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How did EU Stock Markets respond on the Eve of Brexit? A Comparison: Before & During Brexit

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Abstract

This research study examines the response of EU stock markets on the eve of Brexit. Daily data is divided into two sub-periods i.e; before and during Brexit to get a clearer picture. GARCH (1, 1), GARCH-M (1, 1), and EGARCH models are applied to analyze volatility, volatility persistence, deviation in returns, and asymmetric behavior of data in the sample period. The result highlights that stock markets of the UK, Belgium, Netherlands, Portugal, Romania, and Slovenia depicted high volatility during the entire sample period however, volatility increased during the Brexit period. Due to the risk-return swap, the study examined the impact of volatility on returns and observed that stock markets of the UK, Belgium, Croatia, France, Hungary, Italy, Netherlands, Portugal, Romania, Poland, and Spain had positive future returns due to volatility, only before Brexit. Stock markets of all the sample economies are more sensitive to bad news as compared to good news for the whole sample period except for Slovenia and Croatia. The results of the study have implications for investors, policymakers and EU economies.

Keywords: Brexit, Volatility Persistence, Stock Returns

Introduction

Financial deregulations and technological developments have not only lessened transaction and information costs but also lead to integrated and globalized stock markets resulting in diminishing cost of capital, amplifying real investment, and economic growth (Bae, & Zhang, 2015). People get information and respond quickly due to marvelous hi-tech computers and information technology. It is also providing benefit to investors of financial markets around the globe and liquidating the markets as not only investors get and respond to quick information but also, due to speedy information velocity of fluctuation in prices has also expedited. Liquidity is vital for keeping up the worth of traded stocks, so volatility is an indication of highly liquid financial markets (Schwert, 1990).

The time-based change in stock market volatility has gotten the increasing attention of researchers in the past few decades. Volatility in return furnishes important understanding regarding the stream of information among markets (Ross, 1989; Tanizaki and Hamori, 2009). Variation in volatility robustly negatively affects stock returns (Black, 1976) leading stock markets to decline (Malkiel, 1979; Pindyck, 1984). Since 1965, the risk in investors' return on stocks raised due to the variance of firms, which lead huge depression in the market (Pindyck, 1984). From the 1960s to 1980s, expected cash flows and real interest rates were not enough to predict fluctuations in the stock market (Brainard et. al., 1980). In the 1990s financial liberalization after globalization tracked Trans border capital flows and international trade of assets exclusive of limitations within no time. This increased association of nations amplified the effects of spillovers internationally, as a consequence of shock in any economy. After the great depression of the 1930s, the financial crisis from 2007 ~ 2009 initiated in the US financial zone is considered as worst (Classens, Dell'Ariccia, Igan & Laven, 2010) as, it lead sharp decrease in equity markets of emerging economies and widened to European nations, presenting that an event happening in one market has an instant and widespread impact internationally (Dornbusch et al, 2000; Nishimuraa et al., 2018).

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On 23rd June 2016 referendum was held in the UK to get the willingness of British citizens to remain a member of or to leave the EU and the ratio remained 48% to 52% respectively[1]. The event is known as 'British Exit' and abbreviated as Brexit. UK was scheduled to leave EU on 29th March 2019 with 21 month transition period, which was agreed among two parties[2] for smooth the way of post Brexit relations. However, three extensions were accorded to the UK for finalization and approval of an agreement for a future relationship with EU by the Parliament[3] and in that duration, the UK remained a regular member of EU[4]. Finally, on 31st Jan 2020, the UK left the EU with 11 months transition period.

Brexit affected not only the financial markets of the UK but also other EU economies and trading partners of the UK. Several scholars investigated the impact of Brexit on financial markets of different economies in different dimensions. Adesina (2017) checked volatility persistence among stock and exchange markets of the UK and observed a significant increase in volatility persistence in the stock market while a decrease in volatility persistence in the exchange market from pre to post-Brexit period. Oehler et. al. (2017) revealed that in the UK on 24th Jun 2016 negative abnormal returns were observed for both domestic and internationalized firms but the intensity of negative impact was higher for domestic firms as compared to firms having a higher extent of internationalization. Researchers also studied the impact of the intense event on different sectors. Like, Tielmann & Schiereck (2017) considering 107 logistic companies observed that the Brexit vote has harmed the logistic sector on the whole in the EU however, the UK suffered more. Air transportation companies are highly affected as compared to road transport because of numerous flight agreements. Ramiah et. al., (2017) documented that the Banking sector was most negatively affected (-15.37%), life insurance was affected by -8.18%, travel, and leisure by -3.64% while financial services by -3.06% under the umbrella of expected reaction, as a result of Brexit referendum. Some sectors also showed unexpected reactions as, household goods and home construction was affected by -16.81%, real estate investment trusts by -12.19%, construction, and material by -11.06%. Shahzad et. al., (2019) investigated the effect of the Brexit process on the UK stock market and individual firms considering 27 events of the Brexit process. Results revealed that in general, returns of UK firms declined during the whole process however, considerable negative effect during pre-referendums events was observed which became insignificant during post-referendum events.

Utilizing Intraday Volatility Spillover Index Nishimura & Sun (2018) observed increased volatility spillovers among five European stock markets (UK, Germany, France, Spain, and Portugal) in the short run but no impact in the long run, after Brexit. Considering 43 developed and emerging economies foremost indexes from Eurozone, European Union, Europe, BRICS, North and South America, Africa, and Asia. Aristeidis & Elias (2018) investigated the spillover effect of the Brexit referendum and triggering Article 50 by splitting the sample into three sub-periods i.e. pre-referendum, post referendum, and after activation of article 50. The study revealed that volatility rose highly during the pre and post-referendum period relative to the span after activation of Article 50. In general, all stock markets responded negatively and depicted the lowest value in the minute when the result was announced (10:30 AM), which generated instant but insignificant financial contagion due to insufficient interval. Strong contagion was observed in seven countries as a result of the referendum while impact due to activation of Article 50 was limited to Hong Kong, Croatia, and Estonia. Hong Li (2020) investigated volatility spillovers among six European stock markets namely the UK, Germany, France, Italy, Ireland, and Poland from 2015 ~ 2017. The study documented that volatility spillovers increased among stock markets after the Brexit referendum.

