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Research Article

Interrupted Time Series Modelling of Daily Amounts of British Pound Per Euro due to Brexit

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Abstract A look at the time plot of daily amounts of British pound (GBP) per Euro (EUR) from 17th March 2016 to 12th September 2016 reveals an initial generally slight negative trend and an abrupt rise on 24th June 2016 till 12th September 2016. This is an intervention case with 24th June 2016 as the point of intervention. It is noteworthy that on the previous day 23rd June 2016, the nation of Great Britain voted to opt out of European Union in what is known as Brexit. It is speculated here that this observed relative depreciation of the GBP is caused by this Brexit event. This work is aimed at studying this intervention situation. The pre-intervention exchange rates are adjudged to be non-stationary. Non-seasonal differencing makes it stationary and these differences have the autocorrelation structure of a white noise process. Post-intervention forecasts on the basis of this model are obtained and differences between these and the actual post-intervention observations are modeled for the intervention transfer function. The overall intervention model is observed to be significant and to agree closely with the actual observations. Out-of-sample forecasts comparison shows that forecasts and observations closely agree as a further evidence of model adequacy. Intervention measures may be based on this model.

Keywords Euro, British pound, exchange rates, interrupted time series, arima modelling

Introduction

Launched in January 2002, the Euro (EUR) is the official currency of 19 out of 28 members of the Eurozone. After the US dollar it is the second most popular and powerful international currency in the world. This research work is aimed at studying the relationship between the the British pound and the Euro before and after the Brexit. It has been observed that after the British people voted on a 52-48 basis to opt of the European Union that there has been an abrupt decline in the relative value of their currency, the Great Britain Pound (GBP). An observation reveals that this relative depreciation is worsening by the day. Etuk & Amadi [1] have proposed an intervention model for the United States dollar (USD) / GBP exchange rates occasioned by the phenomenon of Brexit.

The approach to the intervention or interrupted time series analysis adopted herein is that proposed by [2]. After its introduction in 1975, this technique which is based on Autoregressive Integrated Moving Average (ARIMA) modeling has been extensively applied by many researchers and successfully too. For instance, [3] studied the effect of on the level of of concentration level of carbon monoxide by the change of the method of calibration of the measuring instrument. Tiao *et al.,* [4] studies a class of intervention problems in respect of some air pollution data involving nitric acid, hydrocarbons, sulphur dioxide, etc. Penfold & Zhang [5] studied the effect of change in the rates of attention-deficit/hyperactive disorder medication on some children. Hanbury *et al.,* [6] noted that with some intervention measures put in place there was significant positive effect on percentage referral rates for psychological treatment of pregnant women. Effect of some intervention measures on some longitudinal data has been noticed by [7]. Cruz *et al.*, [8] observed the effect of a new nursing care delivery on patient satisfaction. The effect of introduction of dichlorodiphenyltrichloroethane on malaria transmission in KwaZulu-Natal has been studied by [9]. This is to cite only a few cases.

The sections of this study are introduction, material and methods, results and conclusions. In the references section all cited references are listed. There is an appendix in which the analyzed data are listed.

Materials and Methods

Data

The data are 180 daily amounts of the GBP per EUR from 17th March 2016 to 12th September 2016 retrieved from the website www.exchangerate.org.uk/EUR-GBP-exchange-rate-history.html. accessed on 13th September 2016. From the same website accessed 19th August 2017, out-of-sample data from 23rd February to 5th March 2017. See Table 2.

Interrupted Time Series Analysis

An interrupted model of a time series $\{X_t\}$ with intervention at point t=T is given by

$$Y_t = N_t + I_tZ_t \quad (1)$$

where $I_t = 0$, $t < T$ and $I_t = 1$, $t \geq T$. N_t is the noise component of the model and Z_t is the intervention component (Box and Tiao, 1975).

Noise Component

An ARIMA(p,d,q) model is fitted to the pre-intervention data. Let this be

$$A(L)\nabla^d X_t = B(L)\varepsilon_t \quad (2)$$

Here, L is the backshift operator defined by $L^kX_t = X_{t-k}$ and A(L) is the autoregressive (AR) operator defined by $A(L) = 1-\alpha_1L-\alpha_2L^2-\ldots-\alpha_pL^p$ and B(L) is the moving average (MA) operator defined by $B(L)=1+\beta_1L+\beta_2L^2+\ldots+\beta_qL^q$. Also, ∇=1-L. The α's and β's are constants such that model (2) is stationary as well as invertible.

Then

$$N_t = \frac{B(L)\varepsilon_t}{A(L)\nabla^d} \quad (3)$$

It is well known that in order to fit the model (2) the pre-intervention series is tested for stationarity by the Augmented Dickey Fuller (ADF) Test, for instance. If found stationary, then d=0. Otherwise the series is differenced and then tested. If stationary, d=1, and so on. The autocorrelation function (ACF) and the partial autocorrelation function (PACF) are computed and plotted. If the ACF cuts off, the cut-off lag is an estimate of q and if the PACF cuts off, the cut-off lag is an estimate of p. The α's and β's are estimated by the least squares procedure or by another non-linear optimization technique.

