Journal of
Economics and Political Economy
www.kspjournals.org
Volume 6 December 2019 Issue 4

The dynamic interrelationship between interest rate and macroeconomic policy objectives: Case of the United Kingdom

By Mostafa E. ABOELSOUD [a†]
Dimitrios PAPARAS [b] Azzouz ZOUAOUI [c]
& Mustafa K. KASIM [d]

Abstract. The objective of this study is to provide empirical evidence on the short- and long-run relationships between the short-term interest rate, London interbank offered rate (LIBOR) and macroeconomic policy objectives, such as price stability, economic growth, and stability of the exchange rate market. For this purpose, we deploy quarterly frequency data from the United Kingdom between 2000 and 2015 and adopt a multiple regression model. Furthermore, this study uses the Johansen, Stock-Watson cointegration test and the Granger Causality test in order to examine the dynamic short- and long-run relationships among LIBOR, the consumer price index as a proxy of price stability, the real gross domestic product as a proxy of economic growth, and the exchange rate as a proxy of exchange rate market stability. The results showed that all variables have the same order of integration and long-run equilibrium relationships exist between them. The results show evidence of long-run equilibrium relationship between the variables with strong evidence of unidirectional granger causality flow from GDP, CPI and exchange rates to LIBOR. The recommendations proposed in this study have important policy implications for the U.K. government. It is therefore recommended that policy makers and government authorities together with the Bank of England develop and pursue sensible fiscal and monetary policies that would aim at stabilizing both the micro- and macroeconomic indicators such as the inflation rate, interest rate, exchange rate, and money supply, to enhance the growth of the economy, especially for the period after the BREXIT decision.
Keywords. Macroeconomics, Interest rate, Monetary policy, London interbank offered rate, United Kingdom.
JEL. E43, E51, E58.

1. Introduction

In general, monetary policy involves using interest rates and other monetary tools to influence the levels of consumer spending and aggregate demand. In particular, monetary policy aims to stabilize the

[†a] Department of Economics, Faculty of Business Administration, Economics & Political Science, The British University in Egypt, Egypt.
☎. +2 (0100) 5211444 ✉. aboelsoud@commerce.suez.edu.eg
[b] LFA Business Management Department, Harper Adams University, Newport, UK.
☎. +44 (0) 1952 820280 ✉. dpaparas@harper-adams.ac.uk
[c] Department of Finance, King Saud University, Riyadh, KSA.
☎. 00966535386487 ✉. azouaoui@ksu.edu.sa
[d] School of Management, University of Brighton, Brighton, United Kingdom.
☎. 01273 600900 ✉. M.kasim1@brighton.ac.uk

economic business cycle, target the inflation rate and avoid recessions. The Bank of England, more precisely, the Monetary Policy Committee (MPC) [2], is responsible for determining the interest rate and sometimes carries out other measures to reach the above-mentioned economic goals.

In terms of analysing the United Kingdom's interest rate, it is important to define and represent the types of interest rates; first is the Bank of England base rate (BOEBR), which is the single most important interest rate in the United Kingdom, set by the Bank of England's MPC. Second, the money market of the United Kingdom issued a rate called the London interbank offered rate (LIBOR). This is considered a benchmark rate that some of the world's leading banks charge each other for short-term loans. Lastly, there is the prime overdraft rate (POR), which is used by banks to price the lending rates offered to clients at either above or below a particular rate (Eatwell, Milgate, & Newman, 1987).

For establishing the suitable monetary policy, it is essential to know if there is a relevant relationship in practice between Gross Domestic Product (GDP) variations, monetary variables and the interest rate. The purpose of this study is to analyze the short-run, long-run relationship and causality between interest rates and RGDP, CPI and exchange rate.In the empirical study for the UK, we will attempt to the answer to the following research questions:

- Is there any short-run/long-run relationship between LIBOR and RGDP, CPI and exchange rate?
- Is there a Granger causality between those variables in the UK?

The novelty of the research lies in the improvement made to the analysis of the methodological framework. The most relevant studies that examined the dynamic relationship between interest rates and several macroeconomic variables such as GDP or CPI combined traditional approaches with unit roots tests, cointegration methods and some of them include the Granger causality tests. However, it seems that those studies lacked the examination of the unit root tests with breaks. The long–run relationship between two tested variables can be affected by the presence of structural breaks in the data series. These possible breaks can be a result of economic regime or a change in the factors (government spending, taxation, population etc.) that determine and affect the tested series. Hence, if structural breaks are not taken into account when investigating the existence of a long–run relationship, there is a possibility that linear methods may fail to confirm the relationship when in fact it does exist. The literature in econometrics includes a large number of studies that attempt

[2] The Monetary Policy Committee (MPC) is a committee of the Bank of England, which meets for three and a half days, eight times a year, to decide the official interest rate for the United Kingdom (the Bank of England Base Rate). This committee is made up of nine members: The Governor, the three Deputy Governors for the Monetary Policy, Financial Stability and Markets and Banking, the Chief Economist and four external members appointed directly by the Governor of the Bank of England. *For more information, see* [Retrieved from].

to solve the problem of structural change. For linear regression models, there are several papers such as Quandt (1958) and Chow (1960) who consider tests for structural change for a known single break date. Those authors included in their models and regression a break date which was treated as an unknown variable. Based on our empirical results, some macroeconomic policies could be recommended in order to have sustainable growth.

The following sections of this paper are organized as follows: section two presents the literature review. In section three, theoretical information is presented for the empirical analysis. Furthermore, section four reports the main empirical results. Finally, the last section of the article draws the conclusion and contains remarks as well as policy implications.

2. Literature review

Empirical evaluation of monetary policy outcomes is not a new phenomenon. Multiple studies have employed different theoretical and empirical perspectives to analyse these outcomes, especially in relation to interest rates, inflation, economic growth and financial system stability. In this section, it is necessary to highlight some of the empirical literature regarding the interest rate and its dynamic relationship with the most significant macroeconomic variables, such as the inflation rate, gross domestic product, and exchange rate.