Financial markets are required to be investigated deeply from the perspective of portfolio diversification and risk management. The investment decision of corporations and sole investors has the impact of supposed risk which is a consequence of considerable volatilities and spillovers. It is equally important for investors, portfolio managers, and economic policymakers to have exposure to volatility and its threatening effects on financial markets for the proper estimation of market risk, hedging strategies, and proper functioning of equity markets (Lidija and Burhan, 2016). The objective of this research study is to examine the response of UK and EU stock markets in terms of volatility,

[1] https://www.bbc.com/news/politics/eu_referendum/results
[2] https://www.bbc.com/news/uk-politics-32810887
[3] https://europa.eu/newsroom/highlights/special-coverage/brexit_en
[4] https://europa.eu/european-union/about-eu/countries/member-countries/unitedkingdom_en#brexit

risk-return swap, volatility persistence, and asymmetric behavior before and during the Brexit period, subject to availability of data. The span before Brexit covers the time from 1st Jun 2012 ~ 31st Mar 2016 and during Brexit from 1st Apr 2016 ~ 31st Jan 2020. Data were taken not only covers normal but also turbulent times. Sample economies which are UK and EU nations have robust trade and financial attachment, are developed and emerging economies, and suffered from the Brexit event. This research is innovative because of its objective, sample, and tenure taken. Up to the best of our effort, we did not find any study that choose EU economies with this tenure completely focusing on the aforesaid objective. This study will provide investors a better perceptive of market volatility for diversification and hedging and policymakers for formulating economic policies and risk management. Furthermore, it may contribute as a benchmark for EU nations willing to withdraw their membership in the future. If markets are not realized properly inadequate policies may be executed.

Empirical Framework

Returns are calculated as per the following equation:

$$R = \log\ (sp) - \log(sp\ (-1)) \tag{1}$$

R Presents current return, log (sp) presents a log of current stock price and log (sp (-1)) presents a log of previous stock price.

Volatility among EU economies is investigated utilizing ARCH/GARCH (Engle, 1982 & Bollerslev, 1986) models:

$$\partial_t^2 = \omega + \beta(L)\partial_{t-1}^2 + \partial(L) \in_t^2 \tag{2}$$

$\in_t^2\ I\psi_{t-1} \sim N(0, \partial_{t-1}^2)$ Are the novelty in the asset return and $\varpi_{t-1}=\{Y_{t-1}, \varepsilon_{t-1}, Y_{t-2}, \varepsilon_{t-2}\}$ where Y_{t-1} presents the return at time $t-i$ and εi is the error resulting of a regression or an ARMA model fitted to returns. B (L) of order p is the autoregressive and polynomial $\partial(L)$ of order q is the moving average term. ARCH (1) and GARCH (1, 1) give a fair depiction of finitely sampled data. ARCH (1) statistic is:

$$\partial_t^2 = \omega + \alpha \in_{t-1}^2 \tag{3}$$

For an adequate positive conditional variance, variables to satisfy: $\omega > 0$ and $\alpha > 0$. GARCH (1, 1) model is:

$$\partial_t^2 = \omega + \alpha \in_{t-1}^2 + \beta\partial_{t-1}^2\ \omega > 0{,}0\beta \le 1{,}0 < \alpha \le 1, \alpha + \beta \le 1 \tag{4}$$

Α quantifies the degree to which current volatility shock nourishes subsequent period volatility however $\alpha + \beta$ measures volatility persistence over time.

ARCH in the mean model (ARCH-M) was presented by Engle, Lilien, and Robins (1987) which was extended by Bollerslev, Engle, and Wooldridge (1988) to GARCH-M (*GARCH-in-mean*). GARCH-M considers risk-return recompense, as follows (Brooks, 2014, p. 445):

$$Y_t = \mu + \delta\partial_{t-1} + U_t\ , \qquad U_t \sim N(0, \partial_t^2) \tag{5}$$

$$\partial_t^2 = \alpha_o + \alpha_1 U_{t-1}^2 + \beta\partial_{t-1}^2 \tag{6}$$

Δ explains risk premium; positive and significant δ presents increased risk and directs an increase in mean return.

Symmetric GARCH is unable to express some important attributes regarding data due to supposition of the symmetric response of volatility against good and bad news (Brooks, 2014). So, a different GARCH model (equation 4) has been suggested which adjusts the conditional variance. AGARCH, TGARCH, and EGARCH statistics acknowledge the asymmetry of good and bad news (Alexandar, 2008). AGARCH and TGARCH just enhance the GARCH equation to depict the asymmetric behavior of data. The EGARCH statistic presented by Nelson (1991) identifies the log of conditional volatility and did not need parameter constraints. EGARCH model is:

$$\ln(\partial_t^2) = \omega + \beta \ln(\partial_{t-1}^2) + \gamma \frac{\epsilon_{t-1}}{\sqrt{\partial_{t-1}^2}} + \alpha \left\{ \frac{I \epsilon_{t-1} I}{\sqrt{\partial_{t-1}^2}} - \sqrt{2/\pi} \right\} \quad (7)$$

Ω, β and *γ* are constants. The EGARCH parameter is asymmetric as the extent of $\varepsilon_{t-1/}$ $1/ \alpha_{t-1}^2$ is incorporated with *the γ* coefficient, which is generally negative. The differences among GARCH and EGARCH parameters (Engle & Ng, 1993, pp. 1752, 1753) are:

i. The EGARCH parameter demonstrates good and bad news distinctly on volatility
ii. The EGARCH parameter also recognizes big news to have a higher effect on volatility as compared to the GARCH parameter.

Data & Basic Statistics

Daily stock prices from websites of yahoo finance and investing.com are extracted. Data is divided into two equal parts i.e. before Brexit (1st Jun 2012 ~ 31st Mar 2016) and during Brexit (1st Apr 2016 ~ 31st Jan 2020).

