Is uncertainty over Brexit damaging the UK and European equities?

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Abstract: The possibility the UK might leave the European Union –also known as Brexit– is a major source of concern. This article seeks to assess the costs of uncertainty over Brexit by delving into the impacts of the attention given to this event (via Google Trends and Twitter) on UK, German and French equities, while controlling for the effects of global financial and economic factors. We use different econometric tools enable to measure the strength of Brexit' effect as alternative to tail distributions (quantile regression approach) and spectral components (frequency domain causality test). Despite a heaviest awareness that it is difficult to properly quantify the costs of uncertainty over Brexit, this study provides evidence that the severity of Brexit' impact was not uniform across the investigated equities. Germany suffered most if the British exit from Europe happens, followed by France and UK. These results are fairly robust among the different methods and the internet proxies used.

Keywords: Brexit; uncertainty; social media; equities; UK; Europe.

1. Introduction

Nowadays talks on a possible "Brexit"[1] focus the attention of media, with significant impacts on UK and European (EU) economies. These effects should be investigated from the political and economic points of view. When looking at outside UK, leaving the Europe (EU) is not just one about is good or worse for UK; instead it appears a question of how such move could change the European policies, cause severe political damage and then weaken Europe geopolitically. Leaving aside the political aspect, the analyses on possible Brexit' costs seem divergent and scenarios are numerous. Effectively measuring the possible effects of a Brexit on the UK and European economies is heavily difficult because nobody knows how the relations between the UK and the EU would be organized after a British exit. Therefore, experts worked with different scenarios. London School of Economics estimates that a rise in trading costs and a drop of productivity would lead to a decrease of about 2.2 percent of GDP in the most cheerful case and a fall of anywhere among 6.3 percent and 9.5 percent in the most gloomy case, very close to the losses resulting from the global financial collapse. Regardless the fact that Britain may lose international political clout by leaving the EU, the major consequences of the Brexit would be financial and economic. In this context, the German foundation Bertelsmann Stiftung advanced that leaving EU would cost for UK by about 78 billion euros a year (for ten years); being outside the EU implies a great decline in foreign trade due to the return of customs barriers. They also anticipated a decrease by 0.3 percent of GDP per capita in France and Germany. Alternatively, a Brexit would increase the prices for British exports and then decrease the level of economic activities and production. In addition, prices for imported goods and services would rise for British consumers and companies, prompting a drop of real GDP in the UK. Further, the sterling would depreciate, and the stock market prices would fall.

For the majority of policymakers and investors in Britain and Europe the possibility the UK might leave the European Union is a big issue. Both the break with the EU and the potent uncertainty associated with it would be bad for trade flows and capital outflows and damaging to the UK and European economies. The overall costs of Brexit are difficult to quantify. This is because there are several scenarios and various channels through which

[1] It is dubbed "Brexit" following the Greek financial collapse since 2012 when experts and with large extent the media were speculating that Greece would be forced being outside the EU due to the fact that the country defaulted on its debt obligations. Unlike Greece, a Britain leaving from the EU is likely to be self-induced rather than forced.

Brexit would impact the UK and EU economies. All the published researches, to our best knowledge, argued that the Brexit' effects on UK and Europe would be negative. Nevertheless, there are no up to now comprehensive and accurate estimates. There are different ways in which the UK and the rest of the EU would be influenced by Brexit, which are not captured via macroeconomic models; one of these major channels is uncertainty. If the majority votes to leave the EU in a referendum, the consequences will be heavily uncertain as there are multiple unknowns such as the timing of the vote, the renegotiation outcomes, and whether or not the establishment of a new stable link with Europe will be easier etc…. If Brexit happens it will be a lengthy process. Although some points on this path are fixed, others are not yet, generating burly uncertainty. These considerations make a basis of the given research.

To analyze the costs of uncertainty over Brexit, this paper introduces the concept of internet concern as quantitative measure to test whether extracting public moods related to "Brexit" exerts a widest influence on UK, German and French equity markets. Millions of users daily interact with search engines, creating valuable sources of data regarding various aspects of the world. It is noticeable that information related to "Brexit" has spread rapidly in the last few years (Figure A, Appendix). With the great uncertainty surrounding possible Brexit, bloggers and economists start dealing with this issue by revolving around various questions: Is Brexit a threat for investors? What might the possibilities be for the UK outside the EU? What would happen if Britain left the EU? etc… As a result, the Internet search becomes day-to-day a potential tie helping to better analyze the market participants' behaviors in vacillating periods. Behavioral finance research considers that traders' investment decisions are driven by emotion (Damasio 1999 and Dolan 2002). Recent literature evaluated how online information predicts "Grexit", crypto-market and oil market (Mitchell et al. 2012, Choi and Varian 2012, Bordino et al. 2012, Kristoufek 2013, Bouoiyour and Selmi 2015 a, b, among others).

Such complexity in the focal issue makes its assessment with standard econometric techniques difficult. The volatile and speculative behaviors of asset markets strengthened the focus on models that allow capturing dynamic dependencies in data. While a large body of work has proposed models for the conditional mean and variance of stock returns, far less work have focused on the full return distribution. This paper uses a quantile regression (QR) approach to gather fresh insights about how would react UK and European stock markets to Brexit. It fortifies the role of different rhythms in the connectivity between the attention to Brexit and UK and EU equities. The correlation asymmetries would ensure that markets participants (investment advisers, investors, traders and regulators) have the opportunity to make informed decisions. Furthermore, it is clearest that time series resulting from a complex process could be a combination of different components operating on distinct frequencies. This means that standard methods which generally consider only frequency or time component separately may lead to erroneous results. In such a context where the direction of links between variables may be dissimilar across different frequencies, an appropriate analytical tool may be represented by frequency domain causality test (Breitung and Calderon 2006). The main advantage of this technique is the ability to disentangle data variables into their spectral components. In this case, the stationary process can be depicted as a weighted sum of sinusoidal components with a certain frequency.

By considering a wide range of quantiles, the reactions of UK and EU stock markets to possible Brexit appear as highly heterogeneous among tail distributions, highlighting the occurrence of asymmetry. The German stock market is typically more responsive than French and UK equities towards the possible British exit from EU. With respect the causality' strength, the results do not fundamentally change whatever the internet proxy used (Google Trends or Twitter). We usually note that Germany equity market would suffer most from possible Brexit, followed by France and UK. These findings provide some answers about the costs of Brexit over distinct tail distributions and scaling components, spelling out relevant implications for markets participants.

The body of this paper is organized in four major sections. In the second section, we propose the empirical strategy, describe the data, and present some hypotheses to be tested. Section three reports and discusses our main findings. The last section draws overall conclusions.

2. Methodology, data and hypotheses

2.1. The quantile regression approach

Even though a large body of work has proposed models for the conditional mean and variance of equity market returns, this research is undertaken towards modeling the full return distribution. Compared to the standard estimation of the conditional mean function (OLS), QR approach assesses each link accurately across random variables (Koenker and Bassett 1978; Koenker and Xiao 2002). It provides a complete description of asymmetric samples, which is one of the main distinguishing characteristics of financial data. Since its introduction by Koenker and Bassett (1978), QR continues to be an interesting tool as it accounts for a set of regression curves that differ across distinct quantiles of the conditional distribution of the dependent variable. A QR is suited to determine how evolve time series for all portions of a probability distribution.

