

## *UK Brexit crisis: Modelling Stock Market Volatility Using an Intervention ARIMA Model*

أزمة البريكسيت: نمذجة تقلبات أسواق المال باستخدام تحليل التدخل مع نموذج الإنحدار

الذاتي والمتوسط المتحرك

Mokhtaria Bouziane, djillali liabès university, Laboratory of Innovation and Marketing Management(MIM), mokhtaria.[bouziane@univ-sba.dz](mailto:bouziane@univ-sba.dz).

Kadri Alaeddine, djillali liabès university, [ALLAEDINEKADRI@yahoo.fr](mailto:ALLAEDINEKADRI@yahoo.fr).

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### **Abstract:**

The study aims to demonstrate the immediate effect of Brexit crisis on the stock indices of four countries- US, UK, Germany and France using ARIMA model intervention time series analysis.

The Brexit was not anticipated by the financial markets and its impacts are still ongoing today; on June 23<sup>rd</sup>2016 the financial market witnessed serve turmoil and volatility in their indices. The results show that event had an immediate effect on UK, US index while the Germany and France did not show an immediate significant change.

**keyword:** Brexit; Stock indices; ARIMA model; Intervention Analysis.

**JEL classification code :** C5, G01.

### **ملخص:**

تهدف الدراسة إلى توضيح التأثير الفوري لأزمة البريكسيت على مؤشرات الأسواق المالية لأربع دول، هي: الولايات المتحدة وبريطانيا وألمانيا وفرنسا باستخدام تحليل التدخل (نموذج الإنحدار الذاتي والمتوسط المتحرك). لم تتوقع الأسواق المالية أزمة البريكسيت، فتبعياتها لازالت مستمرة ليومنا هذا، ففي 23 جوان 2016، شهدت الأسواق المالية اضطرابات حادة وتقلبات في مؤشراتنا. وأظهرت نتائج الدراسة أن الحدث كان له تأثير مباشر على كل من مؤشر السوق المالي للمملكة المتحدة والولايات المتحدة، في حين لم تظهر مؤشرات أسواق المال لكل من ألمانيا وفرنسا تغييراً فورياً كبيراً.

**الكلمات المفتاحية:** بريكسيت؛ مؤشرات أسواق المال؛ تحليل التدخل؛ نموذج ARIMA.

**تصنيف JEL:** C5، G01.

Mokhtaria Bouziane, e-mail: [mokhtaria.bouziane@univ-sba.dz](mailto:mokhtaria.bouziane@univ-sba.dz).

## 1. Introduction :

The debate on the UK leaving the European Union is still ongoing today due to many economic, political, social, and other consequences on many different countries over the world.

On 23 June 2016 (51.9% ) of participating voters voted to leave the UK from the European Union, commonly known as the Brexit vote, in March 2017 starting a two-year process that was due to conclude with the UK withdrawing on 29 March 2019.

The decision made by the UK to leave the EU as a result of the referendum commonly known as Brexit, undoubtedly represents a significant shock to the UK economy and a strong blow to the European Union; the result caused huge amount of turbulence in the global financial markets and volatility in their indices stock markets.

The present study is an attempt to understand and quantify the effect of this event on the stock market of major economies of the and examine whether Brexit has led to any significant changes in the degree of persistence of the indices stock exchange of US, UK, Germany and France.

### **Research Questions:**

This study aims to answer the following question: **What are the effects of Brexit crisis on the stock indices markets?**

## 2. REVIEW OF LITERATURE:

The effect of BREXIT is analyzed by many researchers, For (Aloysius & Jyothi, 2017) studied the impact of brexit on the Stock Indices of US, UK and India The results derived indicate that event had an immediate effect only on UK index The study only evaluates the immediate impact and not the long run effect.

For instance (Guglielmo, Luis, & Tommaso, 2018) has fitted an intervention model to the FTSE occasioned by Brexit, by examines the effects of Brexit on uncertainty in European financial markets the results provides evidence of a significant increase in the persistence of all the series considered except the GBP-JPY, which indicates that Brexit has had a noticeable impact.

An ARIMA intervention study has been conducted by (Mohamed, 2018) on GBP PAIRS and FTSE 100 post Brexit, The Brexit vote immediately caused Thus, the result of the research study indicates that

previous ARIMA models can still be used to forecast efficiently post-Brexit daily exchange rat.