Tables 1 and 2 depict the descriptive statistics of EU nations before and during the Brexit period, respectively. Selected economies have positive daily stock returns except for Poland in the pre-Brexit period. Slovenia has the highest while Portugal has the lowest daily mean return. Austria has the highest while Croatia has the lowest volatility. During the Brexit period, all the stock markets have positive but lowest returns as compared to the pre- Brexit period except for Austria, Greece, Poland, Portugal, Romania, Slovenia, and the UK. Kurtosis is positive and more than 3 for all stock markets depicting leptokurtic distribution in pre and during the Brexit period. The Jarque-Bera statistic rejects the normality of returns for all the selected economies in both spans. All the stock markets are negatively skewed except for Denmark in pre-Brexit and Slovenia during both periods.

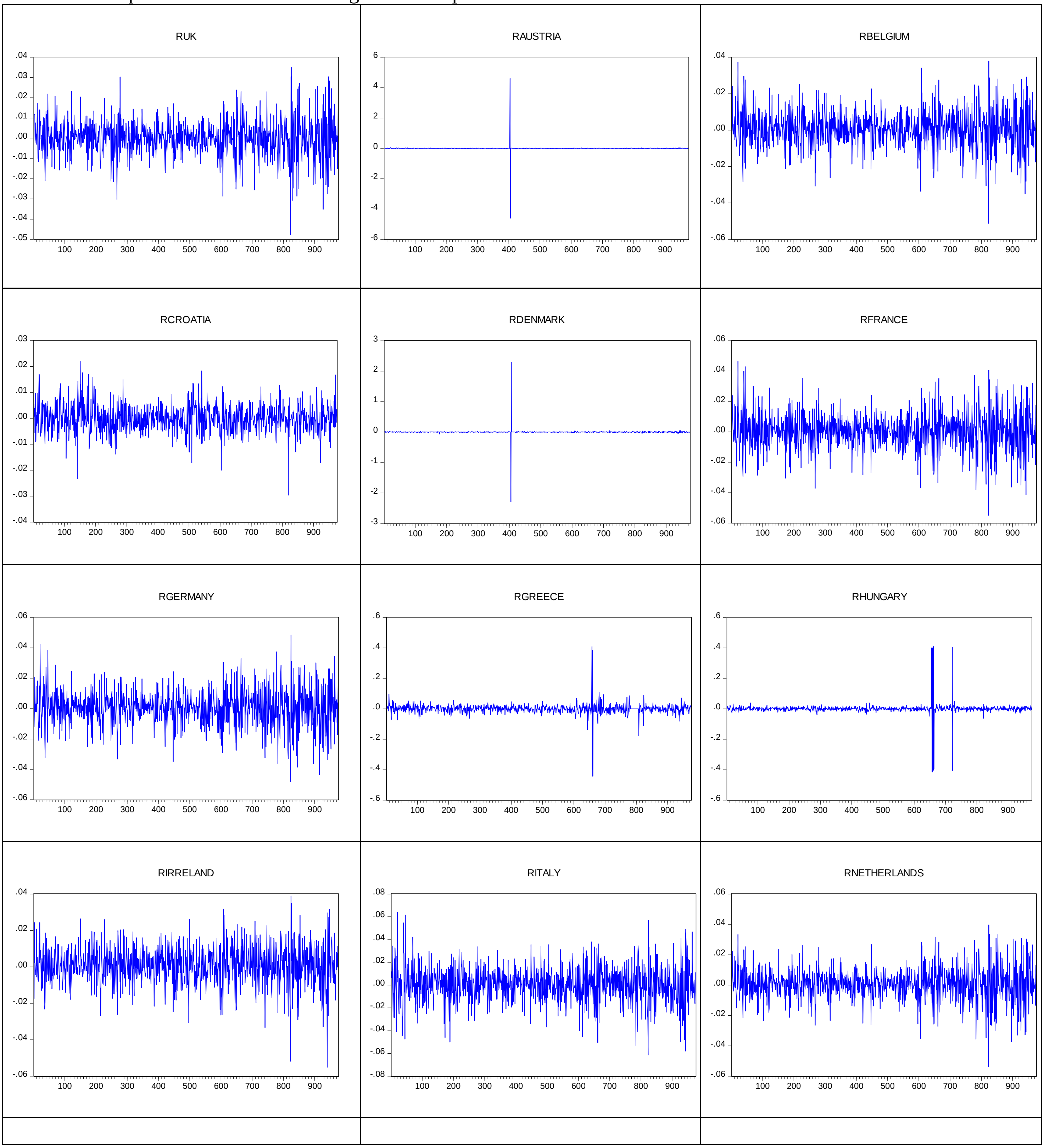
	AUSTRIA	BELGIUM	CROATIA	DENMARK	FINLAND	FRANCE	GERMANY	GREECE	HUNGARY	IRRELAND	ITALY	NETHERLANDS	POLAND	PORTUGAL	ROMANIA	SLOVENIA	SPAIN	SWEDEN	UK
Mean	0.000203	0.000509	2.61E-05	0.000849	0.000596	0.000406	0.000512	0.000186	0.000486	0.000758	0.000361	0.000450	-4.03E-05	0.000123	0.000395	0.002653	0.000373	0.000359	0.000164
Median	0.000571	0.000494	-0.000183	0.001239	0.000549	0.000722	0.001009	0.000563	0.000509	0.000682	0.000000	0.000559	9.83E-05	0.000444	0.000417	3.39E-05	0.000969	0.000734	0.000469
Maximum	4.602662	0.038015	0.021995	2.301940	0.037080	0.046411	0.048521	0.409516	0.410605	0.038934	0.063860	0.039708	0.035258	0.046042	0.034127	2.308785	0.058835	0.039563	0.034976
Minimum	-4.607689	-0.051225	-0.029612	-2.289829	-0.053690	-0.054932	-0.048165	-0.444432	-0.415358	-0.055109	-0.061434	-0.053784	-0.058254	-0.059780	-0.065318	-0.053138	-0.060008	-0.046036	-0.047795
Std. Dev.	0.209009	0.010110	0.005280	0.104652	0.011733	0.012196	0.011948	0.035330	0.042516	0.010435	0.015722	0.010674	0.010510	0.013551	0.008457	0.074520	0.014060	0.010520	0.008985
Skewness	-0.038925	-0.131018	-0.023108	0.147186	-0.149038	-0.106206	-0.165162	-0.741337	-0.126336	-0.339075	-0.084565	-0.194636	-0.281792	-0.382509	-0.729394	30.44127	-0.096350	-0.120661	-0.221370
Kurtosis	484.4450	4.609784	5.122923	476.1533	3.929496	4.451810	4.213789	77.31688	85.53241	4.816780	4.418681	4.945902	5.186557	4.135383	9.604801	942.6002	4.828964	4.601218	5.179280
Jarque-Bera	9416439.	108.0652	183.1756	9094885.	38.70801	87.46037	64.28491	224461.1	276723.8	152.7735	82.92624	159.9841	207.1330	76.14530	1858.653	36016304	137.4036	106.5243	200.9019
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	0.198178	0.496016	0.025478	0.827657	0.581018	0.396239	0.499024	0.181084	0.473703	0.738713	0.352099	0.438861	-0.039299	0.119971	0.384911	2.587088	0.363440	0.350440	0.160325
Sum Sq. Dev.	42.54886	0.099554	0.027154	10.66722	0.134076	0.144880	0.139038	1.215731	1.760653	0.106062	0.240759	0.110972	0.107587	0.178865	0.069668	5.408879	0.192538	0.107802	0.078625
Observations	975	975	975	975	975	975	975	975	975	975	975	975	975	975	975	975	975	975	975

