 10% level with a p-value of 0.09. Overall, the results from PSM sample are largely in line with those from full sample, suggesting that wider yield spreads of British “Yankee” bonds are mostly driven by credit risk, rather than illiquidity. Also note that all CDS spreads data occurred after Feb 20th, 2016 in the matched sample and therefore the “brexit” term is absorbed by the month fixed effects.

[Table 6]

Having established that credit risk mostly drives the widened yield spreads of British bonds, we turn to study which determinants of the credit risk play critical roles affecting the yield spreads. Motivated by Merton (1974), we focus three variables: bond issuer’s

leverage, equity volatility and risk-free rate. We use 5-year constant maturity treasury rate to measure risk-free rate. To control for its nonlinearity, we also include the square term of the risk-free rate. Controlling for the determinants of credit risk, we estimate the same regression as in equation (1) and (2).

Table 6 presents the results of the regressions. Model 1 and Model 2 study the effects of leverage on yield spreads. Model 1 uses book leverage to measure leverage, while Model 2 uses market leverage. Neither leverage measure is statistically significant. In fact, the coefficient estimate β^{y} of $\mathrm{country\_GBR} \times \mathrm{brexit}$ term becomes greater relative to Model 4 in Table 2, and remains significant at 1%. The result remains similar when Model 3 further controls risk-free rate and its square term, implying neither the leverage nor treasury yield drives the yield spreads to widen. In contrast, when Model 4 of Table 6 controls for equity volatility, the volatility is significant at 1 % level and noticeably, the magnitude of β^{y} falls by more than half, implying the volatility is a key determinant driving the yields of British bonds to increase. Figure 2 plots the average volatility between US and British issuers over time. Indeed, the equity volatility of British issuers starts to increase since Brexit announcement and spikes around the referendum day. The conclusion stays intact when Model 5 adds leverage and risk-free rate as extra control variables.

Although the analysis discerns the effects of different credit risk variables on the yield spreads, it merely shows their average effects but does not address the heterogeneity of the effects over time. The effect of the equity volatility on the yield spreads, for instance, might become stronger or weaker over time. Model 5 and Model 6 attempt to address the issue by introducing quarterly dummies similar to equation (2). Model

5 controls for leverage and risk-free rate. Yet, these newly added controls are statistically insignificant and, relative to Model 2 of Table 4, the coefficients of β^q *(*q=$2016Q1, 2016Q2$ and $Post2016Q2$*)* hardly change. On the contrary, when Model 6 controls for equity volatility in addition, the coefficients of first two quarters of 2016 reduce, albeit still strongly significant, and the coefficient of Post2016Q2 loses its significance. Our results, therefore, suggest that while Brexit has direct impact on bond yields during the short term, it influences yield spreads through stock's volatility in the long term.

7. Primary Market Analysis [Table 7, 8]

Our analysis of the yield spreads on the secondary market controls for bond-level and monthly fixed effects and therefore better identify the impacts of Brexit on debt financing cost for British firms. The multitude of data also enables us to discuss extensively Brexit's heterogeneous impact over the term structure and its underlying drivers. Nonetheless, the secondary market does not directly relate to debt financing cost of the firms. It is helpful to study the primary market and offering yields of the bonds.

Unfortunately, new issuance of debt by British firms is far less frequent. Therefore, we expand our sample period and collect new issuance information during 2010-2019 from FISD, including offering dates, offering yields, maturity date, Yankee indicator and credit ratings at issuance. We exclude from the sample all bonds that are convertible, puttable, callable, asset-backed. We also exclude equity-like securities including preferred stocks and preferred securities, pass-through securities and US/foreign agency debt and restrict our sample to US dollar denominated bonds. In

the end, we are left with 239 issues with credit ratings, among which 68 are issued by British firms. To determine the yield spreads at offerings, we choose the daily constant maturity treasury rates from Federal Reserve Board for maturities 0.25, 1, 2, 3, 5, 7, 10, 20 and 30 years, and use linear interpolation to obtain the entire yield curve. The yield spreads are calculated as the difference between the offering yields and the treasury yield at the same maturity on the offering dates.