First, focusing on the inflation rate, Gjerde & Sættem (1999) and Kane & Rosenthal (1982) investigated the relationship between the short-term interest rate, CPI, industrial production index, household consumption expenditure and exchange rate. They found that the short-term interest rates are efficient and have an effect on inflation. Furthermore, studies conducted by Booth & Ciner (2001) and Diba & Oh (1991) confirmed a long-run relationship between the inflation rate and rate of interest. Additionally, Nagayasu (2002) found evidence to support the long-term implications of expectations theory, which showed that the impact of interest rates on the inflation evolution of Japan for the period 1980 to 2000 was very strong, especially when using short-term interest rates. In addition, Kandil (2005), in his study of fifteen developed countries, concluded that both the interest rate and money supply were underlying factors for the formation of price levels and that they were strongly correlated with each other. More recently, Anari & Kolari (2016) argued that there is a dynamic relationship between the interest rate and inflation in the US. The dual existence of the Fisher and Wicksell processes is the method that has been used in terms of investigating the argument. The result showed that the Fisher process represents a positive relationship between inflation and the interest rate, where causality runs from inflation to the interest rate. The Wicksell process represented a negative relationship between the two rates, with causality from the interest rate to inflation. A substantial amount of research has focused on developed countries to prove and establish Fisher hypothesis: among the most noticeable papers are those by Fama (1975), Mishkin (1992), Yuhn (1996), Crowder & Hoffman (1996), Dutt & Ghosh (1995), and Koustas & Serletis (1999). Finally, according to Asgharpur, Kohnehshahri, & Karami (2007), there is a unidirectional causality from interest rate to inflation rate in 40 Islamic countries. The findings have practical policy implications for decision makers in the area of macroeconomic planning particularly in Islamic countries.

Second, with respect to the GDP, Di Giovanni & Shambaugh (2008) explored the connection between interest rates and annual real output growth. The results show that high foreign interest rates had a contractionary effect on annual real GDP growth in the domestic economy, but this effect was centred on countries with fixed exchange rates. Moreover, Agalega & Antwi (2013) investigated the effects of macroeconomic variables on the GDP of Pakistan. Using principal component analysis and the maximum likelihood method of factor analysis, they found that the interest rate and GDP were inversely related to each other. Bhat & Laskar (2016) examined the effect of changes in the interest rate and the inflation rate on the annual GDP of India over the period 1998 to 2012. The result showed a negative relationship between GDP and the interest rate.The relationship between GDP and monetary variables has been widely discussed in the context of real business cycles. Coe (1984) examined which is the level of GDP, where the economy is at its optimal level of production given institutional and natural constraints. If GDP exceeds its potential, the theory says that inflation will accelerate as suppliers increase their prices and built-in inflation worsens. If GDP falls below its potential level, inflation will decelerate as suppliers attempt to fill excess capacity, cutting prices and undermining built-in inflation. However, there was one problem with this theory regarding identifying policy recommendations since the exact level of potential output is generally unknown and tends to change over time. Inflation also seems to act in an asymmetric way, rising more quickly than it falls. Ellison & Sargent (2015), found that nominal variables like inflation and money supply do not significantly explain the real production. However, the results are dependent on the type of economy.

Finally, with respect to the exchange rate, Ogaki & Santaella (2000) studied the relationship between the exchange rate and interest rate in Mexico. They concluded that the one-month and three-month interest rates had opposite effects on the exchange rate. More precisely, an increase in the one-month interest rate tended to appreciate the exchange rate, while an increase in the three-month interest rate tended to depreciate the exchange rate. Furthermore, Bautista (2006) examined the relationship between the real exchange rate and the real interest rate. The results showed that the relationship was characterized by positive correlations through the fixed exchange rate regimes, while the correlation was negative during free regimes. Chen (2006) tried to answer the question of whether a higher interest rate steadies exchange rates in six developing countries. The empirical results indicated that a high-interest rate policy cannot defend the exchange rate. On the other hand, the empirical results of Choi & Park (2008) showed that the tight monetary policy and the consequent rise in interest rates were not effective in stabilizing the exchange rate of the Asian currency. Recently, Andrieș, Căpraru, Ihnatov, & Tiwari (2017) studied the relationship between the exchange rate and interest rate in Romania, a small open emerging economy. The result showed a strong co-movement between the exchange and interest rates in the case of policy changes and turmoil periods. In addition, there was a different behaviour of the relationship between the interest rate and exchange rate in the short-run versus the long run. In the short run, the relationship was negative, confirming the sticky-price models, while over the long run, the relationship was positive, confirming the purchasing power parity theory.

The majority of the studies discussed in the literature review support the hypotheses that there is a relationship between the interest rate, inflation, economic growth and exchange rate. Despite the use of different models and definitions of the aforementioned variables, existing empirical studies support the role of the interest rate in the dynamics of individual economies. The following section presents the methodology, including the model used to evaluate the dynamic relationship between the variables used to evaluate the hypotheses in the context of the United Kingdom.

3. Methodology

3.1. Unit root test

The cointegration test among the study variables requires a previous test for the existence of a unit root for each variable and especially for LIBOR, CPI, rGDP and EX, using the augmented Dickey–Fuller (ADF) (1979) test based on the following regression:

$$\Delta X_t = a_0 + a_2 t + \gamma X_{t-1} + \sum_{i=1}^{p} \beta_i \, \Delta X_{t-i} + u_t$$

The ADF regression tests for the existence of the unit root of X_t, namely, in all model variables at time t. The variable ΔX_{t-i} expresses the first differences with p lags, and u_t is a variable that adjusts the errors of autocorrelation. The coefficients a_0, a_2, γ and β_i are estimated. The null and alternative hypotheses for the existence of a unit root in variable X_t are H_0: $\gamma = 0$ vs. H_1: $\gamma < 0$.

The literature in econometrics includes a large number of studies that attempt to solve the problem of structural change. For linear regression models, there are several papers such as Quandt (1958) and Chow (1960) who consider tests for structural change for a known single break date. Those authors included in their models and regression a break date which was treated as an unknown variable. Lately, Bai & Perron (1998) studied the estimation of multiple structural shifts in a linear model estimated by least squares. They suggested some new methods for structural change for the case with no trending regressors and a selection procedure based on a sequence of tests to estimate consistently the number of break points. Jouini & Boutahar (2005) stated that: "Bai & Perron (2004) assess via simulations the adequacy of these methods. Indeed, they study the size and power of tests for structural change, the coverage rates of the confidence intervals for the break dates and the relative merits and drawbacks of model selection procedures" (Juini & Boutahr, 2005, pp.394).