Table 1. Descriptive Statistics-Before Brexit

	AUSTRIA	BELGIUM	CROATIA	DENMARK	FINLAND	FRANCE	GERMANY	GREECE	HUNGARY	IRRELAND	ITALY	NETHERLANDS	POLAND	PORTUGAL	ROMANIA	SLOVENIA	SPAIN	SWEDEN	UK
Mean	0.000353	0.000168	0.000196	0.000160	0.000296	0.000331	0.000321	0.000468	0.000587	0.000142	0.000295	0.000345	6.89E-05	4.42E-05	0.000407	0.000325	0.000112	0.000291	0.000189
Median	0.000505	0.000457	0.000320	0.000512	0.000595	0.000459	0.000904	0.000945	0.000747	0.000256	0.000824	0.000860	-2.83E-05	0.000210	0.000670	0.000190	0.000295	0.000674	0.000502
Maximum	0.038188	0.030667	0.022825	0.026154	0.031861	0.040604	0.033755	0.059118	0.039199	0.044466	0.046645	0.034328	0.034220	0.031832	0.068169	0.034698	0.036875	0.031769	0.035149
Minimum	-0.073023	-0.066132	-0.031112	-0.054581	-0.087509	-0.083844	-0.070673	-0.144131	-0.045562	-0.104164	-0.133314	-0.058731	-0.046396	-0.072468	-0.118920	-0.027937	-0.131853	-0.088003	-0.032839
Std. Dev.	0.009516	0.008356	0.005401	0.009153	0.009048	0.008842	0.009188	0.013105	0.009102	0.009908	0.011950	0.007988	0.010334	0.008479	0.008742	0.005827	0.010049	0.009055	0.007406
Skewness	-0.626886	-0.831694	-0.645271	-0.678925	-0.934828	-0.968530	-0.639068	-1.367822	-0.158170	-1.704441	-1.415942	-0.721932	-0.094328	-0.675317	-2.600212	0.029933	-2.363453	-1.080138	-0.192560
Kurtosis	7.908920	8.482001	8.311419	5.723794	12.19846	12.77324	7.643532	19.41875	4.249031	20.61598	19.82319	7.596326	3.721437	9.067122	45.41993	5.384418	34.18019	12.59054	5.396549
Jarque-Bera	1015.012	1297.726	1181.373	366.2670	3483.909	3925.239	917.2092	10955.37	65.64503	12730.18	11508.18	917.7998	21.98764	1527.660	72222.65	224.9539	39326.07	3821.512	232.9701
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	0.334861	0.159119	0.185898	0.151402	0.280937	0.314397	0.304629	0.444402	0.557257	0.134481	0.280157	0.327535	0.065356	0.041917	0.386144	0.308189	0.105945	0.276521	0.179358
Sum Sq. Dev.	0.085837	0.066187	0.027655	0.079421	0.077606	0.074113	0.080033	0.162819	0.078533	0.093057	0.135380	0.060496	0.101248	0.068149	0.072456	0.032191	0.095735	0.077728	0.051996
Observations	949	949	949	949	949	949	949	949	949	949	949	949	949	949	949	949	949	949	949

Table 2. Descriptive Statistics-During Brexit

Fig. 1 & 2 present visual diagrams of daily return series in pre and during Brexit period for selected economies, respectively. Volatility clustering is depicted in the selected economies except for Austria and Denmark in a pre-Brexit period which will be excluded from the sample. Moreover, graphs of Greece and Hungary are depicting very low volatility clustering before Brexit. Volatility clustering is depicted in the entire sample economies during Brexit. Moreover, it is depicted that volatility in the sample economies hiked during the Brexit period.