Our regression for the offering yields are the same as equation (1) with two distinctions. First, we control for issuer fixed effect instead of bond issue fixed effect. The 239 issues are from 74 issuers and 83% of the bond issues are from issuers that have more than one new issue during the sample period. Second, we control for year fixed effect instead of month fixed effect.

Table 8 presents the results. Model 1 and Model 2 shows that Brexit premium is also present in the offering yields of British “Yankee” bonds. Model 1 only includes Brexit dummy variable and its interaction with country_GBR dummy. Model 2 controls for credit ratings, time to maturity, (log) offering amount and 5-year treasury rate, and the Brexit effect becomes statistically and economically more pronounced.

Model 3 and Model 4 studies the channels through Brexit could affect the yield spreads. Model 3 controls for market leverage while Model 4 controls for both market leverage and equity volatility. Different from our secondary market analysis, both market leverage and equity volatility contribute to the widened yield spreads post Brexit announcement. Both control variables are significant at 5% level and the interaction term between Brexit dummy and country_GBR dummy loses their significance.

Similar to secondary market analysis, we also test for parallel trends and demonstrate that the yield spreads of US and British "Yankee" bonds during the pre-shock periods are not statistically different by estimating specification (2) with year dummies instead of quarterly dummies. Namely, using 2012 as the baseline, our regression specification is as follows

$$Yield\ Spread_{bt} = \alpha_b^1 + \alpha_t^2 + \sum_{y=2010}^{y=2015} \beta^y \text{country\_GBR} \times Year_t^y + \widetilde{\mathbf{X}_{bt}}\tilde{\boldsymbol{\gamma}} + \boldsymbol{\epsilon_{bt}} \quad \textbf{(2)}$$

As a visualization of our results, Figure 3 plots the estimates of the coefficients and their confidence intervals. The blue diamonds indicate the point estimates of the coefficients of β^y (y=2010, 2011, 2013, 2014, 2015) and the blue lines are the 95 percent confidence intervals. Figure 3 shows there is no difference between the yield spreads between US bonds and British "Yankee" bonds before 2006, confirming the key assumption of parallel trends in the periods before Brexit announcement and referendum.

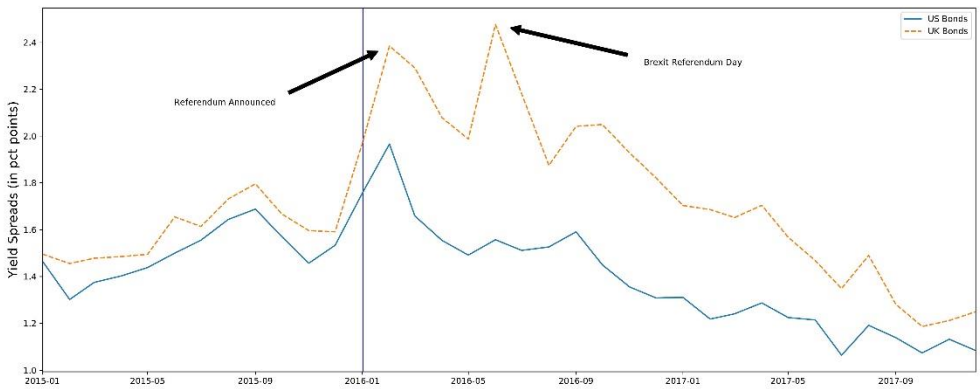
8. Conclusion

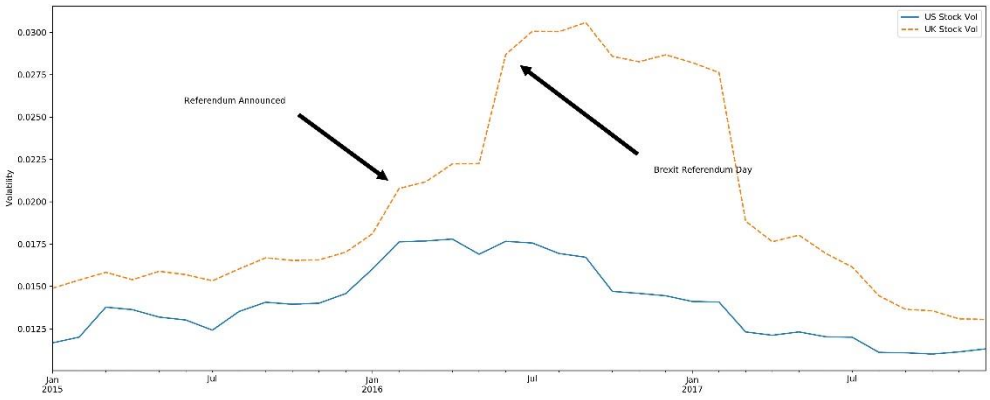
Deglobalization, an emerging social-political trend that impedes the mobility of labor, capital and goods, would have profound economic and financial implications. In this paper, we shed light on this topic by studying the impact of Brexit on corporate bond markets. Our results highlight that Brexit unfolds itself as credit risk in the corporate bond markets and consequently increases the yield spreads of bonds issued by British firms. The impact is long-lasting and manifest in the bond markets one year after the Referendum.