Primarily, the paper was aimed at testing the Autoregressive Integrated Moving Average (ARIMA) modelling on indices stock market after Brexit referendum vote.

It is achieved by observing the effects of Brexit on the value of the four indice stock market of of major economies of US, UK, Germany and France, the modelling it using ARIMA technique.

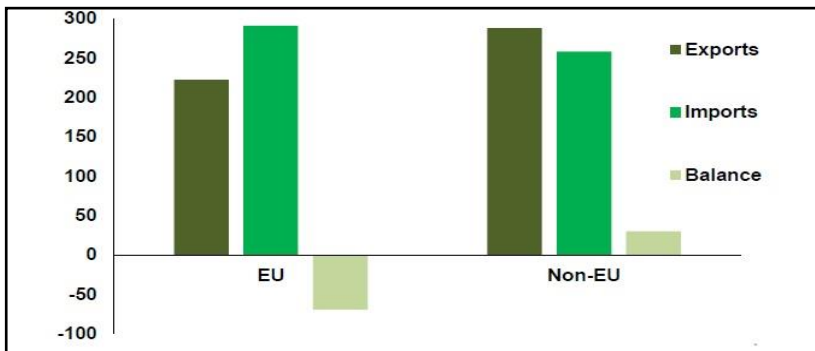
The literature that was conducted reviewed insightful information that was useful in developing the model for the study. First, it confirmed that the Brexit crisis event greatly affected the indice stock market. In particular, it caused the Decrease in the index FTSE by high level of volatility in the financial market .

Secondly, the literature Review shows that ARIMA intervention model is one of the commonly used methods for modelling and forecasting the volatility of indices stock markets in brexit crisis.

### **3. Global Financial Effects of Brexit Crisis:**

Taken the EU is by far the UK’s most important trading partner. In 2015 it accounted for 44% of UK goods and services exports (£222 billion) and 53% of UK imports (£291 billion). These figures are shown in the chart below (Vaughne, 2016, p. 23).

*Figure.1: UK trade with EU and non- EU countries*



*Source: (bulletin, 2016)*

*Table 1: Pattern of Trade between EU Members and UK, 2015*

	Share of UK Exports to EU	Share of UK Imports from EU	UK as share of total exports	EU member as share of UK total
Austria	1.21%	1.31%	3.06%	0.53%
Belgium	8.54%	10.50%	8.92%	3.77%
Bulgaria	0.25%	0.19%	2.55%	0.11%
Cyprus	0.28%	0.03%	10.07%	0.12%
Czech Rep.	1.47%	2.48%	5.25%	0.65%
Germany	23.01%	28.34%	7.43%	10.16%
Denmark	1.71%	1.63%	6.36%	0.75%
Spain	6.46%	6.12%	7.45%	2.85%
Estonia	0.16%	0.10%	2.58%	0.07%
Finland	1.01%	0.82%	4.94%	0.45%
France	13.33%	10.81%	6.27%	5.89%
Greece	0.66%	0.36%	4.25%	0.29%
Croatia	0.10%	0.07%	1.72%	0.05%
Hungary	0.96%	1.15%	3.88%	0.42%
Ireland	12.56%	5.05%	13.66%	5.55%
Italy	6.37%	7.30%	5.53%	2.81%
Lithuania	0.20%	0.34%	4.46%	0.09%
Luxembo	0.16%	0.14%	3.88%	0.07%
Latvia	0.16%	0.16%	5.12%	0.07%
Malta	0.28%	0.05%	6.45%	0.12%
Netherlan ds	12.97%	12.73%	8.98%	5.73%
Poland	2.73%	4.02%	6.81%	1.20%
Portugal	0.94%	1.13%	6.72%	0.41%
Romania	0.73%	0.78%	4.36%	0.32%
Slovakia	0.33%	1.27%	5.54%	0.15%
Slovenia	0.15%	0.18%	2.23%	0.07%
Sweden	3.25%	2.93%	7.19%	1.44%
Total	100.00%	100.00%	6.99%	44.16%