Intervention Component

On the basis of model (2) forecasts are made for the post-intervention period. Let the forecasts be F_t, $t \geq T$. Then for $t \geq T$

$$Z_t = X_t - F_t = \frac{c(1)*(1-c(2)^{t-T+1})}{(1-c(2))} \quad (4)$$

(The Pennsylvania State University, 2016 [10])

Computer Package

Eviews 7 is the software used in this work for all computations. It employs the least error sum of squares criterion for all estimations.

Results and Discussion

The time plot of the exchange rates in Figure 1 shows an initial generally negative trend up to time point 99 (i.e. on June 23, 2016) and then a sudden rise the next day from 0.7639 to 0.8118. The point of intervention is therefore T = 100 (i.e. June 24, 2016). It is noteworthy that the level has not reduced but has risen further.

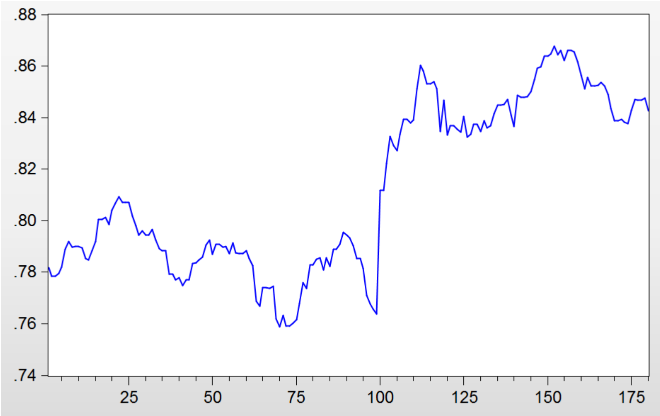

Figure 1: Daily Euro-British Pound Exchange Rates

The pre-intervention data are plotted in Figure 2. This graph shows a slight negative trend and some oscillatory movements. The ADF test statistic is equal to -1.24. The 1%, 5% and 10% critical values are -3.50, -2.89 and -2.58 respectively. The series is therefore adjudged as non-stationary. This necessitates its differencing.

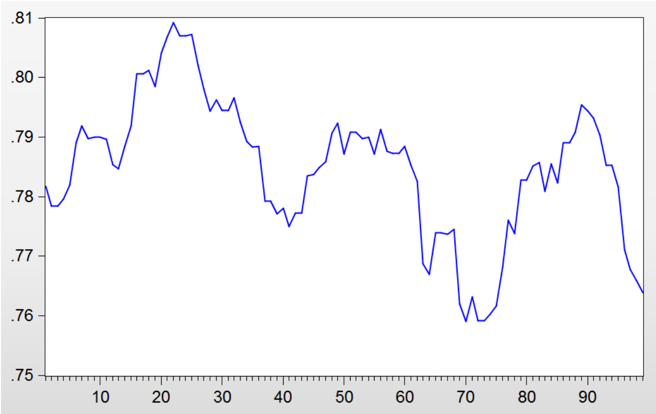

Figure 2: Pre-intervention Euro-Pound Exchange Rates

The non-seasonal differences of this pre-intervention series are plotted in Figure 3. The series is without trend and seasonality. The ADF test statistic is equal to -8.72. With the same critical values as given above the series is adjudged as stationary. The correlogram of the series is given in Figure 4. All autocorrelations and partial autocorrelations are non-significant, suggesting that the series is white noise.

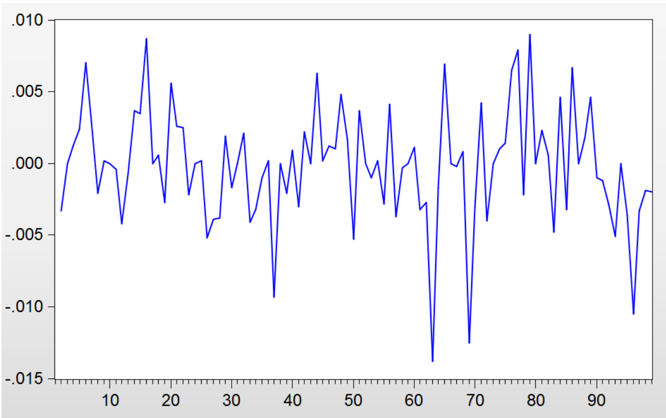

Figure 3: Difference of the Pre-intervention Rates

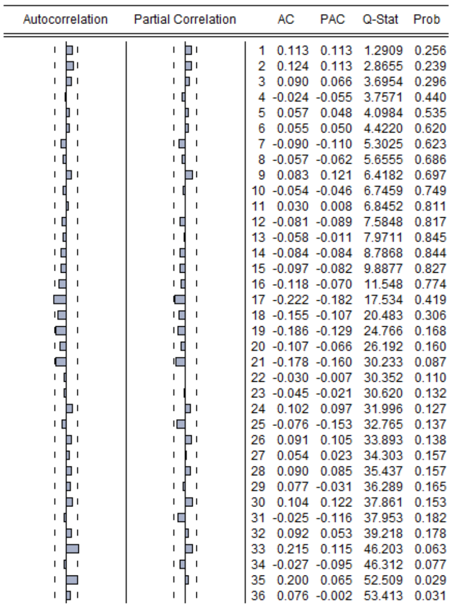

Figure 4: ACF and PACF of the difference of the pre-intervention data

Therefore by (3) the noise component of the model is

$$N_t = \frac{\varepsilon_t}{\nabla} \quad (5)$$

Forecasts on the basis of (5) for the post-intervention period are such that

$F_t = 0.7639$

Modelling $Z_t = X_t - F_t$ has been done as summarized in Table 1. This gives the intervention transfer as