QR is a generalization of median regression analysis to other quantiles. The coefficients of the τth conditional quantile distribution are estimated as follows:

$$\hat{\beta}\ (\tau) = \arg\min \sum_{t=1}^{\tau} (\tau - 1_{\{y_t \prec x'_t\, \beta(\tau)\}}) \left| y_t - x'_t\, \beta(\tau) \right| \qquad (1)$$

where the quantile regression coefficient *β(τ)* determines the connection between the vector *x* (independent variables) and the τth conditional quantile of *y* (the dependent variable). To determine *y* in function of specific independent series, the values of quantile coefficients could be constant where the values of *β(τ)* do not change markedly for the values *τ*. Moreover, it should be symmetric (asymmetric) where the values of *β(τ)* are similar (dissimilar) for lower and upper quantile levels.

We specify then the conditional quantile function for different quantile levels (such as the 10th, 20th... 90th percentiles):

$$Q_y(\tau \mid x) = \alpha(\tau) + \sum_k \beta_k(\tau) x_k + \sum_k \delta_k(\tau) z_k \qquad (2)$$

where *z* corresponds to the additional control variables (to be described later).

Using QR, we can see if the return is indicative of a rapidly improving UK, German and French equities or associated with a market that is highly contracting among various slopes (quantiles from the 10th to the 90th). Although correlation asymmetries can be relevant for investors and regulators to act appropriately, QR remains insufficient to fully judge a "complex" issue as the interaction between anxieties over Brexit and the performance of equity markets. The methodological critical way arises from the fact that correlation does not necessarily imply causality.

2.2. The frequency domain causality test

Instead of computing a single Granger causality measure for the entire link, the Granger causality is determined for each individual frequency. This allows testing if the predictive power is concentrated at the quickly or the slowly fluctuating components (short-run and long term, respectively).

To define the frequency causality test, we start by considering $z_t = [x_t, y_t]$ as a two-dimensional time series vector with $t = 1 \ldots T$. It is supposed that z_t has a finite-order VAR representation $\theta(L)z_t = \varepsilon_t$ where $\theta(L)z_t = 1 - \theta_1 L - \ldots - \theta_p L^p$ is a 2 × 2 lag polynomial with $L^k z_t = z_{t \to k}$. It is assumed that the vector ε_t is white noise with $E(\varepsilon_t) = 0$ and $E(\varepsilon_t \varepsilon_t') = \Sigma$, $E(\varepsilon_t \varepsilon_t') = \sum$ where $\sum$ is a positive definite matrix. The system is stationary denoted as:

$$z_t = \phi(L)\varepsilon_t = \begin{pmatrix} \phi_{11}(L)\phi_{12}(L) \\ \phi_{21}(L)\phi_{22}(L) \end{pmatrix} \begin{pmatrix} \varepsilon_{12} \\ \varepsilon_{21} \end{pmatrix} \tag{3}$$

$$= \Psi(L)\upsilon_t = \begin{pmatrix} \psi_{11}(L)\psi_{12}(L) \\ \psi_{21}(L)\psi_{22}(L) \end{pmatrix} \begin{pmatrix} \eta_{12} \\ \eta_{21} \end{pmatrix}$$

The spectral density can then be derived from the previous matrix and expressed as follows:

$$f_x(w) = \frac{1}{2\pi} \left\{ \left|\psi_{11}(e^{-iw})\right|^2 + \left|\psi_{12}(e^{-iw})\right|^2 \right\} \tag{4}$$

Spectral analysis allows determining the cyclical properties of data. In this study, the Granger causality test-based frequency domain relies on a modified version of the coefficient of coherence. It allows deriving the distributional properties of time series. Let x_t and y_t (the variables of interest) be stationary variables of length T. The main goal of this study is to test whether x_t Granger cause y_t, at a given frequency λ, conditioning upon Z_t (supplementary control variables). Geweke (1982) proposed a measure of causality denoted as:

$$M_{x \to y/Z}(w) = \log\left[1 + \frac{\left|\psi_{12}(e^{-iw})\right|^2}{\left|\psi_{11}(e^{-iw})\right|^2}\right] \tag{5}$$

As $\left|\psi_{12}(e^{-iw})\right|^2$ is a complex function of the VAR parameters, Breitung and Candelon (2006) and in order to resolve this drawback argue that the hypothesis $M_{x \to y/Z}(\omega) = 0$ correspond to a linear restriction on the VAR coefficients.

$$H_0 : R(\omega)\phi(L) = 0 \tag{6}$$

where $R(\omega)=\begin{bmatrix}\cos(\omega)\cos(2\omega)...\cos(p\omega)\\ \sin(\omega)\sin(2\omega)...\sin(p\omega)\end{bmatrix}$

The significance of the causal relationship can be tested by a standard F-test or by comparing the causality measure for ω ∈ [0, π] with the critical value of a χ^2 distribution with 2 degrees of freedom, which is 5.99.

2.3. Data and hypotheses

In this article, the QR model and frequency domain causality test have been carried out to evaluate the reactions of UK and EU stock returns[2], while controlling for the effects of global financial and economic factors. To this end, we use weekly data for over the period from January 2010 to July 2015[3] (with a total of 268 observations) for stock prices of UK (FTSE 100), Germany (DAX 30) and France (CAC 40).We prefer use weekly instead of daily data, given that we hoped to properly characterize the underlying dependence structure. Daily or high-frequency data may be heavily influenced by drifts and noise that could mask or did not reflect appropriately the dependence between the investigated variables and thus complicate modeling of the marginal distributions via nonstationary variances, long memory processes and sudden shifts/jumps.

The stock market prices data are collected from Datastream database. The search queries for keyword related to the British exit from EU (i.e., "Brexit") were collected via Google Trends (http://www.google.com/trends). Note that for twitter, we use the tweet backs related to the same keyword. Three global financial and risk factors that may have a significant role in explaining the focal linkage have been considered. Generally, major global financial and economic factors could be channels through which fluctuations in the world's economic and financial conditions are transmitted to UK and EU equities. These factors include the US equity volatility index (*VIX*), the West Texas Intermediate (*WTI*) oil price and the world gold price. The *WTI* has been largely employed in the literature as the benchmark price for global oil markets. The *WTI* is among the most traded oil on the world markets, and therefore is significantly affected by macro-financial variables. The gold is a precious metal

[2] The stock return (*STR*) is calculated by considering the ratio stock price (in log) at time t and the lagged stock price (in log).
[3] The choice of sample selected for this analysis is dictated by the availability of reliable data.

that has been and continues to be perceived as a hedge against untoward shocks and also a safe haven over extreme stock market fluctuations (Baur and Lucey 2010). Moreover, the literature in finance field has been frequently relied on proxies of uncertainty, most of which have the advantage of being directly observable. Such proxies include the implied volatility of stock returns (i.e., *VIX*). This index may play a a greatest role on the asset allocation and portfolio strategies (Hood and Malik 2013 and Balcilar et al. 2014). It allows seeing whether stock markets react to global market news. These time series data come from quandl website. All the investigated variables have been transformed by taking natural logarithms to correct for potential heteroskedasticity and dimensional differences among time series.