3.2. Co-integration and Johansen test

Granger & Newbold (1974) highlighted that, in terms of time series, if the variables are non-stationary in their levels, they can be integrated with integration order 1 when their first differences are stationary. These variables can also be cointegrated if there are one or more linear combinations among the variables that are stationary. If these variables are cointegrated, there is a constant long-run linear relationship among them. There are two important ways to test for cointegration. The Engle & Granger methodology (1987) seeks to determine whether the residuals of the equilibrium relationship are stationary. The Johansen (1988) and Stock-Watson (1988) methodologies determine the rank of (π), which equals the number of cointegration vectors.

Enders (2004) explained the Engle-Granger testing procedure; he began with the type of problem likely to be encountered in applied studies. Suppose that two variables y_t and z_t are believed to be $I(1)$, and we want to determine whether there exists an equilibrium relationship between these two variables. Therefore, we need to estimate the long-run equilibrium relationship in the following form:

$$y_t = \beta_0 + \beta_1 z_t + e_t$$

To determine whether the variables are actually cointegrated, denote the residual sequence from this equation $\{\widehat{e_t}\}$. Thus, the $\{\widehat{e_t}\}$ series contains the estimated values of the deviation from the long-run relationship. If these deviations are found to be stationary, the $\{y_t\}$ and $\{z_t\}$ sequences are cointegrated of order 1. It would be convenient if we could perform an ADF test on these residuals to determine their order of integration in the form:

$$\Delta\widehat{e_t} = \gamma\widehat{e_{t-1}} + \varepsilon_t$$

Because the $\{\widehat{e_t}\}$ sequence is a residual from a regression equation, there is no need to indicate an intercept term; the parameter of interest is γ, where γ = *ρ-1*. If we cannot reject the null hypothesis $\gamma = 0$, we can conclude that the residual series contain a unit root. Hence, we conclude that the $\{y_t\}$ and $\{z_t\}$ sequences are not cointegrated. Instead, the rejection of the null hypothesis implies that the residual sequence is stationary, and we conclude that the $\{y_t\}$ and $\{z_t\}$ sequences are cointegrated. If the variables are cointegrated, the residual from the equilibrium regression can be used to estimate the error correction model (ECM) (Enders, 2004).

Additionally, according to Johansen (1988), the Johansen test can be observed as a multivariate generalization of the augmented Dickey-Fuller test. The generalization is the examination of linear combinations of variables for unit roots. The Johansen test and estimation strategy – maximum likelihood – makes it possible to estimate all cointegrating vectors when there are more than two variables. If there are three variables each with unit roots, there are at most two cointegrating vectors. For example, let r be the rank of (π), which equals the number of cointegration vectors. There are two tests: 1, the maximum eigenvalue test and 2, the trace test. For both test statistics, the initial Johansen test is a test of the null hypothesis of no cointegration against the alternative of cointegration. The maximum eigenvalue test examines whether the rank of the matrix (π) is zero. The null hypothesis is that rank (π) = 0, and the alternative hypothesis is that rank (π) = 1. If the rank of the matrix is zero, the largest eigenvalue (λ) is zero, there is no cointegration, and tests are performed. If the largest eigenvalue (λ) is nonzero, the rank of the matrix is at least one, and there might be more cointegrating vectors. The test of the maximum (remaining) eigenvalue is a likelihood ratio test. The test statistic is as follows:

$$LR(r_0, r_0 + 1) = -T\, ln\, (1 - \lambda r_{0+1})$$

where $LR(r_0, r_0 + 1)$ is the likelihood ratio test statistic for testing whether rank (π) = r_0 versus the alternative hypothesis that rank (π) = r_0+1.

Moreover, Johansen (1988) explained the trace test. It is a test whether the rank of the matrix (π) isr_0. The null hypothesis is that rank (π) = r_0. The alternative hypothesis is that r_0< rank (π) ≤ n, where n is the maximum number of possible cointegrating vectors. For the succeeding test, if this null hypothesis is rejected, the next null hypothesis is that rank (π) = $r_0 + 1$, and the alternative hypothesis is that $r_0 + 1$ < rank (π) ≤ n. The test statistic is:

$$LR(r_0, n) = -T \sum_{i = r_0 + 1}^{n} ln\, (1 - \lambda_i)$$

where $LR(r_0, n)$ is the likelihood ratio statistic for testing whether rank (π) = r versus the alternative hypothesis that rank (π) ≤ n. This paper will utilize the Johansen methodology to test for cointegration.

3.3. Ramsey's RESET test

A multiple regression model suffers from functional form misspecification when it does not properly account for the relationship between the dependent and observed explanatory variables. To assess model adequacy, several procedures can help determine whether the estimated model is appropriate. One of these procedures is the Ramsey regression equation specification errortest (RESET), which is a general specification test for the linear regression model. More specifically, it tests whether non-linear combinations of the fitted values help explain the dependent variable (Ramsey, 1969).

To implement RESET, we must decide how many functions of the fitted values to include in an expanded regression. There is no correct answer to this question; however, the squared and cubed terms have proven to be useful in most applications. The auxiliary regression for the RESET test statistic can be written as follows:

$$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \ldots + \beta_k x_{kt} + \delta_1 \hat{y}_t^2 + \delta_2 \hat{y}_t^3 + u_t$$

In the aforementioned form, squares and cubes of the fitted values, $\hat{y}_t^2$, $\hat{y}_t^3$, have been added into the model to test for the joint significance of added terms. The null hypothesis of the RESET test says that the model is correctly specified: $H_0\colon \delta_1 = 0,\ \delta_2 = 0$

3.4. Jarque–Bera test: Testing for normality

This is another test for assessing model adequacy. Jarque & Bera (1987) proposed the Jarque-Bera test, usually shortened to the JB test statistic, a type of Lagrange multiplier (LM) test, which is a test fornormality. Normality is one of the assumptions for many statistical tests, such as the t test or F test; the Jarque-Bera test is usually run before one of these tests to confirm normality. It is usually used for large data sets because other normality tests are not reliable when n is large (Mukherjee, White, & Wuyts, 1998). Specifically, the test matches the skewness and kurtosis of data to determine whether they follow a normal distribution. A normal distribution has a skewness of zero and a kurtosis of three; kurtosis provides an indication of the amount of data contained in the tails and gives an idea about how "peaked" the distribution is. The formula for the JB test statistic can be written as follows:

$$JB = \frac{n-k+1}{6}\left(S^2 + \frac{1}{4}(C-3)^2\right)$$

Where n is the number of observations (or degrees of freedom in general); S is the sampleskewness, C is the samplekurtosis, and k is the number of regressors. The null hypothesis for the JB test statistics can be formulated as follows: H_0: errors are normal vs. H_1: errors are non- normal.