*Source: (Martina & Edgar, 2016, p. 8).*

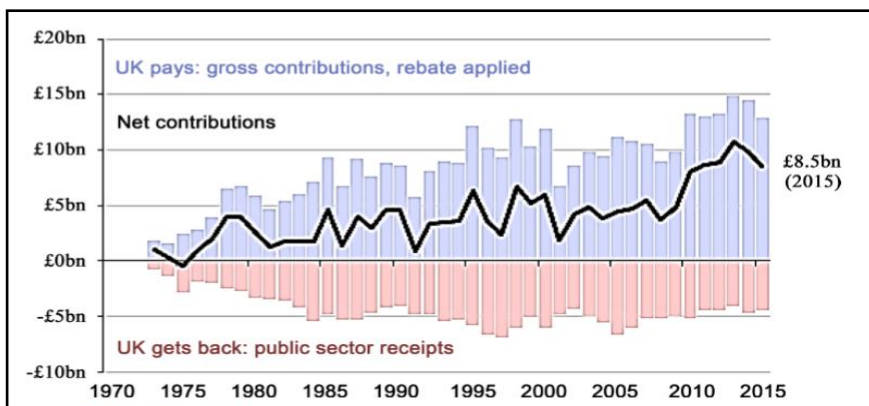
London hosts some 358 banks, many insurance companies and institutional investors, hedge funds and specialized finance providers, and is now also spearheading the growth of fintech companies. It is home to the largest stock exchange in the EU, the most developed derivative market and related clearing and settlement infrastructures (Karel, 2016, p. 2).

The UK’s departure from the EU will have a major impact on the European economy.

Based on agreements financial activities between the UK and the EU are especially affected. After Brexit, most activities will no longer be possible or their regulatory basis too unsecure to rely on it (Michaela & Christian, 2018, p. 8).

The results of the referendum caused "volcanic eruption" across the global financial markets a day after the referendum. This is because many people never expected this outcome (Isaac, Yinping, Braimah, & Ramous, 2016, p. 289).

**Figure.2:** UK payment to US budget



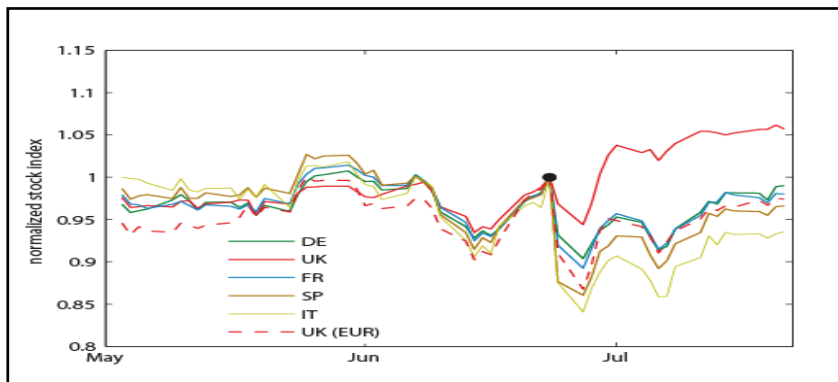
*Source: (Full, 2019)*

The costs and benefits of Britain’s membership of the European Union was a controversial issue even before the decision was taken to hold a referendum.

In 2018 the government spent £864.9 billion on all aspects of public spending, and the UK abatement was £4.5 billion. This means £15.5 billion was transferred from the UK government to the EU in official payments

The Office for National Statistics (ONS) reports that £4.5 billion came back to the UK public sector in credits in 2018.

**Figure.3:** Brexit risk effect financial markets in the United Kingdom and the euro area

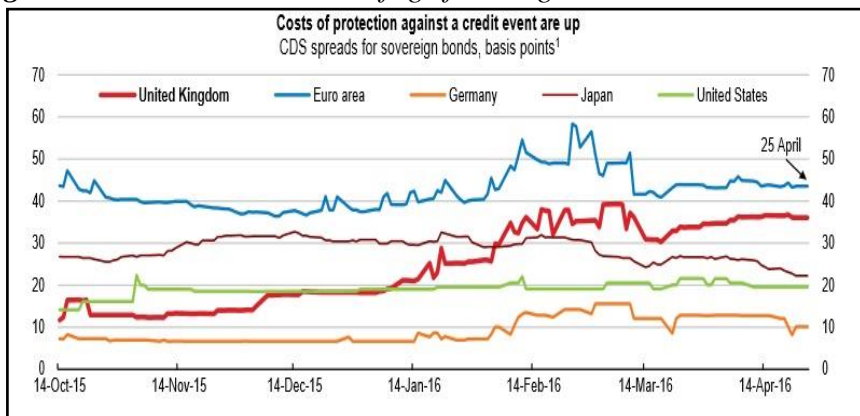


*Source:* (Rafal, Nigel, Elena, & Sanne, 2016, p. 11).