Bearing in mind the difficulty to quantify Brexit costs, we formulate some hypotheses to be tested: ***Is the uncertainty about Britain leaving the Europe exerted a significant influence on UK, German and French equities? If so, do the responses to possible Brexit appear different across these countries?*** To answer these questions, we use a QR approach estimator which is robust to outlying observations on the dependent variable. The model to be estimated is given by:

$$\hat{r}_t^{\tau} = \hat{\omega}(\tau) + \hat{\alpha}(\tau) STR_{t-1} + \hat{\beta}(\tau) Brexit_t + \hat{\delta}_1(\tau) Oil_t + \hat{\delta}_2(\tau) VIX_t + \hat{\delta}_3(\tau) Gold_t \qquad (7)$$

where $\hat{r}_t^{\tau}$ is the estimated $\tau-$conditional quantile of UK, German and French stock returns (STR), and the estimated parameters $\hat{\alpha}(\tau)$, $\hat{\beta}(\tau)$ and $\hat{\delta}_k(\tau)$ for k=1, 2, 3 are function of τ; STR_{t-1}: the lagged stock return may reflect the influence of some potential explanatory variables not included here due to the unavailability of weekly frequency data.

In addition to the interdependence pattern, this research applies a frequency domain causality test to determine whether the causality between the growing interest to Brexit and the central stock market returns vary from one frequency to another.

3. Main findings

3.1. QR results

We first employ OLS regression[4] to find initial information about the reactions of UK and EU equities to Brexit. The idea here is to have a case of benchmarking to compare the

[4] For comparison, we report the OLS and LAD (i.e., the 0.50 quantile) estimates in Table 1. The contrast between the conditional median (i.e., LAD) and the mean (i.e., OLS) estimates can be partially due to the

OLS with QR findings. The OLS results are reported in Table 1 indicate that the Brexit' coefficient (proxied by Google Trends) seems significant only for UK and France, which is non-credible given the large Germany's weight in Europe. The mean effect of the exogenous variable on the endogenous time series may be under or over estimate impacts or even fail to properly determine full possible influences (Cade and Noon 2003); hence the need to perform more elaborate methods.

Using QR technique, we show heterogenous outcomes regarding UK and EU equities reactions to Brexit. For UK, the attention to Brexit exerts a negative and significant influence on stock return at low and middle quantiles (i.e., when investors are pessimistic or when the market is moderately efficient); such relationship is weak, fluctuating between -0.083 and -0.013 (Table 1, Panel 1.1). Unlike UK, Germany would suffer markedly from possible Brexit. Precisely, the British exit from Europe leads to a sharp decrease of German stock return (the slope coefficient moves among -0.48 and -0.23). This result is valid when the stock market is performing weakly, but also in upper quantile (i.e., τ =0.8). For France, the equity reaction to the anxiety over Brexit is negative at low quantiles and around middle quantile (i.e., when the stock market perform less than normal or around the average); such relationship varies between -0.12 and -0.005.

To avoid possible methodological pitfalls lying to omitted variable bias, a vector of additional explanatory variables (discussed above) is incorporated in the model. We include *WTI*, gold price and *VIX*. We notice that the implied volatility index affects statistically and negatively the performance of the UK and EU markets at different quantiles, indicating that the EU stock market returns decrease as the *VIX* increases. This result is expected since the uncertainty is the thing that markets hate the most; such impact occurs in lower quantiles for UK and France, while for Germany the effect appears more important and occurs in upper quantiles. Besides, gold has no influence for the considered countries (except Germany at low quantiles or when pessimism mostly prevailed). This means that gold has not lost its great importance as a safe haven in Germany. It must be recalled that gold possesses no credit risk and cannot turn worthless even though uncertain event. With the financialization of the commodity markets, gold enables to provide a protection against losses when equities undergo large decreases. Then, including gold in portfolios allows investors preventing the downside risk in their investments (Mishra and Mishra 2010). This result does not hold for the

asymmetry of the conditional density and to a strong effect exerted on the least squares fit by the possible outlier observations in the sample.

studied cases (with the exception of Germany in lower quantiles). *WTI* affects positively UK equity return at highest quantiles (i.e., when investors are optimistic) and middle quantiles, but this correlation is weak since it is only significant at 10%. Nevertheless, *WTI* impacts negatively the German stock return around the middle quantile (i.e., τ =0.4 or 0.5). French equity does not seem sensitive to oil price fluctuations.

Table 1 (Panel 1.2) reports a formal test of the equality of the coefficient estimates for various τ-quantiles to evaluate whether the estimated QR relationships are conform to the location shift hypothesis which assumes the same slope parameters for all of the conditional quantile functions[5]. It shows that the coefficient estimates are statistically different from each other if the estimates for lower τ-quantiles are compared with estimates for the higher or intermediate τ-quantiles. These outcomes hold for the coefficient estimates of the variables STR_{t-1} and Brexit. The null hypothesis of equal slope is generally rejected[6] at the conventional significance levels for UK (0.100 vs. 0.900, 0.300 vs. 0.700 and 0.400 vs. 0.600), Germany (0.100 vs. 0.900, 0.200 vs. 0.800 and 0.300 vs. 0.700) and France (0.100 vs. 0.900, 0.200 vs. 0.800, 0.300 vs. 0.700 and 0.400 vs. 0.600).

Table 1. QR estimates: The responses of UK and EU equities to the attention to Brexit (via Google Trends)

		UK		GERMANY		FRANCE	
1.1. Estimated results of quantile regression							
	Quantile	Estimate	p-value	Estimate	p-value	Estimate	p-value
C	0.100	0.077304**	0.0035	-0.030905	0.7145	0.003532	0.8923
	0.200	0.064866**	0.0104	0.047791	0.5798	0.008104	0.8056
	0.300	0.052032**	0.0115	0.058089	0.4532	0.003573	0.9296
	0.400	0.052516***	0.0001	0.031063	0.6737	-0.008268	0.8279
	0.500	0.048883***	0.0000	0.013254	0.8520	0.001133	0.9787
	0.600	0.059693***	0.0000	0.014736	0.8295	0.023373	0.5863
	0.700	0.066684***	0.0000	-0.026926	0.6855	0.037889	0.3851
	0.800	0.066146***	0.0000	0.006986	0.9225	0.061789	0.1186
	0.900	0.088247***	0.0000	0.001472	0.9833	0.052007	0.1744
STR_{t-1}	0.100	0.185203	0.3450	0.259289*	0.0250	0.102956	0.4677
	0.200	0.355120*	0.0925	0.327413*	0.0332	0.275493	0.0814
	0.300	0.502901**	0.0028	0.388326*	0.0403	0.301966	0.1359
	0.400	0.515904***	0.0000	0.495999**	0.0028	0.326534*	0.0706
	0.500	0.521131***	0.0000	0.713286***	0.0001	0.335075*	0.0609
	0.600	0.433996***	0.0000	0.685595***	0.0003	0.409916**	0.0089

[5] The Koenker and Xiao (2002) test computes that all the covariate effects satisfy the null hypothesis of equality of the slope coefficients across τ-quantiles. In particular, the difference between slope estimates at the τ and (1- τ) quantiles is examined. A rejection favors the QR.

[6] The rejection of the null hypothesis implies that the magnitude of the slope coefficient, estimated at the various parts of the return distribution, is different and that the difference is statistically significant.