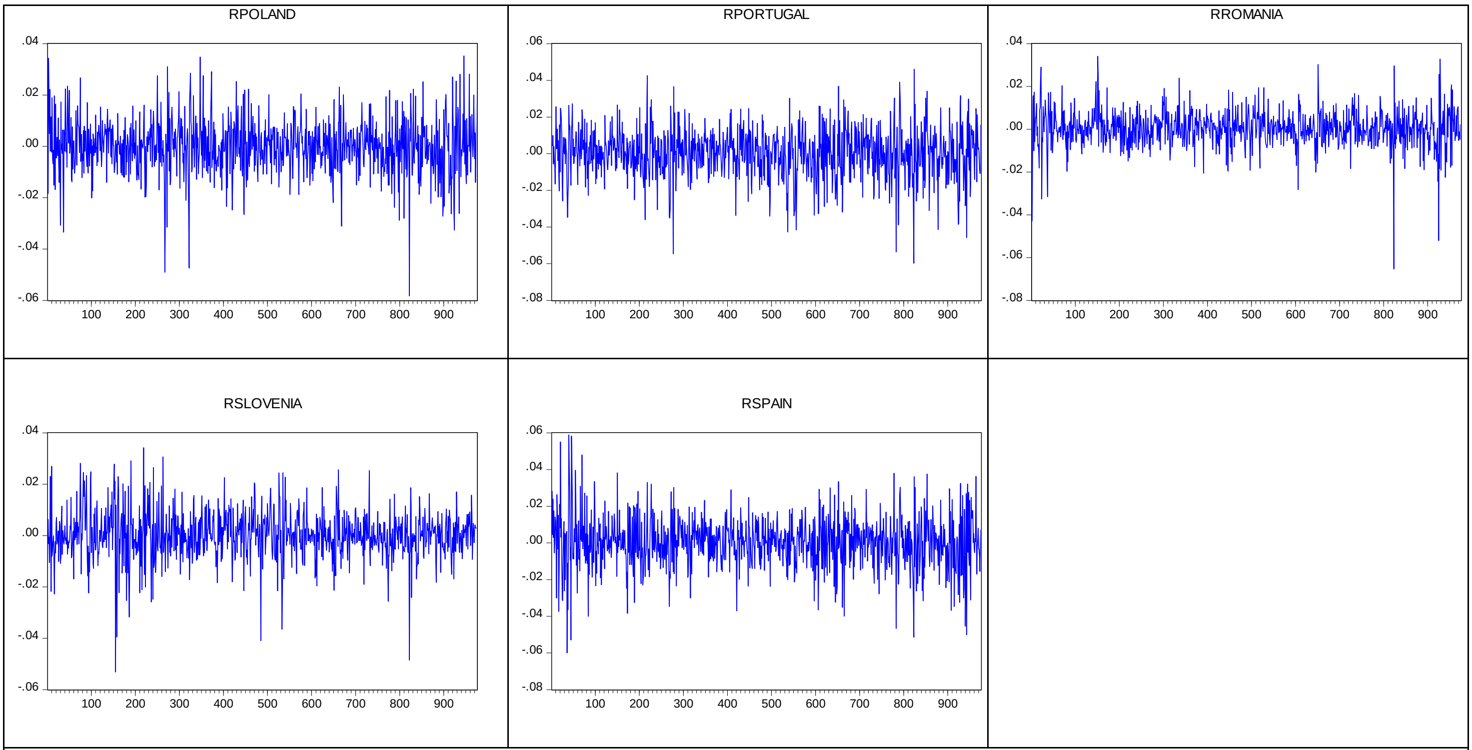
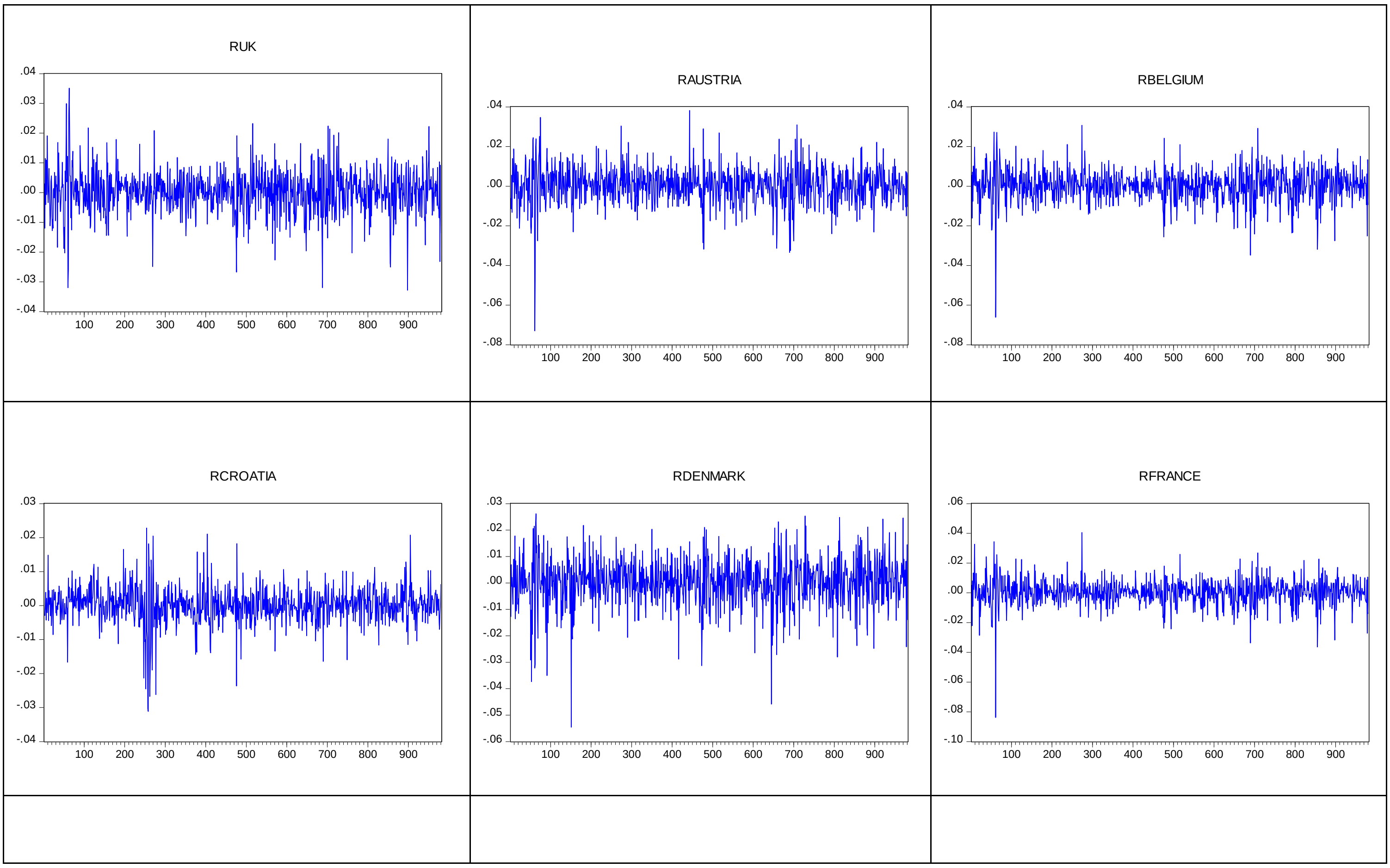