The risk of Brexit is increasingly reflected in financial asset prices. The cost of insuring UK public debt against sovereign default has been rising since 14 October. We can say that CDS spreads remain low relative to the financial crisis period, but their increase since mid-October is significant and higher than for peers.

CDS spreads have also edged up in the euro area. For the UK, the rise reflects investors fears rather than a genuine risk of sovereign default following Brexit, Equity prices in the UK and the euro area have rebounded less than in the US, but remain resilient as many listed companies are global (Rafal, Nigel, Elena, & Sanne, 2016, p. 10).

**Figure.4:** Brexit stock indices of tge five largest EU stock markets

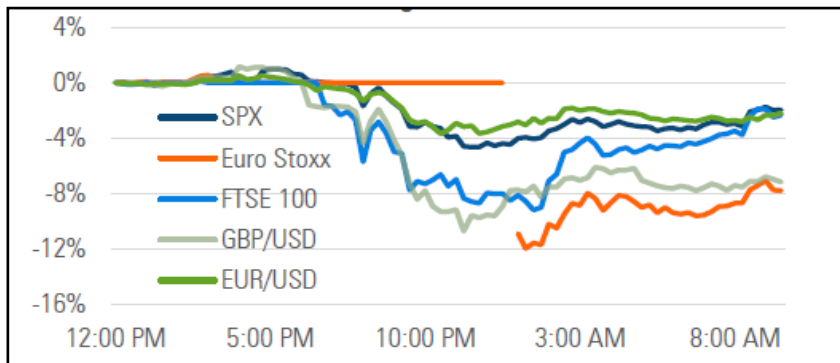


*Source:* (Matthias, 2016, p. 4).

From the figure above we can see the European stock market indices were in a slight upward movement in the first half of 2016 until the beginning of June. After the Brexit vote stock prices dropped by around (10%) and have since then only slowly returned to mid June levels, the day of the Brexit vote is marked by black dot (Matthias, 2016, p. 4).

The Brexit sent waves of shocks across the global financial system. Global stock markets wiped about \$2 trillion in value The FTSE retraced about (9%) Dow Jones plummeted (3.5%) the NASDAQ composite index dropped by (4%) (Akram & Murad, 2018, p. 1), Germany Dax index closed down nearly (7%) (Isaac, Yinping, Braimah, & Ramous, 2016, p. 300).

**Figure.5:** cumulative change day of the Brexit vote



*Source:* (Joe, Adam, & Jeff, 2016, p. 2).

The pound has devalued by 11% against other major currencies— an indication that foreign investors have less confidence in the UK’s economic prospects (Gemma & Alex, 2018, p. 9).

More specifically, on the 27th of June 2016 the pound fell to £1.315 to the U.S.dollar, reaching its 31-year low since 1985, below the value of sterling’s Black Wednesday of 1921(Vasilios, Rangan, & Mark, 2017, p. 2).

#### **4. Econometric Analysis:**

##### **4.1 Methodology:**

Let  $[X_t]$  be a time series encountering an intervention at time  $t=T$ . Box and Tiao (1975) proposed that the pre-intervention part of the series be modeled by ARIMA techniques. That is, for  $t < T$ , suppose that the ARIMA (p, d, q) model (Ette & Unyime, 2018, p. 48)

The ARIMA (p,d,q) model (Gujarati, y Porter, & Gunasekhar, 2012, p. 873) of a time series refers to the model which is stationary at level with autoregressive terms and q moving average terms. It may be denoted by:

$$\theta(B)(1 - b)^d Y_t = \theta(B)\varepsilon_t$$

Where  $\Phi(B) = 1 - \Phi_1 B - \Phi_2 B^2 \dots - \Phi_p B^p$  (Autoregressive parameter)

$\theta(B) = 1 - \theta_1 B - \theta_2 B^2 \dots - \theta_q B^q$  (Moving Average parameter)

$\varepsilon_t$  – is the noise term and B is the backshift operator.