$$Z_t = \frac{0.026888\,(1-0.026888^{\,t-99})}{(1-0.679551\,)},\ t \geq 100 \quad (6)$$

Therefore combining (5) and (6), the overall intervention model is

$$Y_t = \frac{\varepsilon_t}{\nabla} + \frac{0.026888\,(1-0.679551^{\,t-99})I_t}{(1-0.679551\,)} \quad (7)$$

where $I_t = 0$, $t < 100$, $I_t = 1$ otherwise. It is noteworthy that from table 1, the coefficients of the transfer function are both significant. This is an indication of model adequacy. Furthermore out-of-sample forecasts comparison is conducted ás summarized in Table 2. With a Pearson's Chi-square value of 0.0107, the data agree very closely with the forecasts (p >0.99) which is another evidence of model adequacy.

Table 1: Estimation of the Intervention Transfer Function

Dependent Variable Z Z=C(1)*(1-C(2)^(T-99))/(1-C(2))				
	Coefficient	**Std. Error**	**t-Statistic**	**Probability**
C(1)	0.026888	0.003340	8.051096	0.0000
C(2)	0.679551	0.040807	16.65297	0.0000

Table 2: Out-of–sample goodness-of-fit test

Date	**Actual Observation**	**Intervention Forecast**
23rd February 2017	0.8430	0.847807
24th February 2017	0.8480	0.847807
25th February 2017	0.8480	0.847807
26th February 2017	0.8511	0.847807
27th February 2017	0.8510	0.847807
28th February 2017	0.8538	0.847807
1st March 2017	0.8585	0.847807
2nd March 2017	0.8560	0.847807
3rd March 2017	0.8639	0.847807
4th March 2017	0.8639	0.847807
5th March 2017	0.8635	0.847807

Conclusion

It may be concluded that model (7) is an intervention model for daily amounts of GBP per EUR. It is to be noted that the GBP is relatively depreciating by the day. This work has shown that BREXIT has a negative impact on the relative value of the GBP. The said model might be useful in the proffering of a solution to redeem the value of the GBP.

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APPENDIX

Data*

0.7817 0.7784 0.7784 0.7796 0.7820 0.7890 0.7919 0.7898 0.7900 0.7900 0.7896 0.7854 0.7847 0.7884 0.7919
0.8006 0.8006 0.8012 0.7985 0.8041 0.8067 0.8092 0.8070 0.8070 0.8072 0.8020 0.7981 0.7943 0.7962 0.7945
0.7945 0.7966 0.7925 0.7893 0.7883 0.7885 0.7792 0.7792 0.7771 0.7780 0.7750 0.7772 0.7772 0.7835 0.7837
0.7849 0.7859 0.7907 0.7924 0.7871 0.7908 0.7908 0.7898 0.7900 0.7872 0.7913 0.7876 0.7873 0.7873 0.7884
0.7852 0.7825 0.7687 0.7670 0.7739 0.7739 0.7737 0.7745 0.7620 0.7590 0.7632 0.7592 0.7592 0.7602 0.7616
0.7681 0.7760 0.7738 0.7828 0.7828 9.7851 0.7857 0.7809 0.7855 0.7823 0.7890 0.7890 0.7908 0.7954 0.7944
0.7932 0.7903 0.7852 0.7852 0.7816 0.7711 0.7678 0.7659 0.7639 0.8118 0.8118 0.8222 0.8326 0.8292 0.8271
0.8336 0.8393 0.8393 0.8379 0.8391 0.8513 0.8604 0.8581 0.8531 0.8531 0.8540 0.8511 0.8347 0.8467 0.8332
0.8370 0.8370 0.8356 0.8344 0.8405 0.8325 0.8335 0.8374 0.8374 0.8348 0.8389 0.8361 0.8368 0.8416 0.8449
0.8449 0.8450 0.8470 0.8409 0.8365 0.8486 0.8480 0.8480 0.8483 0,8501 0.8547 0.8592 0.8597 0.8640 0.8640
0.8648 0.8678 0.8644 0.8660 0.8621 0.8662 0.8662 0.8656 0.8618 0.8565 0.8513 0.8556 0.8524 0.8524 0.8527
0.8536 0.8522 0.8490 0.8435 0.8388 0.8388 0.8393 0.8382 0.8377 0.8429 0.8470 0.8468 0.8468 0.8475 0.8427

*Read row-wise