3.5. White, Durbin–Watson and Breusch-Godfrey tests

To further assess model adequacy and to test robustness, three more tests were applied, the White test, which is astatistical test that establishes whether the variance of the errors in the OLS regression modelis constant, i.e., a test for homoscedasticity (White, 1980). Likewise, the Durbin–Watson statistic is atest statisticused to detect the presence ofautocorrelationin theresidualsfrom the OLS regression analysis (Durbin & Watson, 1951). As an alternative to the DW test, the Breusch-Godfrey Lagrange multiplier test was applied; the latter is another test of serial correlation in the residuals (Breusch & Godfrey, 1980).

3.6. Granger causality tests

The Granger causality test is based on a standard F-test which seeks to determine if changes in one variable cause changes in another variable. A variable X is said to 'Granger cause' variable Y, if the previous values of X could predict the current value of Y. If two variables are cointegrated, we can use the Granger causality test (Granger, 1969) in order to check the short-run relationship between variables. The Granger causality test examines whether variable Y's current value can be explained by its own past value and whether the explanatory power could be improved by adding the past value of another variable X. If the coefficient of X is statistically significant, X is said to Granger Cause Y. The Granger causality test is very sensitive to the lags used in the OLS regressions (Gujarati, 2003). In our analysis, various lag length selection criteria are used in order to determine the lags for the Granger causality test. The tests we use are the following: LR – sequential modified LR test statistic, FPE – Final prediction error, AIC – Akaike information criterion, SC – Schwarz information criterion and HQ – Hannah-Quinn information criterion. These tests determined one lag.

4. Emprical analysis

4.1. Data and variables

To empirically investigate the dynamic interrelationship between LIBOR and the macroeconomic policy indicators, namely, the CPI, rGDP, and EX, this paper utilizes the Peria, Soledad, & Mody (2004) model. Originally, this model was developed by Thomas & Saunders (1981) and was extended by Allen (1988), and Angbazo (1997).

Moreover, to investigate the relationship between the aforementioned variables and in conformity with the availability of the necessary data and accepted number of observations, data were chosen from the Federal Reserve Bank of St. Louis, as well as the Bank of England websites. The data are in quarterly frequency for the United Kingdom from 2000:q1 to 2015:q4, including 64 observations. The LIBOR is the endogenous variable in the form:

$$LIBOR_t = \alpha + \beta_1 CPI_t + \beta_2 rGDP_t + \beta_3 EX_t + U_t$$

where LIBOR is the London interbank offered rate in period t, CPI is the consumer price index in period t, rGDP is the real gross domestic product in period t, EX is the exchange rate in period t, and α, β are parameters, while U_t is the disturbance term.

4.2. Results and Discussion

4.2.1. Summary Statistics and correlations

Table 1 presents the results of the summary statistics and the correlations. The summary statistics show the distribution properties of the individual variables, while the correlation matrix shows the relationship between these variables in our proposed model.

Table 1. *Summary statistics and correlations*

	LIBOR	CPI	rGDP	EX
Mean	3.090	85.083	385057	1.655
Median	3.890	82.750	390176	1.605
Maximum	6.310	100.290	434924	2.040
Minimum	0.490	72.140	329268	1.420
Std. Dev	2.192	9.728	27623	0.169
Skewness	-0.032	0.308	-0.353	0.720
Kurtosis	1.321	1.611	2.347	2.413
Jarque-Bera	7.531	6.160	2.470	6.447
Probability	0.023	0.046	0.291	0.039
Obs.	64	64	64	64
LIBOR	1.000			
CPI	-0.847	1.000		
rGDP	0.590	0.873	1.000	
EX	-0.463	-0.151	0.272	1.000

Source: Authors' calculations.

From the correlation matrix in Table 1, we can conclude that there is a strong and significantly positive relationship between *LIBOR* and *rGDP*. However, there is a strong and significantly negative relationship between *LIBOR* and the other variables under study.Clearly, all of the correlation signs are consistent with the economic theory. The next step is to test for co-integration.

4.2.2. Co-integration and unit root tests

The first step in processing the data is transforming the data using the natural logarithm. Logging time series data is very helpful in analysis of data, mainly since data in this form is easier to work with. Maybe the most important issue to consider for modelling time series data nowadays is to test for stationarity of the collected data. Brooks (2002) implied that when we use non-stationary data this can lead to a spurious regression, which means that the empirical results may seem in accordance with theory and the tested hypotheses, however, results are without valid meaning.

The cointegration test among the variables used in the model requires a previous test for the existence of a unit root for each variable, using the ADF (1979) test; the results of this test appear in Table 2.

Table 2. *Dickey-Fuller test*

	In Levels		1st differences	
Variables (X_t)	lag	Test Statistic ADF	lag	Test Statistic ADF
LIBOR	1	-1.44	1	-3.40**
CPI	1	-1.51	1	-6.76***
rGDP	1	-1.14	2	-3.89**
EX	2	-1.61	1	-6.52***

Notes: MacKinnon (1996) critical value at 1% = -4.1130 and at 5% = -3.4839.*** and ** denote statistical significance at the 1% and 5% levels, respectively. Lag orders used in tests are selected according to the Akaike information criterion (AIC) and Schwarz information criterion (SIC).
Source: Authors' calculations.