The intervention model has two components- the noise component which represents the pre-intervention period and the intervention component that incorporates the effect of the intervention in the model. It may be represented as: (Aloysius & Jyothi, 2017, p. 2)

$$Y_t = \frac{\omega(B)}{\delta(B)} B_b I_t + \frac{\theta(B)}{\phi(B)} \varepsilon_t$$

Where:

**Y<sub>t</sub>**: the response series

**I**: the indicator variable (dummy variable)

**ω(B)**: the slope parameter

**δ(B)**: the impact parameter

**φ(B)**: the autoregressive parameter (AR)

**θ(B)**: the moving average (MA)

#### 4.2 DATA Description:

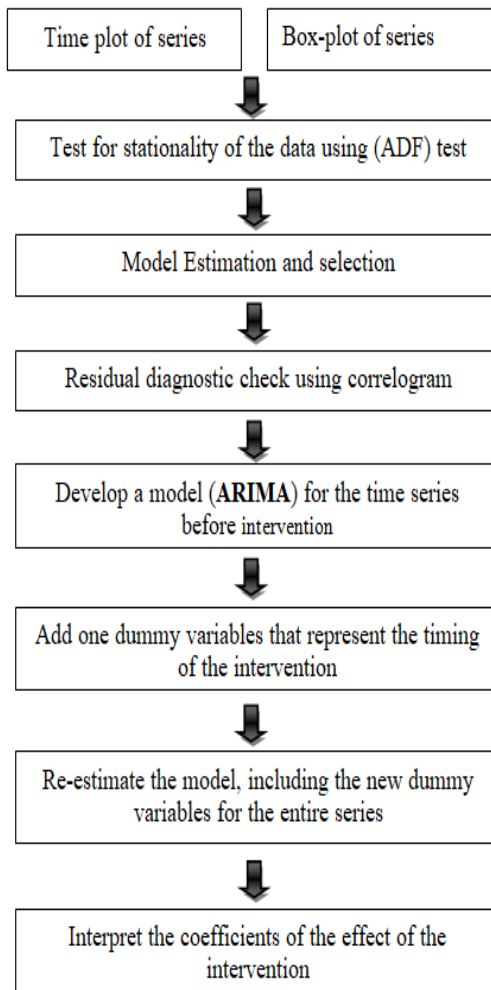
We considered the Brexit crisis to be the major event affecting the stock markets in EU countries the period under study, The data used in the study includes pre and post stock indices of four economies- Britain, France, Germany and the United States.

The daily index of **SandP**, **FTSE**, **CAC** and **DAX** are collected from June 23rd 2015 to June 23rd 2016 as pre- intervention period and from 24 June 2016 to June 23rd 2017 as post-intervention period

It is worth noting here that the Brexit referendum was on Thursday, 23 June, but the results were released on Friday, 24th and both are trading days.



**Figure.6: Step involving ARIMA model Intervention**

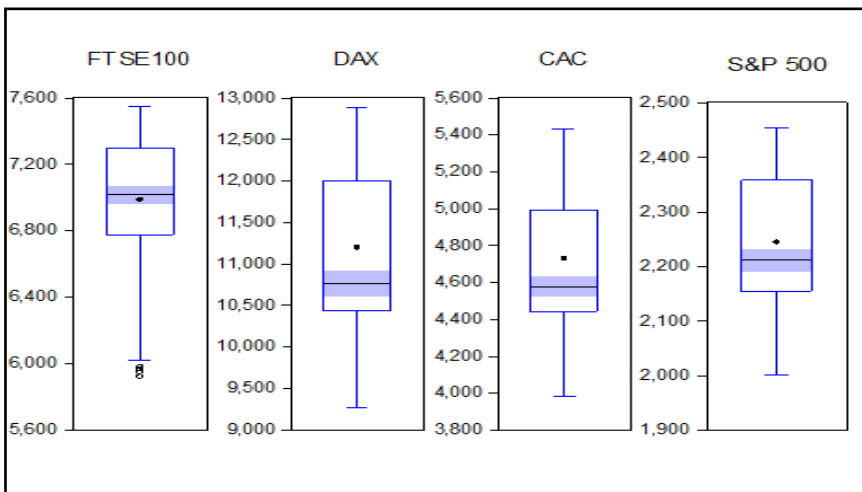


**Source: Authors' Construct.**

### 4.3 Descriptive analysis:

In the descriptive analysis, a brief description that summarised the whole dataset is provided; the descriptive analysis of the four indices is carried out Box-plots of four sets of indices presented in Figure (7).