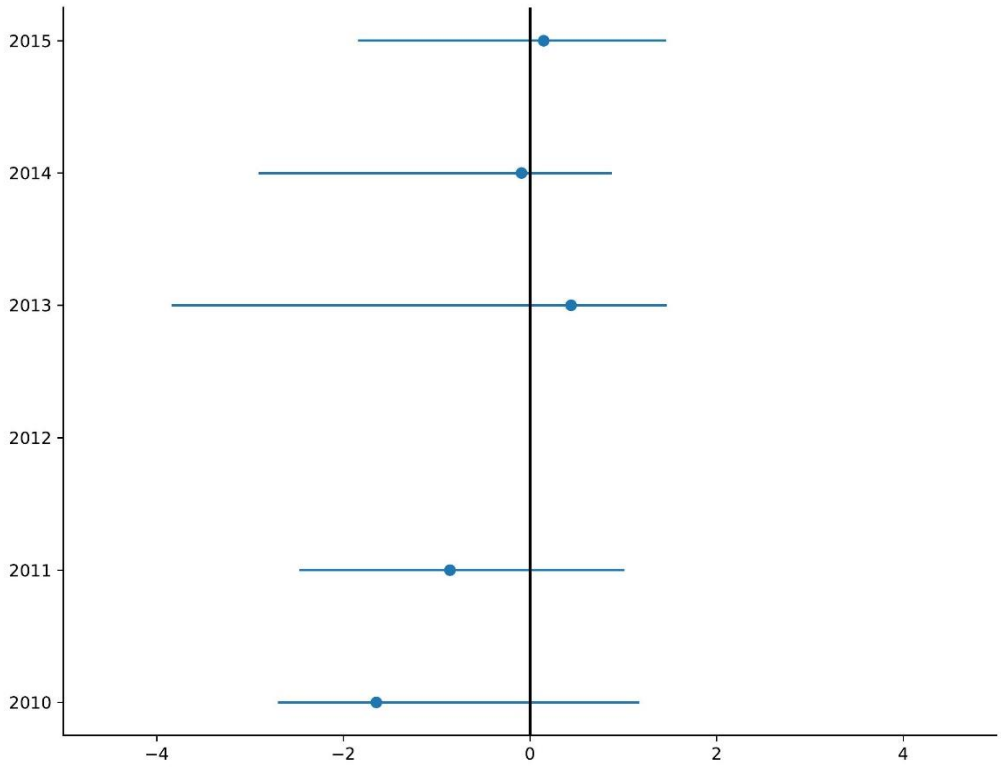
The financial implications of Brexit can have real consequences. The rising cost of borrowing can potentially hinder investment and lower employment. Many studies have documented slow economy growth, sluggish investment and increased

unemployment in the UK caused by Brexit. In addition to serving as a channel through which Brexit affects the real economy, the financial markets could also offer valuable information and guide policy decision-making. Our study of the term structure of the bond markets reveals the expectation of bond investors that the adverse impact of Brexit and associated uncertainty will last for 4 to 8 years. In light of the growing frictions on the mobility of goods, capital and labor, our results suggest that policy makers should gauge the policy impact from the financial markets, while considering measures to properly bolster the credit markets.