The results in Table 2 suggest that the null hypothesis of a unit root in the time series in levels cannot be rejected at the 5% level of significance. Therefore, none of the time series appear to be stationary, which means that all four variables, (*LIBOR*), (*CPI*), (*rGDP*) and (*EX*), contain roots. Furthermore, the minimum values of the Akaike information criterion (AIC) (1973) and Schwarz criterion (SC) (1978) statistics provide a better structure for the ADF equations as well as the relative numbers of time lags under the indication 'Lag'. If we take the first difference, the ADF test results in Table 2 support the stationarity of all five variables. The null hypothesis of a unit root in the time series cannot be accepted at the 5% level of significance for all five variables.

Table 3. *Unit Root Tests with Multiple Breaks*

Dependent variable :LLIBOR	Break Dates
Independent Variables: LRGDP, LCPI, LEX	2003Q2, 2008Q4, 2011Q2

Furthermore, the results in Table 3 indicate that the null of non-existence of breaks can be rejected at 5% level of significance. According to Bai-Perron test the break date for our equation are 2003Q2, 2008Q4, 2011Q2. However, only the break 2008Q4 is significant, thus, we are going to include it as a dummy in our Cointegration approach.

Because it has been determined that the variables under examination are integrated of order 1, a cointegration test can be performed. The cointegration test investigates whether the variables (*LIBOR*), (*CPI*), (*rGDP*), (*BOEBR*), (*EX*) and the dummy variable for the structural break of 2008Q4, have a long-run linear relationship among them. Using the Johansen (1988) maximum likelihood procedure, the results of the cointegration test appear in Table 4.

Table 4. *Co-integration test*

Unrestricted Co-Integration Rank Test								
Hypothesized	Eigenvalue		Statistic		Critical Value 5%		Prob.**	
No. of CE(S)	Trace	Maximum Eigenvalue	Trace	Maximum Eigenvalue	Trace	Maximum Eigenvalue	Trace	Maximum Eigenvalue
None*	0.4	0.4	84.3	35.2	60.0	30.4	0.00	0.01
At most 1*	0.3	0.3	49.1	27.4	40.1	24.1	0.00	0.01
At most 2	0.2	0.2	21.6	12.7	24.2	17.7	0.1	0.24
At most 3	0.1	0.1	8.8	7.5	12.3	11.2	0.17	0.2
At most 4	0.01	0.01	1.2	1.2	4.1	4.1	0.3	0.3

Notes: Both the trace & max-eigenvalue test indicate 1 co-integrating eqn(s) at the 0.05 level.* denotes rejection of the hypothesis at the 0.05 level.** MacKinnon-Haug-Michelis (1999) p-values.
Source: Authors' calculations.

The result in Table 4 provides two types of tests; the first is the unrestricted cointegration rank test (Trace), which measures the cointegration between the variables by using the T-statistic. As observed, the null hypothesis of a no long-run relationship cannot be accepted. Hence, the variables under examination are cointegrated. In the next category of the Trace test, which states that one to four variables at most have cointegration, the null hypothesis is rejected, which means there is a possibility of having at least one, two, three and four variables with a long-run linear relationship. The second test is the maximum eigenvalue test. The null hypothesis cannot be accepted, which means there is an association between the variables in the long run. Consequently, the maximum eigenvalue test can be statistically allowed to run the ordinary least square (OLS) regression at various levels without falling into spurious regression. The results of the OLS regression appear in Table 5.

Table 5. *Ordinary Least Square (OLS)*

Endogenous variable	Explanatory variables	Coefficient (Std. Error)	T-stat (P-value)	Adjusted R^2	F-stat. (P-value)	Durbin-Watson stat.
	Constant	-0.8398	-1.398			
		(0.6007)	(0.1673)			
	CPI	0.0168	1.2387			
LIBOR		(0.01356)	(0.2204)	0.7523	47.3037***	1.9399
	rGDP	-8.67E-06**	-2.1311		(0.0000)	
		(4.07E-06)	(0.0373)			
	EX	1.8860***	5.7550			
		(0.3277)	(0.0000)			

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' calculations.

If we invoke the assumption that $u_t \approx N(0,\sigma^2)$, then we can use the *t* test to test the hypothesis regarding any individual partial regression coefficient. The null and alternative hypotheses in this case for β_i are H_0: $\beta_i = 0$ vs. H_1: $\beta_i \neq 0$. If the computed *t* value exceeds the critical *t* value at the chosen level of significance, we may reject the null hypothesis; otherwise, we may not reject it. The results in Table 4 suggest that we cannot accept the null hypothesis that $\beta_2, \beta_3,$ and β_4 have no effect on the endogenous variable (LIBOR).

In terms of expressing the relationship between CPI and the endogenous variable, LIBOR, it can be observed from Table 4 that we cannot reject the null hypothesis at any significance level. Hence, CPI has no effect on LIBOR. This could be completely different from what the economic theories have stated. However, Kanwal, Abbasi, Burney, & Mubin (2014) found that Pakistan's interest rate had a positive relationship with both the CPI and exchange rate. In addition, Mehra (1995) highlighted that time lags could be responsible for a different relationship between the inflation rate and the interest rate. In terms of the real GDP, the *p*-value of the negative rGDP coefficient is significant at 5% and is consistent with the theoretical assumption. Lastly, the p-value of the exchange rate coefficient is significant at 1%, and therefore, EX has an effect on LIBOR, which means that a 1% increase in the exchange rate causes a 1.89% increase in LIBOR.

Additionally, the adjusted R^2 value in Table 4 indicates that approximately 75% of the variations in LIBOR can be explained, on average, by variations in CPI, rGDP and EX. Moreover, the Durbin-Watson statistic is equal to 1.939, which is higher than the upper value (d_U), which is equal to 1.727, and the lower value (d_L), which is equal to 1.444 [(3)]. Accordingly, there is no statistical evidence of positive first-order serial correlation in the residuals. Alternatively, there is another test of serial correlation, based on Breusch & Godfrey (1980), which is preferred in most applications. The null hypothesis of the Breusch-Godfrey Lagrange multiplier test is that there is no serial correlation in the residuals up to the specified order. EViews reports a statistic labelled "F-statistic" and "Obs*R-squared" (NR^2). The (NR^2) statistic has an asymptotic x^2distribution under the null hypothesis. The distribution of theF-statisticis not known but is often used to conduct an informal test of the null hypothesis. The results of the Breusch-Godfrey LM test with a lag of 2 appear in Table 5.