	0.700	0.391121	0.0005	0.773887***	0.0000	0.390235**	0.0051
	0.800	0.387219**	0.0012	0.674492***	0.0000	0.381744**	0.0037
	0.900	0.209733	0.1252	0.627506***	0.0001	0.383025**	0.0010
Brexit	0.100	-0.083993**	0.0033	-0.48154***	0.0243	-0.117189*	0.0983
	0.200	-0.014670*	0.0303	-0.236929**	0.0034	-0.122635	0.1096
	0.300	-0.01394***	0.0000	-0.233814**	0.0028	-0.120403*	0.0838
	0.400	-0.005084	0.9200	0.572133	0.4174	-0.050241*	0.0239
	0.500	-0.02680***	0.0004	0.670985	0.3099	-0.101040*	0.0567
	0.600	0.001541	0.9750	0.603817	0.3460	0.066139*	0.0309
	0.700	0.008991	0.8655	0.856050	0.1614	0.038380	0.8682
	0.800	0.026093	0.6357	-1.125378*	0.0580	0.019523	0.9429
	0.900	0.056692	0.3974	0.721225	0.3378	0.305296	0.3285
VIX	0.100	-0.04008***	0.0000	0.022716	0.9650	0.033893	0.8856
	0.200	-0.028987	0.2433	-0.006368	0.9914	-0.0663***	0.0000
	0.300	-0.030483	0.1807	0.059453	0.9250	-0.08361**	0.0010
	0.400	-0.023118*	0.0599	0.062712	0.9186	0.054198	0.8219
	0.500	-0.018411**	0.0013	0.044525	0.9435	0.137597	0.5803
	0.600	-0.000563	0.9705	-0.555275	0.4505	0.058270	0.8293
	0.700	-0.004913	0.7407	-0.151472	0.8663	0.264772	0.3052
	0.800	-0.011102	0.5554	-1.546686*	0.0708	0.308036	0.2623
	0.900	-0.016769	0.5354	-1.489976*	0.0400	0.678603	0.1324
GOLD	0.100	0.086380	0.5811	0.106887***	0.0000	-0.002877	0.9685
	0.200	0.031492	0.8237	0.229520***	0.0007	-0.021702	0.8094
	0.300	0.043922	0.7576	-1.027557	0.5093	-0.026687	0.8030
	0.400	-0.068214	0.5609	-1.232541	0.4644	0.091388	0.3440
	0.500	-0.105971	0.3466	-1.640870	0.3817	0.113711	0.2817
	0.600	-0.122657	0.2730	-0.354343	0.8666	0.116332	0.3097
	0.700	-0.144008	0.1873	-1.151907	0.5488	0.040614	0.7572
	0.800	-0.068177	0.5164	-2.494569	0.2734	0.071093	0.5507
	0.900	-0.193233	0.2877	-3.452253	0.1069	0.106502	0.4113
WTI	0.100	0.148765	0.1288	0.084605	0.9158	-0.026335	0.9450
	0.200	0.110016	0.1490	0.031912	0.9719	-0.077867	0.8707
	0.300	0.058996	0.4244	-0.525284**	0.0237	-0.017937	0.9736
	0.400	0.090488	0.2244	-0.592380*	0.0952	-0.220419	0.7307
	0.500	0.127165*	0.0888	-0.225534**	0.0012	-0.446058	0.5560
	0.600	0.125311	0.1191	0.286035	0.7348	-0.761129	0.2497
	0.700	0.109325	0.2327	1.097638	0.1972	-0.842381	0.2067
	0.800	0.170636*	0.0810	1.108329	0.2084	-0.357306	0.4675
	0.900	0.235583*	0.0734	1.398832	0.1727	-0.067096	0.8725
OLS (*Brexit*)		-0.026531**	0.0346	0.156782	0.3456	-0.05341**	0.0076
1.2. Statistic tests of the equality of slope estimates across various quantiles							
0.100 vs. 0.900		3.18*	0.0691	12.58**	0.0032	10.76**	0.0014
0.200 vs. 0.800		0.00	0.9208	15.26**	0.0011	6.22*	0.0108
0.300 vs. 0.700		5.03**	0.0085	4.83*	0.0439	23.15***	0.0000
0.400 vs. 0.600		6.77**	0.0083	1.75	0.1264	11.69**	0.0055

Notes: The right columns of this table present the F tests of the equality of slope parameters across various quantiles. ***, ** and * imply significance at the 1%, 5% and 10%, respectively;

These results do not appear highly sensitive to the Brexit attention proxies used. By considering the number of tweet backs as quantitative measure, the findings change slightly (Table 2). First of all, a systematic pattern exists for the quantile-varying estimates of the Brexit coefficient among the investigated countries, that the classical methods unknown. It is often revealed that UK and EU equities respond dissimilarly to the anxiety over Brexit. For all the concerned countries, a negative and significant relationship between the central variables occurs when the stock market perform badly. However, the severity (the magnitude) of the effect of uncertainty surrounding Brexit was not uniform across UK and EU markets. In particular, Germany suffered most, while France and UK (in this order) experienced a moderate influence. More accurately, we show that the Brexit' impact on UK stock return moves within -0.04 (10th) and -0.02 (20th and 30th). In France, the interest to the Britain being outside EU exerts a strong influence on investors' confidence, as its effect on equity return fluctuates among -0.11 (10th) and -0.17 (20th). For Germany, the situation appears more serious, since the attention to Brexit affects deeply the stock market returns (varying among -0.25 (20th) and -0.46 (50th)). In sum, the reactions of UK and EU stock markets to Brexit looms is asymmetric; When concentrating on the additional control variables, the results appear quite interesting. We note that the uncertainty index usually displays higher coefficient for Germany and with less extent UK (but in lower quantiles), while French equity market weakly influenced (at higher quantiles). Oil price affects significantly the three investigated markets around the average; such effect seems stronger for UK followed by Germany and modest for the case of France. Over the current uncertainty encompassing the British exit from EU, gold plays as a hedge for Germany, while its influence on UK and French equities appears negligible. The same result has been found in Table. A further investigation consists on re-applying the same exercise using Koenker and Xiao (2002) test. The results change slightly compared to Table1[7]. In sum, these findings sustain the usefulness to consider the distribution heterogeneity when examining an unsettled context where standard methods are unbefitting.

Table 2. QR estimates: The responses of UK and EU equities to the attention to Brexit (via Twitter)

		UK		GERMANY		FRANCE	
Estimated results of quantile regression							
	Quantile	Estimate	p-value	Estimate	p-value	Estimate	p-value
C	0.100	0.052985*	0.0323	-0.019697	0.3092	0.003988	0.5794
	0.200	0.034371**	0.0013	0.009315	0.6460	0.009455	0.2382
	0.300	0.035970***	0.0003	0.011011	0.6618	0.013079	0.1481
	0.400	0.043796***	0.0000	0.007925	0.7835	0.01549*	0.0959
	0.500	0.048029***	0.0000	0.032688	0.2759	0.02024*	0.0414
	0.600	0.054015***	0.0000	0.026345	0.3780	0.03266**	0.0038
	0.700	0.053331***	0.0000	0.030519	0.2014	0.0651***	0.0000
	0.800	0.067277***	0.0000	0.057537*	0.0117	0.0830***	0.0000
	0.900	0.079079***	0.0000	0.061460**	0.0059	0.0872***	0.0000
STR_{t-1}	0.100	0.414711*	0.0803	0.265216**	0.0051	0.118053	0.4018

[7] Specifically, we note that the slope coefficient of the attention to Brexit via Twitter differs at 30th against 70th and 40th against 60th quantiles for UK and Germany, and at 10th against 90th and 20th against 80th for the case of France.