Figures


US Bonds
UK Bonds
Referendum Announced
Brexit Referendum Day
Yield Spreads (in pct points)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
2015-01
2015-05
2015-09
2016-01
2016-05
2016-09
2017-01
2017-05
2017-09


US Stock Vol
UK Stock Vol
Referendum Announced
Brexit Referendum Day
Volatility
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
Jan
2015
Jul
Jan
2016
Jul
Jan
2017
Jul


2015
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Tables

Table 1:

Variable	mean	25%	50%	75%	std	Count
yield spreads	1.43%	0.79%	1.29%	1.91%	0.94%	6487
time to maturity	10.06845	2.35205	6.0575	12.863	11.71075	6487
quantity	452382.1	13000	50000	330000	1003768	6487
Equity Volatility	0.014692	0.01124	0.01357	0.016949	0.00515	6042
book leverage	0.334266	0.188923	0.249944	0.436788	0.233415	5444
market leverage	1.283259	0.033987	0.19128	2.487291	1.646482	5421
CDS Spreads	0.009114	0.00425	0.008673	0.012641	0.00583	1150
5-year Treasury	1.566	1.31	1.54	1.83	0.311202	6487

Table 2:

	Dependent variable:					
	Yield Spread (1)	Yield Spread (2)	Yield Spread (3)	Yield Spread (4)	Yield Spread (5)	Yield Spread (6)
brexit×country_GBR	0.209***	0.537***	0.217***	0.216***	0.233***	0.238***
	(0.040)	(0.035)	(0.046)	(0.044)	(0.040)	(0.042)
brexit	-0.338***	-0.120***	0.300***	-0.269**	-0.200	-0.132
	(0.116)	(0.020)	(0.037)	(0.116)	(0.150)	(0.143)
rating_AA		-1.420***	-0.882***	-0.863***		-0.673***
		(0.071)	(0.207)	(0.207)		(0.220)
rating_A		-1.221***	-0.837***	-0.810***		-0.629***
		(0.062)	(0.202)	(0.203)		(0.217)
rating_BBB		-0.636***	-0.819***	-0.733***		-0.639***
		(0.066)	(0.196)	(0.197)		(0.219)
ttm		0.028***	0.343***	2.047**		2.252*
		(0.001)	(0.028)	(0.816)		(1.242)
log(quant)		-0.026***	-0.006**	-0.006**		-0.007**
		(0.005)	(0.003)	(0.003)		(0.003)
Bond Fixed effects	Yes	No	Yes	Yes	Yes	Yes
Month Fixed effects	Yes	No	No	Yes	Yes	Yes
Observations	6,487	6,487	6,487	6,487	4,027	4,027
R^2	0.011	0.330	0.200	0.038	0.019	0.049
Note:						*p<0.1, **p<0.05, ***p<0.01

Table 3:

	Dependent variable:							
	Yield Spread (1)	Yield Spread (2)	Yield Spread (3)	Yield Spread (4)	Yield Spread (5)	Yield Spread (6)	Yield Spread (7)	Yield Spread (8)
brexit×country_GBR	0.205***	0.208***	0.277***	0.101	0.215***	0.263***	0.281***	0.164***
	(0.053)	(0.065)	(0.050)	(0.079)	(0.058)	(0.057)	(0.054)	(0.054)
brexit	-0.350***	-0.244*	-0.235**	-0.265	-0.374***	0.025	-0.186	-0.002
	(0.074)	(0.145)	(0.101)	(0.169)	(0.072)	(0.189)	(0.142)	(0.238)
rating_AA	-0.380***	-0.955***	-0.779***	-1.487***	-0.393***	-0.640***	-0.737***	-0.024
	(0.065)	(0.220)	(0.219)	(0.226)	(0.066)	(0.205)	(0.216)	(0.058)
rating_A	-0.393***	-0.891***	-0.716***	-1.429***	-0.381***	-0.596***	-0.665***	-0.043
	(0.058)	(0.214)	(0.215)	(0.202)	(0.056)	(0.194)	(0.210)	(0.064)
rating_BBB	-0.455***	-0.716***	-0.732***	-1.205***	-0.437***	-0.549***	-0.703***	
	(0.044)	(0.194)	(0.216)	(0.105)	(0.041)	(0.196)	(0.213)	
log(quant)	-0.011**	-0.004	-0.009***	-0.002	-0.010*	-0.004	-0.009**	-0.0001
	(0.004)	(0.004)	(0.004)	(0.005)	(0.006)	(0.004)	(0.004)	(0.005)
Bond Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,871	3,616	3,989	2,498	2,160	1,867	2,984	1,043
R^2	0.017	0.043	0.052	0.036	0.019	0.079	0.057	0.027
Note:								*p<0.1, **p<0.05, ***p<0.01