Table 6. *Breusch-Godfrey Serial Correlation LM Test*

F-statistic	2.7909	Prob. F(2,57)	0.0701
Obs*R-squared (NR^2)	5.7125	Prob. Chi-Square (2)	0.0875

Source: Authors' calculations.

The results in Table 6 suggest that the null hypothesis of no serial correlation up to order two cannot be rejected. Hence, the LM test indicates that the residuals are not serially correlated at the 5% level of significance.

Moreover, some tests have been proposed to detect general functional form misspecification when the model does not properly account for the relationship between the endogenous and observed explanatory variables. The Ramseyregression equation specification errortest (RESET) has proven to be useful in this regard. The squares and cubes of the fitted values, $\hat{y}_t^2$, $\hat{y}_t^3$, were added into the model to test for the joint significance of added terms. The results of the RESET test appear in Table 7.

[3] Source: DW table at 60 observations and k=4, where k is the number of regressors excluding the intercept, at 5% level of significance.

Table 7. *Ramsey Regression Equation Specification Error Test*

F-statistic	0.7289	Prob. F(2,57)	0.4870
Dependent variables	Independent variables	Coefficient (Std. Error)	T-stat (P-value)
	Fitted^2 ($\hat{y}_t^2$)	-0.3362	-0.6925
LIBOR		(0.4855)	(0.4915)
	Fitted^3 ($\hat{y}_t^3$)	-0.0933	-0.5258
		(0.1775)	(0.6011)

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' calculations.

The results in Table 6 indicate that the RESET statistic is 0.7289; this is the value of an $F(2,57)$ random variable (n=64, k=7), and the associated p-value is 0.4870. Consequently, the null hypothesis of the test, which states that the model is correctly specified: $H_0: \delta_1 = 0,\ \delta_2 = 0$, cannot be rejected at any level of significance. Accordingly, it can be concluded that there is no specification error in the model.

Furthermore, to assess model adequacy and to test robustness, WHITE'S test and the Jarque-Bera test were applied to detect whether thevarianceof thedisturbance term in the OLSregression modelwas constant, that is, to determine homoscedasticity and to detect whether the disturbance term followsa normal distribution, respectively.The results of these two tests appear in Table 8.

Table 8. *White and Jarque-Bera tests*

Heteroscedasticity, WHITE'S test			
F-statistic	1.0825	Prob. F(14,49)	0.3957
Obs*R-squared	15.1189	Prob. Chi-Square (14)	0.3701
Jarque-Bera test			
Jarque-Bera	1.3332	Probability	0.5134

Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' calculations.

The results in Table 8 suggest two important outcomes. First, concerning heteroscedasticity (WHITE's test), the value of an $F(14,49)$ random variable (n=64, k=15) can be determined, and the associated p-value is 0.3957. Consequently, the null hypothesis of the test, which is homoscedasticity, cannot be rejected at any level of significance. Finally, in terms of the Jarque-Bera test, and with a p-value equal to 0.5134, we can conclude that the disturbance term is normally distributed.

The results are reported in Table 9 and indicate that Granger causality is running from CPI, RGDP and EX to LIBOR, while we cannot reject the null hypothesis that LIBOR does not cause CPI, RGDP, EX. So, there is evidence of a unidirectional causality running from the examined macroeconomic variables to LIBOR.

Table 9. *Granger causality test*

	F-stat	P-value		F-stat	P-value
LLIBOR causes LRGDP	2.36	0.08	LRGDP causes LLIBOR*	10.10	0.000*
LLIBOR causes LCPI	0.28	0.75	LCPI causes LLIBOR*	5.33	0.007*
LLIBOR causes LEX	0.38	0.85	LEX causes LLIBOR*	4.17	0.003*

Notes: * indicate rejection of the null hypothesis at the 5% level of significance.
Source: Authors' calculations.

5. Conclusion and policy implications

The relationship between interest rates, the inflation rate, the exchange rate and economic growth has been the focus of a large number of researchers and has been a policy debate for a long period. The purpose of the empirical analysis was to examine the dynamic relationship between LIBOR, the inflation rate, the exchange rate and economic growth in the United Kingdom. This paper makes an attempt to justify the mixed and often contradictory results that have been obtained by a large number of studies in this field.

Johansen cointegration test was adopted to discover whether there is a long-run relationship between the examined variables or not and granger causality test was employed to accommodate the short-run relationship and to find out whether the flow of relationship is bi-directional or unidirectional the results showed that all variables have the same order of integration and long-run equilibrium relationships between them. The results show evidence of long-run equilibrium relationship between the two variables with strong evidence of unidirectional granger causality flow from GDP, CPI and exchange rates to LIBOR. Additionally, the OLS model, on the other hand, suggested that a short-run relationship between LIBOR and the consumer price index, as a measure of inflation, does not exist.

The study concludes that the relationship between interest rate and inflation rate in the U.K. is unidirectional and runs from inflation rate to interest rate. It is therefore inflation rate that causes fluctuations in interest rates and not vice versa. The study further concludes that interest rates does not have a significant influence on the inflation rate in the U.K. as the results failed the significance tests. Therefore, the fluctuations in the inflation rates over the recent past have not had a major impact on the levels of interest rates. The empirical results also concludes that GDP is a major determinant of interest rates in the U.K., since the causality runs from RGDP to LIBOR.

The Government can therefore make policy decisions regarding how to control those variables. The study is also important to researchers and academics as it will be a useful guide for future researchers interested in undertaking a study on the determinants of inflation rate in the country after Brexit.

5.1. Limitations of the study

One major limitation of the study was the availability of monthly data as this was the initial plan for the study to use monthly data to perform the analysis. Since this was not possible, the researcher reverted to the use of quarterly data as this was readily available. The use of quarterly data meant that the number of observations was less than what had been initially planned. The limits of the research are given by the fact that interest rates or GDP fluctuations could be explained also by other variables not included in our analysis, but the purpose of this research was only to have a view of the relationship between LIBOR and several macroeconomic variables. In future research, we intend to evaluate the impact of fiscal measures on GDP variations and combine this approach with the monetary one. Another potential limitation is that the Johansen procedure was found to be sensitive to lag length chosen.Various authors including Gonzalo (1994:220), Hawtrey (1997:344) and Yuhn (1996:42) have all also reported similar sensitivity.