	0.200	0.627097***	0.0000	0.226769*	0.0471	0.28048*	0.0705
	0.300	0.637144***	0.0000	0.330034*	0.0757	0.31648*	0.0883
	0.400	0.561870***	0.0000	0.527488***	0.0009	0.41446*	0.0243
	0.500	0.542995***	0.0000	0.659070**	0.0017	0.5877***	0.0002
	0.600	0.504320***	0.0000	0.677864**	0.0013	0.590***	0.0001
	0.700	0.514409***	0.0000	0.784196***	0.0000	0.4479**	0.0062
	0.800	0.411687***	0.0000	0.810639***	0.0000	0.4817**	0.0091
	0.900	0.305533*	0.0130	0.811372***	0.0000	0.701656	0.0020
Brexit	0.100	-0.04473***	0.0002	-0.431865*	0.0769	-0.11007*	0.0902
	0.200	-0.02281***	0.0000	-0.257121*	0.0112	-0.1727**	0.0054
	0.300	-0.02676***	0.0000	-0.424442*	0.0055	-0.133***	0.0000
	0.400	0.038677	0.3349	-0.464107**	0.0049	-0.144***	0.0000
	0.500	0.004696	0.9027	-0.11167***	0.0000	-0.017095	0.8572
	0.600	-0.012201	0.7557	0.630502	0.3294	-0.09423*	0.0451
	0.700	-0.002318	0.9509	0.730724	0.2099	-0.102749	0.3342
	0.800	-0.031175	0.4114	0.403495	0.4862	-0.059095	0.5865
	0.900	0.049920	0.4650	1.080137	0.1915	-0.124581	0.2811
VIX	0.100	-0.177211**	0.0064	-0.165043	0.8277	-0.162700	0.6216
	0.200	-0.114345*	0.0158	-0.484926*	0.0735	-0.136848	0.9522
	0.300	0.456242	0.9232	-0.447242*	0.0461	-0.756460	0.8743
	0.400	1.315345	0.9792	-0.152919	0.7812	-0.059562	0.7952
	0.500	1.289688	0.6562	0.125419	0.6577	-0.788413	0.2279
	0.600	0.024949	0.7197	-0.415203	0.2446	-1.502949	0.8221
	0.700	0.401490	0.3006	-0.009345	0.1209	-0.0090**	0.0045
	0.800	0.490723	0.1696	0.278196	0.9613	-0.03446*	0.0294
	0.900	-1.938552	0.1626	-0.613779	0.9274	-0.0432**	0.0010
GOLD	0.100	0.086380	0.5811	0.106887***	0.0000	-0.002877	0.9685
	0.200	0.031492	0.8237	0.229520***	0.0007	-0.021702	0.8094
	0.300	0.043922	0.7576	-1.027557	0.5093	-0.026687	0.8030
	0.400	-0.068214	0.5609	-1.232541	0.4644	0.091388	0.3440
	0.500	-0.105971	0.3466	-1.640870	0.3817	0.113711	0.2817
	0.600	-0.122657	0.2730	-0.354343	0.8666	0.116332	0.3097
	0.700	-0.144008	0.1873	-1.151907	0.5488	0.040614	0.7572
	0.800	-0.068177	0.5164	-2.494569	0.2734	0.071093	0.5507
	0.900	-0.193233	0.2877	-3.452253	0.1069	0.106502	0.4113
WTI	0.100	1.473951	0.5682	0.739456	0.5748	-1.104859	0.7221
	0.200	1.082668	0.8870	0.481473	0.9521	-0.869632	0.3580
	0.300	0.005958	0.9906	-0.416135*	0.0554	-0.2040**	0.0064
	0.400	0.665325*	0.0243	-0.473920*	0.7343	-0.23534*	0.0810
	0.500	0.519166*	0.0614	-0.120784	0.6110	0.013033	0.8013
	0.600	-0.583889	0.2492	-0.348164	0.2592	-0.055399	0.2579
	0.700	-0.528580	0.1811	-3.708769	0.4411	-0.518038	0.2699
	0.800	-0.654508	0.1544	-4.119389	0.1509	-0.559562	0.9060
	0.900	-0.987736	0.1202	-4.470263	0.2170	-0.834317	0.9498
OLS (*Brexit*)		0.034564	0.3568	-0.104***	0.0003	0.009672	0.4512
Statistic tests of the equality of slope estimates across various quantiles							
0.100 vs. 0.900		0.76	0.2154	0.13	0.8965	3.56**	0.0011
0.200 vs. 0.800		1.97*	0.0404	0.22	0.8123	10.14***	0.0000
0.300 vs. 0.700		2.12**	0.0091	3.07*	0.0297	1.89*	0.0412
0.400 vs. 0.600		7.65***	0.0000	5.62**	0.0038	0.21	0.3781

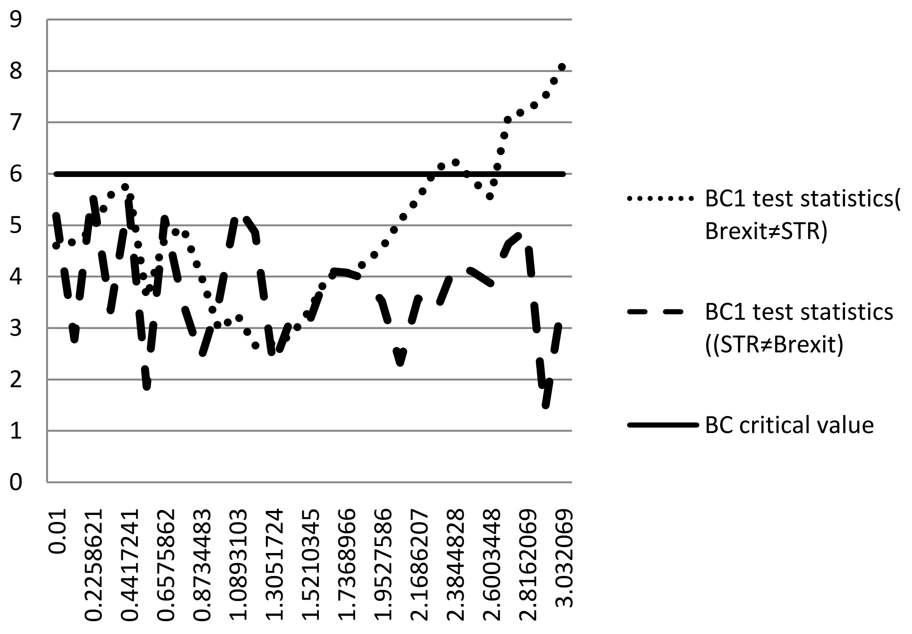
Notes: The right columns of this table present the F tests of the equality of slope parameters across various quantiles. ***, ** and * imply significance at the 1%, 5% and 10%, respectively.