Fig. 1 Graphs of daily returns of selected economies-Before Brexit



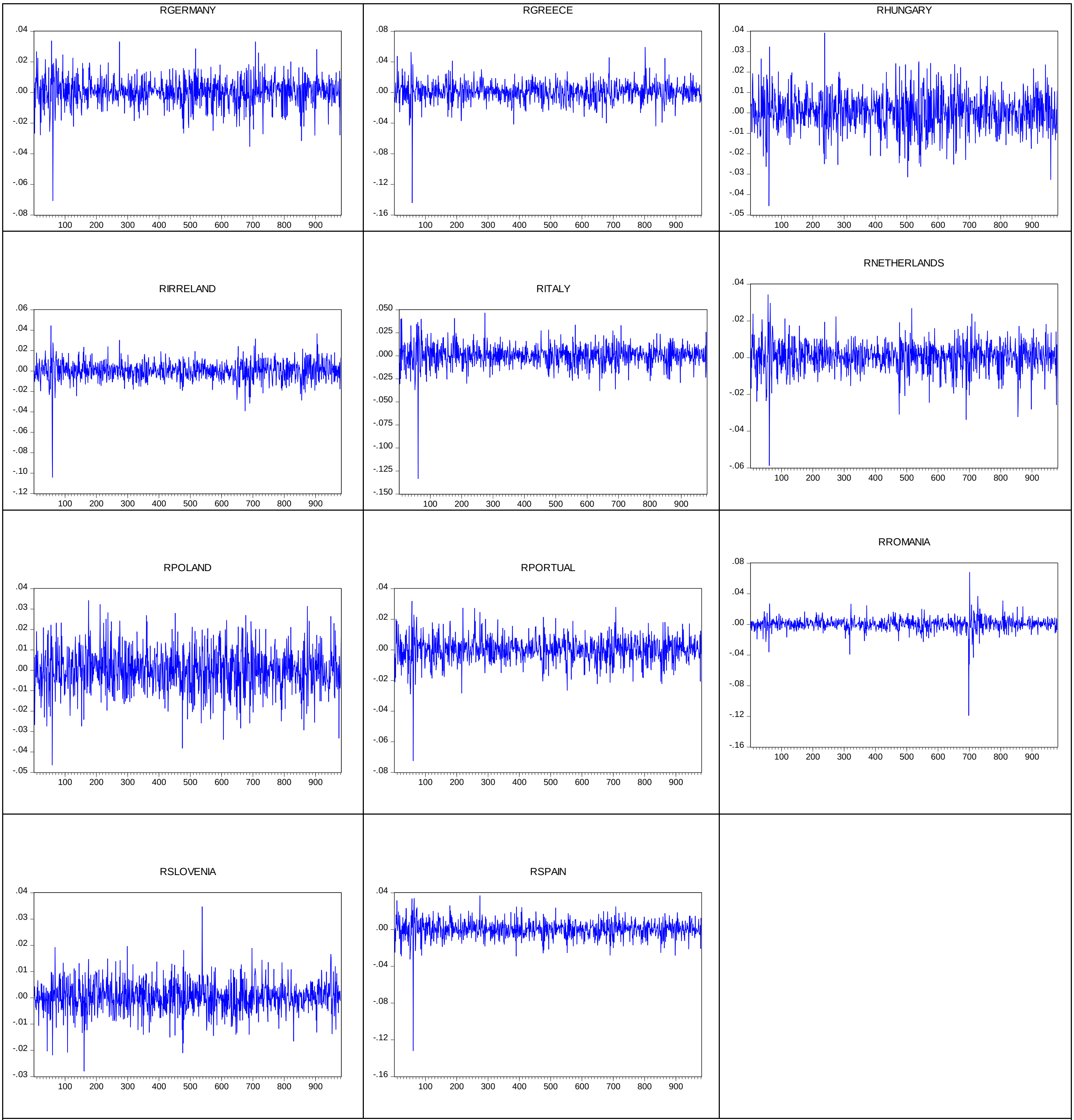


Fig. 2 Graphs of daily returns of selected economies-During Brexit

Findings & Discussion

Volatility Persistence

Volatility persistence defines the nature of volatility and whether the volatility of the previous period affects current volatility. Generally, GARCH (1, 1) model is used to examine volatility persistence. If the total of ARCH and GARCH terms is adjacent to one, the effects of shocks will dissolve gradually, the smaller the value, the speedily the shocks will dissolve. The value of the Arch parameter varies from 0.05 (for secure and safe market) to 0.1 (for tense market). So α determines up to which level shocks of today's returns transfer to the volatility of subsequent period. $\alpha + \beta$ quantifies how long this effect will remain. GARCH parameter (β) depicts the impact of past shocks on returns in long run and varies from 0.85 ~ 0.98.

Before Brexit

Table 3 shows volatility persistence for sample economies before Brexit. The table presents extreme stock movements in Hungary, Romania, Slovenia, the UK, Portugal, Belgium, and the Netherlands. Next Ireland and Germany. Spain, Italy, Greece, and Poland indicate stable volatility in the short run. The GARCH effect in the sample economies ranges from 0.92 in Croatia to 0.63 in Romania. Collective ARCH and GARCH terms of Croatia (0.96), France (0.97), Germany (0.98), Greece (0.98), Italy (0.95), Netherlands (0.96), Poland (0.97), and Spain (0.96) are near to one exhibiting that here effects of volatility will move away slowly. UK (0.94), Belgium (0.93), Ireland (0.92), Portugal (0.88), Romania (0.81), and Slovenia (0.86) have less volatility persistence and the effects of shocks will move away speedily. The stock market of Hungary (1.29) is indicating abnormal behavior.