Table 4:

	Dependent variable:		
	Yield Spread	Yield Spread	Yield Spread
	(1)	(2)	(3)
country_GBR×2015Q1	-0.059	-0.025	-0.069
	(0.046)	(0.042)	(0.046)
country_GBR×2015Q2	0.037	0.051	0.041
	(0.041)	(0.041)	(0.047)
country_GBR×2015Q3	0.016	0.012	0.020
	(0.034)	(0.034)	(0.037)
country_GBR×2016Q1	0.335***	0.344***	0.289***
	(0.078)	(0.079)	(0.082)
country_GBR×2016Q2	0.473***	0.487***	0.468***
	(0.084)	(0.088)	(0.090)
country_GBR×Post2016Q2	0.120**	0.137**	0.162***
	(0.050)	(0.053)	(0.049)
brexit	-0.326***	-0.258**	-0.092
	(0.118)	(0.117)	(0.155)
rating_AA		-0.835***	-0.662***
		(0.216)	(0.233)
rating_A		-0.808***	-0.638***
		(0.212)	(0.229)
rating_BBB		-0.728***	-0.638***
		(0.207)	(0.230)
ttm		2.007**	2.157*
		(0.805)	(1.284)
log(quant)		-0.006**	-0.008**
		(0.003)	(0.003)
Bond Fixed effects	Yes	Yes	Yes
Month Fixed effects	Yes	Yes	Yes
Observations	6,487	6,487	4,156
R^2	0.021	0.048	0.059
Note:			*p<0.1, **p<0.05, ***p<0.01

Table 5:

	Dependent variable:					
	CDS Spread	CDS Spread	ILLIQ	ILLIQ	CDS Spread	ILLIQ
	(1)	(2)	(3)	(4)	(5)	(6)
brexit×country_GBR	0.002**	0.002**	0.036	0.029	0.004***	0.086*
	(0.001)	(0.001)	(0.027)	(0.026)	(0.001)	(0.051)
brexit	0.0001	0.001	0.071	0.142***		-0.025
	(0.001)	(0.001)	(0.052)	(0.055)		(0.071)
rating_AA		-0.002**		-0.034	-0.003***	-0.077
		(0.001)		(0.046)	(0.001)	(0.060)
rating_A		-0.001		-0.011	-0.003***	-0.021
		(0.001)		(0.044)	(0.001)	(0.049)
rating_BBB		0.0004		-0.032	0.001**	0.004
		(0.001)		(0.041)	(0.0005)	(0.046)
ttm		0.016		3.801***	0.007	4.671**
		(0.010)		(1.050)	(0.012)	(1.837)
log(quant)		0.0001		-0.022***	0.0001**	-0.030***
		(0.00004)		(0.004)	(0.0001)	(0.008)
Bond Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,150	1,150	9,167	9,167	691	2,552
R^2	0.015	0.027	0.0002	0.012	0.024	0.036

Note: *p<0.1, **p<0.05, ***p<0.01

Table 6:

	Dependent variable:						
	Yield Spread (1)	Yield Spread (2)	Yield Spread (3)	Yield Spread (4)	Yield Spread (5)	Yield Spread (6)	Yield Spread (7)
brexit×country_GBR	0.278***	0.272***	0.271***	0.113***	0.155***		
	(0.050)	(0.051)	(0.051)	(0.043)	(0.053)		
country_GBR×2016Q1						0.333***	0.285***
						(0.104)	(0.103)
country_GBR×2016Q2						0.488***	0.349**
						(0.147)	(0.139)
country_GBR×Post2016Q2						0.193***	-0.034
						(0.074)	(0.084)
book leverage	-0.487						
	(0.423)						
market leverage		0.036	0.034		0.020	0.041	0.027
		(0.024)	(0.024)		(0.023)	(0.025)	(0.024)
volatility				18.977***	19.018***		24.474***
				(3.466)	(3.367)		(3.459)
5-year treasury rate			-1.687		-1.536	-1.756	-1.545
			(1.127)		(1.138)	(1.119)	(1.123)
5-year treasury rate square			0.435		0.383	0.450	0.377
			(0.336)		(0.336)	(0.334)	(0.333)
rating_AA	-0.689***	-0.718***	-0.722***	-0.596***	-0.606***	-0.704***	-0.550***
	(0.155)	(0.169)	(0.172)	(0.163)	(0.170)	(0.178)	(0.183)
rating_A	-0.647***	-0.674***	-0.679***	-0.560***	-0.579***	-0.661***	-0.528***
	(0.146)	(0.161)	(0.163)	(0.156)	(0.162)	(0.169)	(0.174)
rating_BBB	-0.571***	-0.602***	-0.607***	-0.484***	-0.502***	-0.587***	-0.447***
	(0.134)	(0.150)	(0.153)	(0.147)	(0.151)	(0.159)	(0.165)
ttm	2.173***	2.182***	2.322***	2.425***	2.307***	2.339***	2.319***
	(0.833)	(0.832)	(0.848)	(0.850)	(0.855)	(0.842)	(0.840)
log(quant)	-0.008**	-0.007**	-0.007**	-0.005*	-0.006*	-0.007**	-0.006*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
brexit	-0.290**	-0.289**	-0.280**	-0.235**	-0.240**	-0.253**	-0.228**
	(0.118)	(0.118)	(0.115)	(0.107)	(0.105)	(0.116)	(0.103)
country_GBR×2015Q1						-0.055	-0.131**

						(0.056)	(0.057)
country_GBR×2015Q2						0.093*	0.080
						(0.056)	(0.055)
country_GBR×2015Q3						0.017	-0.035
						(0.055)	(0.054)
Bond Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,444	5,421	5,421	6,042	5,397	5,421	5,397
R^2	0.035	0.035	0.037	0.042	0.050	0.040	0.062
Note:						*p<0.1, **p<0.05, ***p<0.01	

Table 7: Primary Market Summary Statistics

Variable	mean	25%	50%	75%	std	count
yield spreads	1.70%	0.90%	1.37%	2.19%	1.40%	239
time to maturity	8.941701	3.0329	5.0247	10.0274	8.272451	239
quantity	1138351	500000	1000000	1500000	782726.9	239
Equity Volatility	0.01929	0.011967	0.015514	0.020996	0.015639	210
book leverage	0.317269	0.178564	0.278553	0.40895	0.175205	191
market leverage	2.324106	0.039856	0.561748	3.443541	3.19085	189
5-year Treasury Rate	1.487029	1.155	1.51	1.735	0.509331	239

Table 8: Primary Market DiD Analysis

	Dependent variable:			
	Yield Spread	Yield Spread	Yield Spread	Yield Spread
	(1)	(2)	(3)	(4)
brexit×country_GBR	0.634*	0.740**	0.023	-0.098
	(0.325)	(0.376)	(0.195)	(0.193)
brexit	0.142	0.220	0.534	0.500
	(0.212)	(0.249)	(0.501)	(0.454)
rating_AA		-1.020**	-2.079*	-2.050*
		(0.512)	(1.114)	(1.093)
rating_A		-0.521	-2.293**	-2.233**
		(0.407)	(1.069)	(1.057)
rating_BBB		0.222	-1.791*	-1.616
		(0.257)	(1.072)	(1.070)
ttm		0.021***	0.031*	0.031*
		(0.006)	(0.018)	(0.018)
log(amount)		0.112**	-0.007	0.079
		(0.055)	(0.051)	(0.055)
5-year treasury rate		-0.374	0.828	0.743
		(0.795)	(0.859)	(0.812)
5-year treasury rate square		0.005	-0.408	-0.399
		(0.222)	(0.273)	(0.265)
market leverage			0.067***	0.057***
			(0.020)	(0.019)
volatility				18.176**
				(8.477)
Issuer Fixed effects	Yes	Yes	Yes	Yes
Year Fixed effects	Yes	Yes	Yes	Yes
Observations	239	239	189	187
R^2	0.857	0.898	0.405	0.445

Note: *p<0.1, **p<0.05, ***p<0.01