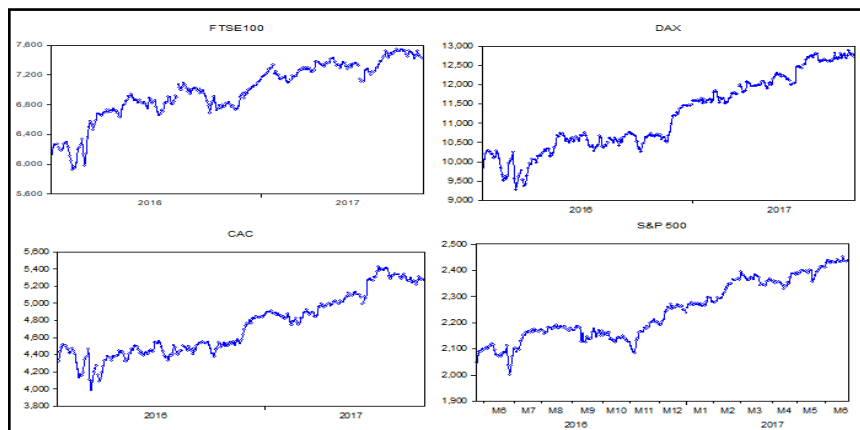
*Figure.7: Box-plot of the four indices*



*Source: Data Processed EViews.10.*

The series is A Daily Closing prices of financial markets indices from 23 May 2016 to 23 June 2017 The researcher used **Eviews 10** in the statistical analysis.

Figure.8: Time plot of the four indices



Source: Data Processed EViews.10.

From time series plot of a realization of daily indice stock markets we noticed an irregular movement, with two sudden jumps the first in the period 23 June 2016 the effect of the Brexit vote, therefore there is two intervention points.

Table 2: Descriptive statistics of the pre and post Brexit data

	FTSE		dax		cac		SandP	
	Pre	post	Pre	post	Pre	post	Pre	post
Average	6 178,9	7 062,33	9977,7	11307,26	4353,3	4762,3	2094,3	2259
SD	119.17	298.68	259.55	930.34	122.74	351.22	17.36	108.04
Skewness	-0.93	-0.39	-0.71	0.04	-0.77	0.22	-0.41	0.096
Kurtosis	2.66	2.86	2.08	1.86	2.27	1.94	2.90	1.74
Jarque-Bera	3.42 (0.18)	<b>6.59*</b> (0.03)	2.76 (0.25)	<b>13.51*</b> (0.001)	2.76 (0.25)	<b>13.64*</b> (0.001)	0.65 (0.72)	<b>16.75*</b> (0.0002)
N	24	248	24	248	24	248	24	248

Source: By Authors from Eviews.10 output.

•Statistical value of a coefficient Skewness:

We compared it to zero indicating the uniformity of distribution so achieve the hypothesis of normal distribution, the negative skewness of turned to be positive skewness at post-Brexit period for dax cac SandP while the other are negatively skewed in pre and post Brexit.

•**Statistical value of a coefficient Kurtosis:**

According to the table, the values of Kurtosis refer to normal distribution because it's more than 3.

•**Statistical value of Jarque-Bera:**

We find that the value of probability (p.value) less than the level of significance for the four indice which indicates that were following Normality assumption just in the pre- Brexit period.

**4.4Stationarity test:**

To analyse the impact ARIMA model with intervention analysis is carried out. As a pre-requisite for ARIMA the series are check for their stationarity. The stationarity of the series is tested by Augmented Dickey Fuller test whose results are given in table (3).

*Table 3: ADF test for stationarity*

Index	Level	P value	Conclusion	First diff	P value	Conclusion
<b>FTSE</b>	-2.907531	0.0459	stationary	-	-	-
<b>dax</b>	-1.162265	0.6910	Not stationary	-15.57834	0.0000	<b>stationary</b>
<b>cac</b>	-1.286738	0.6362	Not stationary	-17.99175	0.0000	<b>stationary</b>
<b>SandP</b>	-1.726313	0.4167	Not stationary	-17.99175	0.0000	<b>stationary</b>

*Source: By Authors from Eviews.10 output.*

Note from the table (3) that the first series is stable at level but the all three remaining series seem to attain stationarity only at first difference. Hence the series at first difference is used for developing ARIMA model. As the first part of the study, best fit ARIMA model is estimated for the pre- Brexit period, this is done by considering the least AIC values.