3.2.Frequency domain causality findings

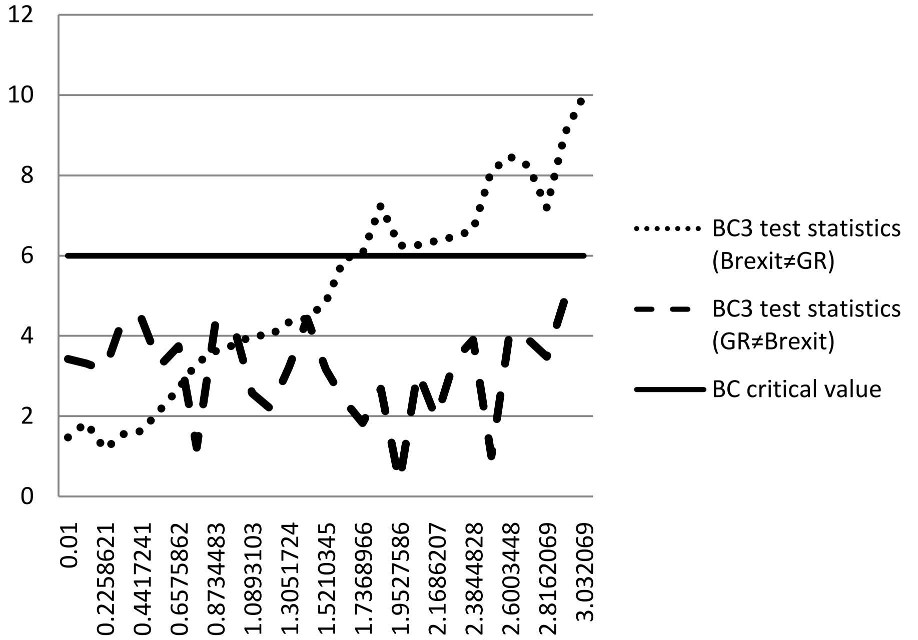
As mentioned above, the focus of the use of frequency domain causality test is on detecting cycles in the intensity of Brexit' impact on UK and European stock markets. Figure 1 depicts the evolution of the linkage between the interest to Brexit (measured via Google Trends) and UK and EU equities conditioning upon gold price, uncertainty (or VIX) index, and WTI. The figure contains the test statistics with their 5 percent critical values for the different frequency bands involved (solid line) over the interval [0, π]. The frequency (ω) on the horizontal axis can be translated into a cycle or periodicity of T weeks by $T = (2\pi/\omega)$ where T is the period. The results of Granger coefficient for causality running from the attention to Brexit to UK, German and French equities show that searching the keyword "Brexit" via Google Trends Granger-cause UK and EU equities (Figure 1) at level of frequencies reflecting short-run business cycle (or high frequencies). The cycle appears lengthy for Germany (when $\omega \in [1.73\pi - 3.03\pi]$, corresponding to a cycle within four weeks) compared to France (when $\omega \in [1.84\pi - 3.03\pi]$, corresponding to a cycle length of 3.4 weeks) and UK (when $\omega \in [2.27\pi - 2.49\pi] \cup [2.60\pi - 3.03\pi]$, corresponding to a cycle between 2.4 and 2.7 weeks). The reverse causality is not supported at any case.

Figure 1. The frequency domain causality between the attention to Brexit (via Google Trends) and UK and EU equities

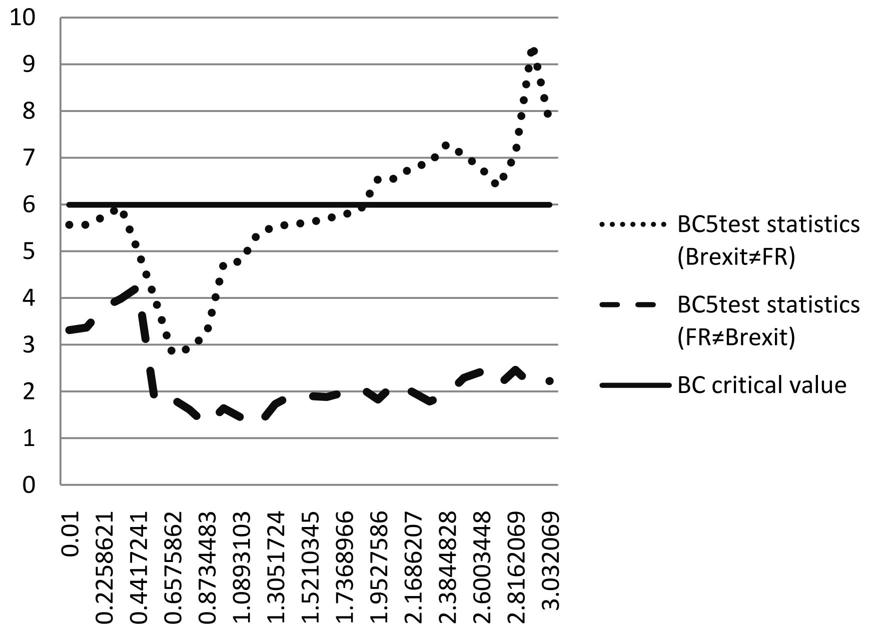
UK



GERMANY



FRANCE



Note: The horizontal line represents the 5% critical value of the null hypothesis test of no Granger causality at frequency *w*.

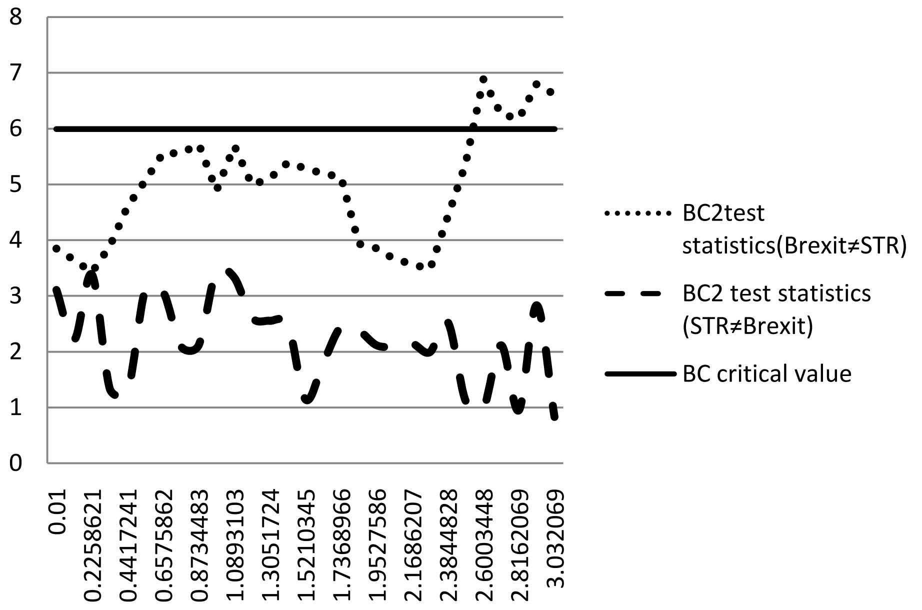
In further step, the same testing procedure is implemented to the Twitter data related to "Brexit" (Figure 2). The results remain fairly solid, but the cycles vanish for all the considered countries. The strength of causality is often more pronounced for Germany where we show that there is a significant causality from Brexit to stock returns when $\omega \in [2.06\pi - 3.03\pi]$, corresponding to a cycle of three weeks, whereas the causal cycles are less lengthy for France (when $\omega \in [2.16\pi - 3.03\pi]$, corresponding to a wave length inferior to 2.9 weeks) and UK (when $\omega \in [2.38\pi - 3.03\pi]$, corresponding to a cycle less than 2.6 weeks).

We should mention here that the followed interpolation procedure has affected the strength of Granger-causality (the cycles fall when using the number of tweets as measure of the interest to Brexit), but not the direction of causality. Our hypothesis that the disquiets over the possible Brexit Granger-cause UK, Germany and France equities evolves over the frequencies involved. The aforementioned findings prove slight differentiability among Googlers and Twitters. Even though Twitter has become a popular way of highly directing followers to news (in particular, blogs), the social media discussion (especially, Twitter) stand out from users as more likely to be high earners and college-educated.