Table 3. Volatility Persistence-Before Brexit

	UK	Belgium	Croatia	France	Germany	Greece	Hungary	Irreland
Arch(-1) (α)	0.137386 (0.0000)	0.120419 (0.0000)	0.037259 (0.0001)	0.083551 (0.0000)	0.085113 (0.0000)	0.068258 (0.0000)	0.476677 (0.0000)	0.088397 (0.0000)
Garch(-1) (β)	0.810251 (0.0000)	0.812230 (0.0000)	0.927929 (0.0000)	0.887644 (0.0000)	0.896922 (0.0000)	0.917595 (0.0000)	0.816768 (0.0000)	0.833941 (0.0000)
α + β	0.947	0.932	0.965	0.9711	0.9820	0.9858	1.2934	0.922
	Italy	**Netherlands**	**Poland**	**Portugal**	**Romania**	**Slovenia**	**Spain**	
Arch(-1) (α)	0.069790 (0.0000)	0.106518 (0.0000)	0.051422 (0.0000)	0.113807 (0.0000)	0.182754 (0.0000)	0.163879 (0.0000)	0.072869 (0.0000)	
Garch(-1) (β)	0.882628 (0.0000)	0.861291 (0.0000)	0.921720 (0.0000)	0.773651 (0.0000)	0.636762 (0.0000)	0.702046 (0.0000)	0.895066 (0.0000)	
α + β	0.952	0.967	0.973	0.887	0.819	0.865	0.967	

During Brexit

Table 4 shows volatility persistence for sample economies during Brexit. Stock markets of UK (0.17), Austria (0.10), Belgium (0.144), France (0.19), Germany (0.10), Greece (0.10), Ireland (0.12), Italy (0.13), Netherlands (0.17), Portugal (0.15), Romania (0.47), Slovenia (0.97) and Spain (0.13) depicts extremely high volatility in short run. Croatia (0.07), Denmark (0.07), and Hungary (0.07) depicted moderate volatility in the short run. The long-term impact of past shocks on returns quantified by GARCH ranges from 0.92 in Poland to 0.49 in Romania. However, UK (0.64), Belgium (0.76), Denmark (0.75), France (0.73), Ireland (0.79), Netherlands (0.71) and Portugal (0.70) has less volatility in long run. Collective ARCH and GARCH terms of Hungary (0.95), Romania (0.96), and Slovenia (0.99) are near to one exhibiting high volatility persistence. Austria (0.92), Belgium (0.91), Croatia (0.92), France (0.92), Germany (0.93), Greece (0.92), Ireland (0.92), Italy (0.93), Poland (0.94) and Spain (0.93) has moderate volatility persistence however, UK (0.82), Denmark (0.82), Netherland (0.89) and Portugal (0.85) depicts low volatility persistence.

Table 4. Volatility Persistence-During Brexit

	UK	Austria	Belgium	Croatia	Denmark	France	Germany	Greece	
Arch (-1) (α)	0.177325 (0.0000)	0.109118 (0.0000)	0.144001 (0.0000)	0.078571 (0.0000)	0.074730 (0.0000)	0.192388 (0.0000)	0.107943 (0.0000)	0.105790 (0.0000)	
Garch (-1) (β)	0.648262 (0.0000)	0.813559 (0.0000)	0.767143 (0.0000)	0.841613 (0.0000)	0.753675 (0.0000)	0.734799 (0.0000)	0.822583 (0.0000)	0.822586 (0.0000)	
α + β	0.825	0.922	0.9111	0.920	0.828	0.927	0.930	0.928	
	Hungary	**Irreland**	**Italy**	**Netherlands**	**Poland**	**Portugal**	**Romania**	**Slovenia**	**Spain**
Arch (-1) (α)	0.078542 (0.0000)	0.125242 (0.0000)	0.135492 (0.0000)	0.174118 (0.0000)	0.025017 (0.0597)	0.157055 (0.0000)	0.473791 (0.0000)	0.972137 (0.0000)	0.131231 (0.0000)
Garch (-1) (β)	0.879426 (0.0000)	0.799826 (0.0000)	0.800720 (0.0000)	0.716182 (0.0000)	0.920298 (0.0000)	0.700549 (0.0000)	0.495935 (0.0000)	0.026573 (0.7453)	0.801130 (0.0000)
α + β	0.957	0.925	0.936	0.89	0.945	0.857	0.96977	0.99	0.93

GARCH in Mean (1, 1)

GARCH-in-Mean is applied to investigate whether rise in volatility directs increase in future returns of selected economies in the sample period.

Before Brexit

Table 5 presents results of GARCH-M (1, 1) statistics before Brexit. The coefficient of conditional standard deviation (δ) in the mean equation is statistically significant at the level of 5% and positive for the UK, Belgium, Croatia, France, Hungary, Italy, Netherlands, Portugal, Romania, and significant at the level of 10% for Poland and Spain presenting that hike in volatility in these economies will also lead a hike in future returns.

Table 5. GARCH-M (1, 1)-Before Brexit

	UK	Belgium	Croatia	France	Germany	Greece	Hungary	Ireland
@SQRT(GARCH) (δ)	0.357505 (0.0082)	0.361213 (0.0225)	0.861967 (0.0110)	0.332093 (0.0223)	0.154074 (0.2298)	0.164444 (0.2246)	0.096261 (0.0000)	0.131330 (0.5356)
	Italy	**Netherlands**	**Poland**	**Portugal**	**Romania**	**Slovenia**	**Spain**	
@SQRT(GARCH) (δ)	0.410227 (0.0267)	0.276585 (0.0348)	0.374275 (0.0675)	0.473176 (0.0331	0.386798 (0.0358)	-0.094461 (0.5456)	0.281229 (0.0763)	

During Brexit

Table 6 presents the result of GARCH-M (1, 1) statistics during Brexit. GARCH-in-Mean (δ) presenting an increase in future returns due to rising volatility is positive only for the UK, Hungary, Italy, Poland, Portugal, Romania, and Slovenia but statistically insignificant for all economies in the sample period.