5.2. Recommendations for policy and practice

The study recommends that in controlling the interest rates in UK, the Central Bank alone through the use of base lending rates is not enough as evidence suggests that the levels of CPI as well as the GDP and exchange rates are important determinants of interest rates in the country. Therefore, policy makers can expand the variables they need to control for the interest rates to be kept at levels that can encourage borrowing. The Central Bank therefore needs to not only focus on the base lending rates but also on other variables. Due to the important role played by expectations of future inflation in all policy decisions, further insight into the dynamics of inflationary expectations will provide valuable information for monetary authorities.

5.3. Areas for further research

Studies need to explore this relationship further by using monthly data to examine the relationship between interest and inflation rates, GDP and exchange rates. This was a major limitation of the present study as the time did not allow the collection of monthly data and therefore use of such data may enhance the reliability of results. Furthermore, studies should expand the list of control variables in order to gather more determinants of interest rates in the U.K. as this may help inform policy makers on what factors they need to control to keep inflation and interest rates low. There is also need to use a combination of both primary and secondary data in order to gather qualitatively the issues that may affect the levels of interest and inflation rates in the U.K. as such methodologies have not been explored in this area. Moreover, most researches address the issue of the equilibrium between interest rates and macroeconomic variables without taking the asymmetric properties of the adjustment process in the equilibrium relationship between interest and macroeconomic variables into account. Granger & Terasvrita (1993) documented that most of the economic variables have nonlinear characters.

References

Agalega, E., & Antwi, S. (2013). The impact of macroeconomic variables on gross domestic product: empirical evidence from Ghana. *International Business Research*, 6(5), 108-116. doi. 10.5539/ibr.v6n5p108

Akaike, H. (1973). Information theory and an extension of the maximum likelihood principle, in *Proceeding of 2nd International Symposium on Information Theory*, Budapest: Akademiai Kiado. doi. 10.1007/978-1-4612-1694-0_15

Allen, L. (1988). The determinants of bank interest margins: A note. *The Journal of Financial and Quantitative Analysis*, 23(2), 231-235. doi. 10.2307/2330883

Anari, A., & Kolari, J. (2016). Dynamics of interest and inflation rates. *Journal of Empirical Finance*, 39, 129-144. doi. 10.1016/j.jempfin.2016.08.008

Andrieș, A.M., Căpraru, B., Ihnatov, I., & Tiwari, A.K. (2017). The relationship between exchange rates and interest rates in a small open emerging economy: The case of Romania. *Economic Modelling*, 67, 261-274. doi. 10.1016/j.econmod.2016.12.025

Angbazo, L. (1997). Commercial bank net interest margins, default risk, interest-rate risk, and off-balance sheet banking. *Journal of Banking & Finance*, 21(1), 55-87. doi. 10.1016/S0378-4266(96)00025-8

Asgharpur, H., Kohnehshahri, L.A., & Karami, A. (2007). The relationships between interest rates and inflation changes: An analysis of long-term interest rate dynamics in developing countries, Tehran: Iran. Economic Research Center. [Retrieved from].

Bai, J. & Perron P. (1998). Estimating and testing linear models with multiple structural changes. *Econometrica*, 66(1), 47-78. doi. 10.2307/2998540

Bank of England (2019). [Retrieved from].

Bautista, C.C. (2006). The exchange rate–interest differential relationship in six East Asian countries. *Economics Letters*, 92(1), 137-142. doi. 10.1016/j.econlet.2006.01.016

Bhat, S.A., & Laskar, M.R. (2016). Interest rate, inflation rate, and gross domestic product of India. *International Journal of Technical Research & Science*, 1(9), 284-288.

Booth, G.G., & Ciner, C. (2001). The relationship between nominal interest rates and inflation: international evidence. *Journal of Multinational Financial Management*, 11(3), 269-280. doi. 10.1016/S1042-444X(01)00030-5

Breusch, T.S., & Godfrey, L.G. (1980). *A Review of Recent Work on Testing for Autocorrelation in Dynamic Economic Models*. University of Southampton.

Brooks, C. (2002). *Introductory Econometrics for Finance*, Cambridge U. Press, Cambridge, UK.

Chen, S.-S. (2006). Revisiting the interest rate–exchange rate nexus: a Markov-switching approach. *Journal of Development Economics*, 79(1), 208-224. doi. 10.1016/j.jdeveco.2004.11.003

Choi, I., & Park, D. (2008). Causal relation between interest and exchange rates in the Asian currency crisis. *Japan and the World Economy*, 20(3), 435-452. doi. 10.1016/j.japwor.2007.01.003

Chow, G.C. (1960). Tests of equality between sets of coefficients in two linear regressions. *Econometrica*, 28(3), 591-605. doi. 10.2307/1910133

Coe, D.T. (1984). Nominal wages. The NAIRU and wage flexibility. *Organisation for Economic Co-operation and Development*. [Retrieved from].

Crowder, W. & Hoffman, D. (1996). The long-run relationship between nominal interest rates and inflation: the Fisher equation revisited. *Journal of Money, Credit and Banking*, 28(1), 102–118. doi. 10.2307/2077969

Di Giovanni, J., & Shambaugh, J.C. (2008). The impact of foreign interest rates on the economy: The role of the exchange rate regime. *Journal of International Economics*, 74(2), 341-361. doi. 10.1016/j.jinteco.2007.09.002

Diba, B.T., & Oh, S. (1991). Bounds for the correlations of expected inflation with real and nominal interest rates. *Economics Letters*, 36(4), 385-389. doi. 10.1016/0165-1765(91)90203-W

Dickey, D.A., & Fuller, W.A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74(366), 427-431. doi. 10.1080/01621459.1979.10482531

Durbin, J., & Watson, G.S. (1951). Testing for serial correlation in least squares regression. II. *Biometrika*, 38(1/2), 159-177. doi. 10.2307/2332325

Dutt, S.D., & Ghosh. D. (1995). The Fisher hypothesis: Examining the Canadian Experience. *Applied Economics*, 27(11), 1025-1030. doi. 10.1080/00036849500000084

Eatwell, J., Milgate, M., & Newman, P. (1987). *The New Palgrave: A Dictionary of Economics*. Palgrave Macmillan UK.