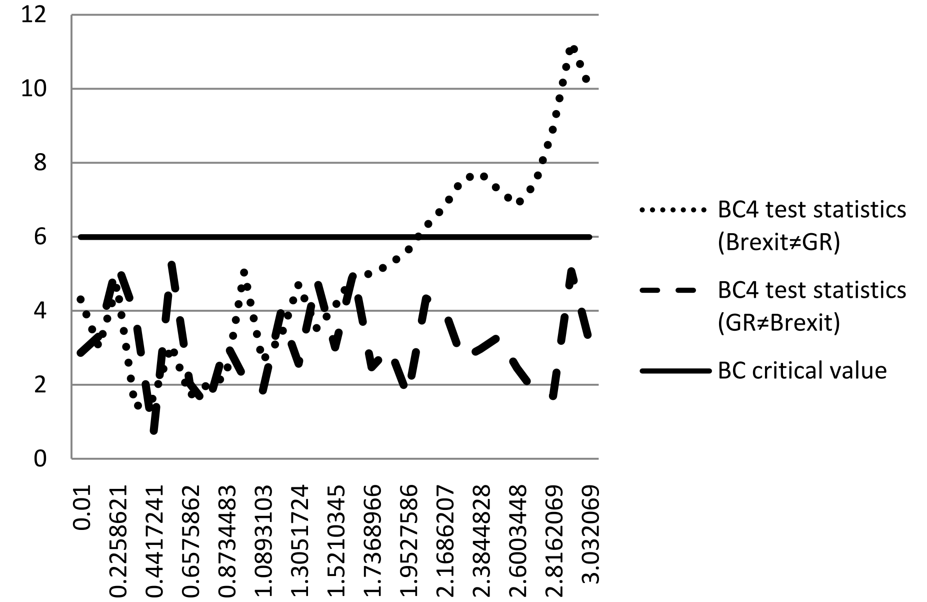
Despite their computational differences, QR and frequency domain causality test are likely to be complementary rather than substitute with respect the reactions of UK and EU stock returns to the attention towards Brexit. Indeed, whatever the internet proxy used (Google Trends or Twitter), both methods employed show the same hierarchy in terms of the effect of Brexit on the equity returns (Germany, France and UK). The results are fairly robust, all suggesting the need to account for asymmetry and cyclicality when assessing the equities behaviors over an uncertain framework.

Figure 2. The frequency domain causality between the attention to Brexit (via Twitter) and UK and EU equities

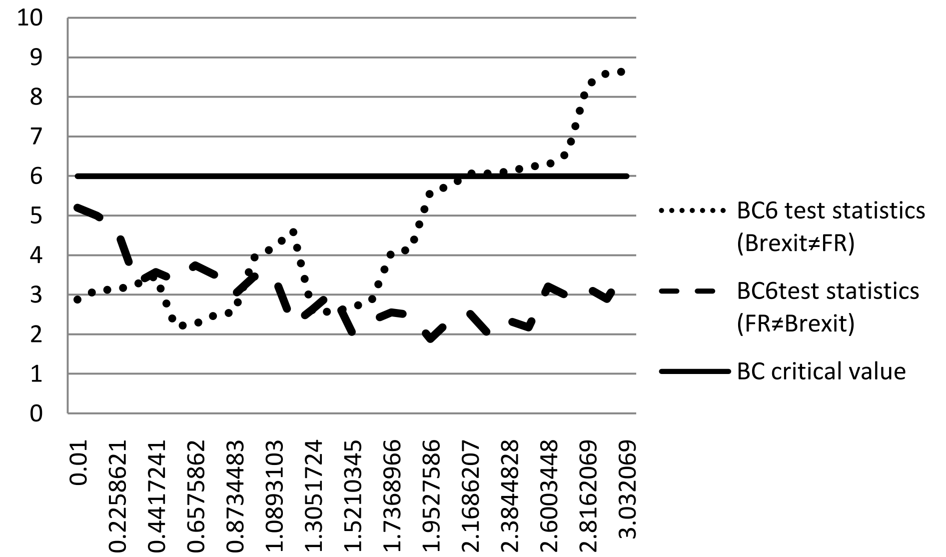
UK



GERMANY



FRANCE



Note: The horizontal line represents the 5% critical value of the null hypothesis test of no Granger causality at frequency *w*.

3.3. Interpretation of results

We must start by advancing that our primary focus in this study is to test whether uncertainty over British exit from EU affects significantly the performance of UK and European stock markets. The growing attention to Brexit was extracted via Google Trends and Twitter. This strategy is rather subjective and cannot reflect the full effect (economic, political, social, etc...) of Brexit. Nevertheless, the results seem quite intuitive. The great anxiety over the possible Brexit exerts a significant impact onGerman, French and UK equities (with large extent Germany). This significant influence is expected because UK's trade is geared heavily towards the EU. More than 50 percent of its exports are to the EU, and also more than 50 percent of imports come from European States. Also, the fact that the investors' fears have substantial impact on the German market seems logical due to the strong power or the dominant role of Germany in the European Union. Compared to France, Germany enjoyed deeper trade and investment relations with the UK. Based on UNCTAD statistics, in 2013, Germany represents the second export destination after USA with approximately 11 percent of overall exports, followed by the Netherlands (8.7 percent) and then France (6.6 percent). With respect to imports structure, Germany is positioned as the number one with 13.3 percent, then China (8.7 percent), the Netherlands (7.5 percent), the USA (6.9 percent) and France (5.9 percent). Moreover, the EU and UK are becoming increasingly inter-connected via investment relationships. Arguably, the Netherlands (227.3 USD millions), Germany (123.7 USD millions) and France (102.8 USD millions) are the biggest investor nations, representing together around 60 percent of FDI from the EU (Figure B, Appendix).

Besides, the fact that UK stock market appears less impacted by the possible Brexit may reflect the difficulty to predict whether Britain should stay or leave the EU and thus hesitation surrounding UK traders' decisions. According to YouGov[8] polling data, the UK is divided into 41 percent asserting they would vote to leave and 41 percent saying that they would vote to still in the European Union. But if negotiations between the UK and other EU states lead to important outcomes around some issues, the percentage of supporters to stay in EU increases to 50 percent, compared to 23 percent voting to be outside the Europe. Some asserted that Britain should lose its trading relationships with EU by forming economic and political partnerships with countries outside Europe; but others proposed achieving formal linkages with European countries by ensuring a European Free Trade Association.

Regardless of the referendum outcome and beyond the harmful financial and economic consequences the uncertainty over British exit from EU[9] will have serious geopolitical effects and will damage the prospects for European integration.

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[8] YouGov is a global market research and data company built on the idea that the more people participate in the decisions made by the institutions will be, better will be the decisions-making. For more details about this company, please refer to this link: https://yougov.co.uk/find-solutions/

[9] We should mention that the UK has an important position with respect the global decision making. It is a prominent member of the United Nation's Security Council, G7 (one of four EU member states), G20 (one of

4. Conclusion

> "A referendum on whether Britain should leave the European Union would create economic uncertainty," IMF chief Christine Lagarde proclaimed.

Despite our consciousness that it is too difficult to measure the uncertainty over Brexit and also too early to estimate its costs, this paper tries to bring some answers about the impact of anxiety over Brexit on the performance of UK and European (in particular, the two most powerful nations on the European continent: Germany and France) equity markets. A fundamental purpose is to test how plays media' stance towards the Brexit (by introducing the concept of Internet concern as a quantitative measure) in exacerbating uncertainty across UK, German and French financial markets.