Table 6. GARCH-M (1, 1)-During Brexit

	UK	Austria	Belgium	Croatia	Denmark	France	Germany	Greece	Hungary
@SQRT(GARCH) (δ)	0.101559 (0.5575)	-0.005029 (0.9764)	-0.089115 (0.5687)	-0.017950 (0.9237)	0.220632 (0.4323)	-0.074801 (0.5407)	-0.006026 (0.9691)	-0.033146 (0.8417)	0.108109 (0.5416)
	Ireland	**Italy**	**Netherlands**	**Poland**	**Portugal**	**Romania**	**Slovenia**	**Spain**	
@SQRT(GARCH) (δ)	-0.065831 (0.6744)	0.107110 (0.4553)	-0.011671 (0.9341)	0.343553 (0.4797)	0.032445 (0.2993)	0.021864 (0.8534)	0.670294 (0.1351)	-0.156471 (0.3351)	

EGARCH

Before Brexit

Table 7 presents the results of the EGARCH model before Brexit. The EGARCH asymmetry term is highly significant and negative for the UK, Belgium, France, Germany, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Romania, and Spain indicating that the sample markets are more responsive to negative news as compared to good news. Bad news shock produces more volatility relative to the good news to some extent.

Table 7. EGARCH-Before Brexit

	UK	Belgium	Croatia	France	Germany	Greece	Hungary	Ireland
RESID(-1)/@SQRT(GARCH(-1)) (γ)	-0.176256 (0.0000)	-0.185566 (0.0000)	-0.001157 (0.9251)	-0.205683 (0.0000)	-0.141211 (0.0000)	0.320885 (0.0000)	-0.608572 (0.0000)	-0.153351 (0.0000)
	Italy	**Netherlands**	**Poland**	**Portugal**	**Romania**	**Slovenia**	**Spain**	
RESID(-1)/@SQRT(GARCH(-1)) (γ)	-0.177691 (0.0000)	-0.201918 (0.0000)	-0.083072 (0.0000)	-0.173725 (0.0000)	-0.093071 (0.0000)	-0.027582 (0.1908)	-0.123108 (0.0000)	

During Brexit

Table 8 presents the results of the EGARCH model during Brexit. The EGARCH asymmetry term is highly significant and negative for all the economies except for Slovenia and Spain in the sample period, again confirming that sample markets are more responsive to negative news as compared to good news and bad news produces more volatility relative to the good news of the same extent.

Table 8. EGARCH-During Brexit

	UK	Austria	Belgium	Croatia	Denmark	France	Germany	Greece	
RESID(-1)/@SQRT(GARCH(-1)) (γ)	-0.142856 (0.0000)	-0.125152 (0.0000)	-0.124161 (0.0000)	-0.033457 (0.0371)	-0.160907 (0.0000)	-0.154699 (0.0000)	-0.131867 (0.0000)	-0.053722 (0.0089)	
	Hungary	**Ireland**	**Italy**	**Netherlands**	**Poland**	**Portugal**	**Romania**	**Slovenia**	**Spain**
RESID(-1)/@SQRT(GARCH(-1)) (γ)	-0.089335 (0.0000)	-0.073639 (0.0000)	-0.086566 (0.0000)	-0.169728 (0.0000)	-0.047428 (0.0248)	-0.095777 (0.0000)	-0.179485 (0.0000)	-0.004173 (0.7797)	-0.026499 (0.2674)

Conclusion and Implications

This research examined the response of EU stock markets before and during Brexit. GARCH (1, 1), GARCH-M (1, 1), and EGARCH statistics are applied to capture facts about the stock returns during the entire period.

Stock markets of the UK, Belgium, Netherlands, Portugal, Romania, and Slovenia depicted high volatility during the entire sample period (before & during Brexit). However, the stock markets of Austria, France, Germany, Greece, Ireland, Italy, and Spain became more volatile during the Brexit period. Market volatility determines the risk involved in financial markets which leads to uncertain returns. Generally, investors desire markets having high returns but high returns always follow high risk. Higher risks investments are recouped with high returns. Furthermore, UK and Portugal have low volatility persistence during both periods. Croatia, France, Germany, Greece, Italy, Netherlands, Poland, and Spain have high volatility persistence before Brexit while Hungary, Romania, and Slovenia have high volatility persistence during the Brexit period.

GARCH-M (1, 1) model depicted that rise in volatility will direct a rise in future returns in the UK, Belgium, Croatia, France, Hungary, Italy, Netherlands, Poland, Portugal, Romania, and Spain only before the Brexit period. It is in line with the findings of Engle et al. (1987). Lim and McNelis (1998) also explored the same results for Japanese and US stock markets and Fabozzi et al. (2004) for Shenzhen and the Shanghai markets. However, it is contradictory to the findings of Panait and Slavescu (2012) and Tah (2013) for Romanian and Kenya's stock markets, respectively.

Finally, EGARCH (1, 1) parameter depicted that all sample markets except for Croatia (before Brexit), Spain (during Brexit), and Slovenia (before & during Brexit) are more responsive to negative news as compared to good news for the entire sample period, which is in line with the findings of Abbas et al, (2013) and Dedi and Yavas (2016).

Investors must examine stock market volatility before taking an investment decision (Rajput et al., 2012). Volatility quantifies the uncertainty and risk attached to a particular market. Variation of volatility in the international financial market may distress the domestic financial market. As high volatility represents a high risk, individual and institutional investors may precept regarding pricing, hedging, and trading securities. Furthermore, shocks in closely linked financial markets may not only limit the benefit of monetary policy but also diminish the possible advantage of international diversification and dispense transmission of volatility shocks. Regulators and Policymakers by estimating this effect may formulate policies. In addition, reaction and patterns of stock markets on the eve of Brexit, especially of UK stock market may be considered as a benchmark for the member economies willing to leave the EU in the future.

It is recommended to extend the study to investigate volatility spillovers on the same pattern. Moreover, a sector-wise study in the terms of volatility, volatility spillover, and asymmetric behavior of EU economies may also give a clearer image.

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