Among the various suggested models. Hence the best models for the pre-Brexit period are found to be ARIMA(2,1,2) for FTSE, ARIMA(1,1,0)for DAX, ARIMA(1,1,0) for CAC and ARIMA (1,1,1).

**Table 4: ARIMA Models of the Pre- Intervention Period**

	C	AR(1)	AR(2)	AR(4)	MA(1)	MA(2)	AIC
<b>FTSE</b>	8.81806	-	-	-	-	0.953777	11.39222
TStatistic	0.44074	-	0.283383	0.571449	-	0.563222	
P value	0.6646	-	0.0627	0.0026	-	0.0604	
<b>DAX</b>	33.9045	0.498479	-	-	-	-	12.70109
TStatistic	0.67877	0.212035	-	-	-	-	
P value	0.5055	0.0297	-	-	-	-	
<b>CAC</b>	13.8057	0.497326	-	-	-	-	11.09310
TStatistic	0.55924	0.193844	-	-	-	-	
P value	0.5825	0.0189	-	-	-	-	
<b>SandP</b>	1.39220	0.942160	-	-	-	-	7.959962
TStatistic	7.12082	31.66939	-	-	-	-	
P value	0.0000	0.0000	-	-	1.00000	0.01685	
					0.9866	-	

*Source: By Authors from Eviews.10 output.*

As the second part of the study intervention ARIMA model is developed by introducing an intervention variable as dummy variables with values:

$$\begin{cases} 0 & \text{for pre-Brexit} \\ 1 & \text{for Post- Brexit period} \end{cases}$$

The hypothesis model is:

$$Y_t = \frac{\omega(B)}{\partial(B)} B_b I_t + \frac{\theta(B)}{\phi(B)} \varepsilon_t$$

*Table 5: ARIMA Models of the post-Intervention Period*

<b>FTSE100</b>	<b>Coefficient - p</b>	<b>t</b>	<b>p - value</b>
AR(2)	0.460547	1.818960	0.0701
MA (2)	-0.598335	-2.515949	0.0125
General Mean ( $\mu$ )	129.9234	3.018118	0.0028
Impact( $\omega$ )	17.77747	1.818960	0.0710
Slope( $\delta$ )	0.979740	137.5775	0.0000
<b>DAX</b>	<b>Coefficient - p</b>	<b>t</b>	<b>p - value</b>
AR(1)	0.115145	2.439827	0.0154
General Mean ( $\mu$ )	83.31161	0.901425	0.3682
Impact( $\omega$ )	-8.929799	-0.381566	0.7031
Slope( $\delta$ )	0.994251	109.6326	0.0154
<b>CAC</b>	<b>Coefficient - p</b>	<b>t</b>	<b>p - value</b>
AR(1)	0.120011	2.477701	0.0138
General Mean ( $\mu$ )	48.85368	1.030871	0.3035
Impact( $\omega$ )	4.893480	0.456054	0.6487
Slope( $\delta$ )	0.120011	2.477701	0.0138
<b>SandP</b>	<b>Coefficient - p</b>	<b>t</b>	<b>p - value</b>
AR(1)	0.996857	147.4781	0.0000
MA (1)	0.999900	0.626363	0.5316
General Mean ( $\mu$ )	2245.393	15.94998	0.0000
Impact( $\omega$ )	2.408763	2.2361139	0.0262
Slope( $\delta$ )	0.495555	122.5925	0.0000

*Source: By Authors from Eviews.10 output.*

## 5. Conclusions and Implications:

This paper attempts to empirically examine certain indice stock market reaction to the crisis of Brexit referendum that occurred on 24 Jun 2016, by using the Intervention Arima model.

The result of Intervention model of FTSE indicates a significant impact (17.77747) and slope (0.979740) is negligible, also the SandP indicates has a significant impact (2.408763) and slope (0.495555) is negligible. But the DAX and CAC indicate a non-significant impact.

The analysis show that Brexit Crisis had an immediate effect in UK and US stock index values but their impact was not significant in France and Germany.

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