We use a QR approach and a frequency domain causality test enable to model the link between the attention to Brexit and stock market returns more appropriately than is possible with standard methods including the OLS and the standard Granger causality test. While OLS regression allows estimating the impact of Brexit on the conditional mean of UK, German and French equities, QR brings a broader picture in helping analyze the correlation between the current returns and various parts (slopes from the minimum to the maximum responses) of the lagged conditional returns, accounting therefore for possible asymmetry. Beyond the correlation asymmetries, we test the causality between the uncertainty over Brexit and UK and EU stock returns among distinct frequencies (from quickly to slowly fluctuating components). We have initially considered the OLS and LAD regression techniques for estimating the effect of Brexit looms on the focal equities. We show an insignificant dependence in the case of Germany, which is unexpected due to the strong UK-Germany trade and investments relationships. In addition, we have employed standard Granger causality test, suggesting an insignificant causal relationship for the case of Germany (Table A, Appendix). This highlights the inefficacy of these techniques to find solid insights into the convoluted linkage between uncertainty over Brexit and UK and EU asset markets, and the functionality of more appropriate methods enable to analyze this linkage as alternative to tail distributions (asymmetry) and cyclical components.

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four EU member states), the International Monetary Fund and World Bank (almost 4.2 percent of the voting power) and the Financial Stability Board (one of six EU member states).

Using QR and frequency domain causality test, quite interesting findings have been emphasized:

(i) The reactions of UK and EU equities to uncertainty over Brexit are sharply heterogeneous among various quantile levels and frequencies, underscoring the complexity of this relationship and the occurrence of asymmetry and cyclicality.

(ii) The seriousness of Brexit costs is not uniform across the investigated countries. Indeed, Germany appears to suffer most from this uncertainty followed by France and UK.

To the extent that global investors increasingly use portfolio diversification as appropriate strategy to lighten risks, a meticulous evaluation of the equities' responses to uncertainty over Brexit appears useful for the investor's optimal asset allocation decisions. In fact, this article' outcomes may be used for portfolio construction and diversification, as variant sensitivities to anxiety over Brexit are found among UK and European equities. Varying considerably from bottom to upper quantiles and from highest to lowest frequencies, these responses may have deepest consequences for portfolios that trade with various rebalancing horizons. Holding diversified portfolio could palliate risk management. Beyond this research' findings, it must be pointed out that Brexit and the potent uncertainty associated to it could change the fate of European integration by leading to an unparalleled political disunity and instability in the world.

Last but not least, this paper has proved the usefulness of search query data (via Google Trends) as well as the number of tweets (via Twitter) in measuring the attention to "Brexit". Search volume is a practical way to compute the interest given to this event, helping then to determine possible Brexit costs. It should be pointed out that these findings remain preliminary and several extensions appear warranted. It is recommended to conduct further research by employing other measures of attention to Brexit with other Internet-based data in the Big Data Era to reach better paths into this "complex" topic.

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Appendix

Figure A. The attention given to "Brexit" via Google Trends and Twitter

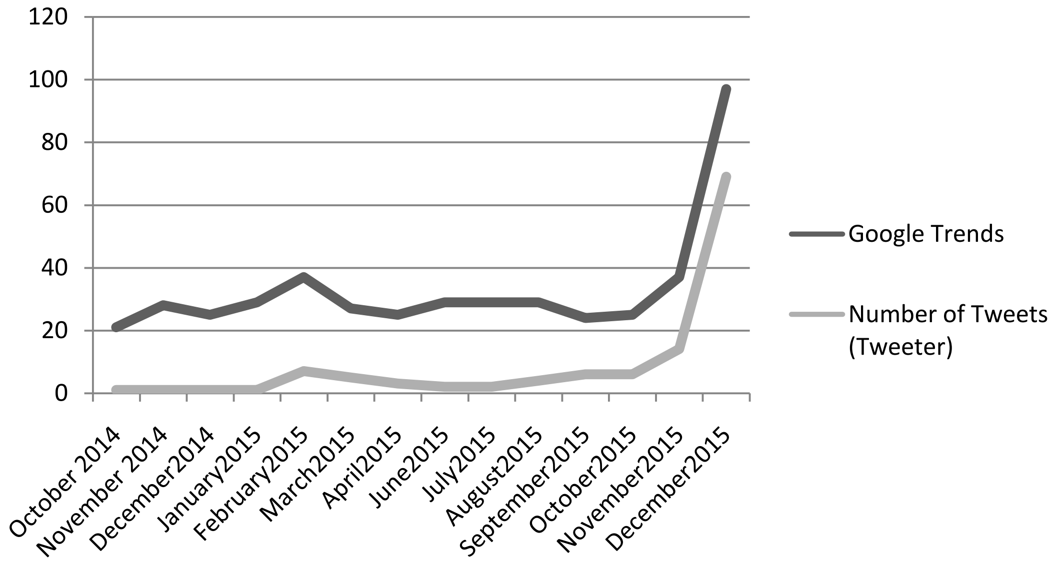
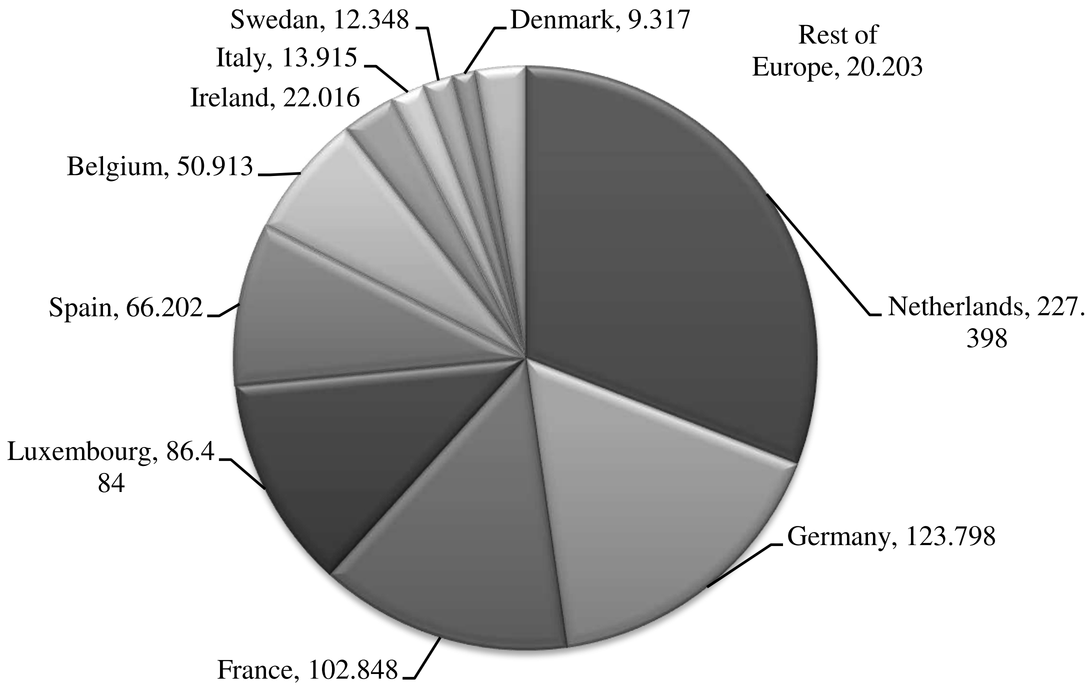


Figure B. Countries of origin for EU FDI stock in UK (in USD millions)



Source: UNCTAD Bilateral FDI Statistics.

Table A. Standard Granger causality test: The causality between Brexit and UK and European stock returns

	UK	Germany	France
H_0: *Brexit* does not-Granger cause *STR*	0.0005***	0.1826	0.0049**

Notes: (.): the p-value; p-value<1%: ***; p-value<5%: **; p-value<10%: *.