Ellison, M., & Sargent, T.J. (2015). Welfare cost of business cycles with idiosyncratic consumption risk and a preference for robustness. *American Economic Journal: Macroeconomics*, 7(2), 40–56. doi. 10.1257/mac.20130098

Enders, W. (2004). *Applied Econometric Time Series* (2nd ed.): Wiley.

Engle, R.F., & Granger, C.W.J. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, 55(2), 251-276. doi. 10.2307/1913236

Fama, E. (1975). Short term interest rate as predictor of inflation. *American Economic Review*, 65(3), 269-282.

The Federal Reserve Bank of St. Louis (2019). [Retrieved from].

Gjerde, Ø., & Sættem, F. (1999). Causal relations among stock returns and macroeconomic variables in a small, open economy. *Journal of International Financial Markets, Institutions and Money*, 9(1), 61-74. doi. 10.1016/S1042-4431(98)00036-5

Gonzalo, J. (1994). Five alternative methods of Estimating long-run equilibrium relationships. *Journal of Econometrics*, 60(1-2), 203-233. doi. 10.1016/0304-4076(94)90044-2

Granger, C.W.J., & Newbold, P. (1974). Spurious regressions in econometrics. *Journal of Econometrics*, 2(2), 111-120. doi. 10.1016/0304-4076(74)90034-7

Granger, C.W. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, 37(3), 424-438. doi. 10.2307/1912791

Granger, C.W. & Terasvrita, T. (1993). Strategies for modeling nonlinear time-series relationships. *The Economic Record*, 69(3), 233-238. doi. 10.1111/j.1475-4932.1993.tb02103.x

Gujarati, D.M. (2003). *Basic Econometrics*, (4th edn) McGraw-Hill/Irwin, New York.

Hawtrey, K.M. (1997). The Fischer effect and Australian interest rates. *Applied Financial Economics*, 7(2), 337-346. doi. 10.1080/096031097333457

Jarque, C.M., & Bera, A.K. (1987). A test for normality of observations and regression residuals. *International Statistical Review / Revue Internationale de Statistique*, 55(2), 163-172. doi. 10.2307/1403192

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12(2-3), 231-254. doi. 10.1016/0165-1889(88)90041-3

Jouini, J. & Boutahar, M. (2005). Evidence on structural changes in U.S. time series. *Economic Modelling*, 22(3), 391-422. doi. 10.1016/j.econmod.2004.06.003

Kandil, M. (2005). Money, interest, and prices: Some international evidence. *International Review of Economics & Finance*, 14(2), 129-147. doi. 10.1016/j.iref.2003.11.013

Kane, A., & Rosenthal, L. (1982). International interest rates and inflationary expectations. *Journal of International Money and Finance*, 1, 97-110. doi. 10.1016/0261-5606(82)90007-9

Kanwal, K., Abbasi, M.A., Burney, A.I., & Mubin, M. (2014). Determinants of Interest Rate: Empirical Evidence from Pakistan. *Journal of Economics and Sustainable Development*, 5(13), 25-30.

Koustas, Z. &Serletis, A. (1999). On the Fisher effect. *Journal of Monetary Economics*, 44(1), 105-130. doi. 10.1016/S0304-3932(99)00017-3

MacKinnon, J.G. (1996). Numerical distribution functions for unit root and cointegration tests. *Journal of Applied Econometrics*, 11(6), 601-618. doi. 10.1002/(SICI)1099-1255(199611)11:6<601::AID-JAE417>3.0.CO;2-T

Mehra, Y.P. (1995). Some key empirical determinants of short-term nominal interest rates. *Federal Reserve Bank of Richmond Economic Quarterly*, 81(3), 33-51.

Mishkin, F.S. (1992). Is the Fisher effect for real? *Journal of Monetary Economics*, 30(2), 195-215. doi. 10.1016/0304-3932(92)90060-F

Mukherjee, C., White, H., & Wuyts, M. (1998). *Econometrics and Data Analysis for Developing Countries* (Pap/Dskt ed.): Routledge.

Nagayasu, J. (2002). On the term structure of interest rates and inflation in Japan. *Journal of Economics and Business*, 54(5), 505-523. doi. 10.1016/S0148-6195(02)00104-2

Ogaki, M., & Santaella, J.A. (2000). The exchange rate and the term structure of interest rates in Mexico. *Journal of Development Economics*, 63(1), 135-155. doi. 10.1016/S0304-3878(00)00103-6

Peria, M., Soledad, M., & Mody, A. (2004). How foreign participation and market concentration impact bank spreads: Evidence from Latin America. *Journal of Money, Credit & Banking*, 36(3), 511-537. doi. 10.4324/9780203966143

Quandt, R.E. (1958). The estimation of parameters of a linear regression system obeying two separate regimes. *Journal of the American Statistical Association*, 55, 873-880.

Ramsey, J.B. (1969). Tests for specification errors in classical linear least-squares regression analysis. *Journal of the Royal Statistical Society. Series B (Methodological*), 31(2), 350-371.

Schwarz, G. (1978). Estimating the dimension of a model. *Ann. Statist*., 6(2), 461-464. doi. 10.1214/aos/1176344136

Stock, J.H., & Watson, M.W. (1988). Testing for common trends. *Journal of the American Statistical Association*, 83(404), 1097-1107.

Thomas, S.Y.H., & Saunders, A. (1981). The determinants of bank interest margins: Theory and empirical evidence. *The Journal of Financial and Quantitative Analysis*, 16(4), 581-600. doi. 10.2307/2330377

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica*, 48(4), 817-838. doi. 10.2307/1912934

Yuhn, K. (1996). Is the Fisher effect robust? Further evidence. *Applied Economics Letters*, 3, 41-44. doi. 10.1080/758525514