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The impact of macroeconomic variables on Stock market in United Kingdom[1]

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Abstract

The key objective of this study is to shed light on the relationship between the stock market and macroeconomic factors (Interest rate, Consumer Price Index, Exchange rate) in United Kingdom for the period Pre Global Financial Crisis 2008 (GFC); from January 1999 to December 2007. The finding of **Johansen** Cointegration, and **Granger** and Toda Yamamoto (**TY**) Causality tests show respectively that there is no co-integration between variables, no causal relation is detected from macro factors to stock return, and a unidirectional causal relation is depicted from exchange rate to stock price. While from VAR Granger non Causality/Block Exogeneity Wald Tests results, both inflation (INF) and exchange rate growth (EXCG) Granger cause the UK stock market Return. Moreover, the **ARDL** specification show a stable **long run** effect of all considered macroeconomic factors on the UK stock price. Precisely, the results of the ECM show that all considered macroeconomic factors drives UK stock price toward long-run equilibrium at a fast speed.

Key words: UK Stock market, Macroeconomic variables, Causality, ECM, Cointegration, ARDL model, $\mathbf{F}_{PSS}$Test.

Jel classification: C32; E44; G14.

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I. Introduction

Economic theory suggests that **stock prices** should **reflect** expectations about future corporate performance while corporate **profits** generally **reflect** the level of economic activities. Then, if stock prices accurately reflect the underlying fundamentals, the stock prices should be employed as leading indicators of future economic activities.

On the other hand, the efficient market hypothesis (EMH), in particular **semi-strong** form efficiency, states that stock prices must contain all relevant information including publicly available information, (Fama, 1970). At an efficient capital market, security prices **adjust rapidly** to new information. Therefore, the current prices reflect all information about the security so that **no investor** is able to employ readily available information in order **to predict** stock price movements quickly enough **so as** to make a **profit** through trading shares.

Over the past few decades, numerous researchers, economists and practitioners have continually researched the relationship between macroeconomic factors and stock returns. It is often assumed that a variety of basic macroeconomic factors such as interest rate, industrial output, exchange rate, money supply, and inflation rate cause the stock return. And the impact of macroeconomic factors on stock returns for various countries has been captured and verified by a fair number of models and tests.

In fact, any country's stock market must be treated as a benchmark of its own power in economic terms. There are many variables, including not only economic, but also social, and political variables, according to the literature, that can affect the working success of a stock market.

This research aims to identify the nature of the relationship between the stock market and three macroeconomic variables. The variable under investigation concern United Kingdom (UK) market stock price (SP) or return as proxy for the UK stock market. Macroeconomic variables are Consumer price index (CPI), Interest rate (INT), and exchange rate (EXC) for UK economy.

Three testable hypotheses are considered to represent the relationship between dependent variable (stock market price or return) and dependent / independent variables (inflation, interest rate, and exchange rate):

> **H_1**: Interest rate does not affect stock market price.
>
> **H_2**: Inflation does not affect stock market return.
>
> **H_3**: Exchange rate does not affect stock market price.

In order to reach the objective of this article, different econometrics technics are applied such as unit root tests, Vector Auto Regression (VAR) for optimal lag length selection, VEC Model and (Johansen, 1988) test for co-integration, ARDL framework and F_{PSS} test procedure, VAR Granger non Causality/Block Exogeneity Wald Tests, and Toda and Yamamoto Wald causality test.

This paper investigates the nature of the causal static and dynamic relationships between the UK stock price (return) and the considered macroeconomic variables in UK economy for the period between January 1999 and December 2007 using UK data extracted from International Monetary Fund (IMF). All investigations are done by Eviews 10.

(Poon & Taylor, 1991) conducted a study on equity prices from UK stock markets and macroeconomic variables. Their results are dissimilar to (Chen, Roll, & Ross, 1986), concluding that macroeconomic indicators do not have significant effects on equity returns.

Based on more recent data (between January 1999 and December 2007), this paper results confirmed the influence of macroeconomic variables on the UK stock market prices. This paper provides then a basis and guidelines to investors and financial experts for making investment decisions in the UK share market. Also, it may be useful for the policy and decision makers of the UK economy.

This article is arranged as follows. Section I comprises the introduction. Section II give a selection literature review. Section III describes methodology (subsection 1) and the used data (subsection 2), and analyzes the estimation and tests results (subsection 3). Finally, section IV concludes the paper.

II. A selected literature review

The literature demonstrate the associations between **equity returns** and different macroeconomic indicators, but the debate continues regarding which indicator has a substantial effect on **equity markets**. Various Macroeconomic indicators have been considered such as Gross Domestic Product, Inflation, Oil Prices, Exchange rate, Interest rates, Gold prices, Money supply, Foreign Direct Investment, Imports, and Exports.

In the first systematic studies undertaken by (Fama, 1970) and (Roll & Ross, 1980), the effect of macroeconomic factors on financial markets was extensively researched. They studied different macroeconomic variables and their influence on volatility in stock prices and showed that some macroeconomic variables appear to have a very strong impact on stock prices, while others remain at best inconclusive.

Later, (Maysami, Howe, & Hamzah, 2004) examined empirical long run relationship between stock prices in Singapore and a set of economic variables including exchange rate, money supply, inflation, and industrial production. They found that the stock market index forms a co-integration relationship with considered variables. Similarly, (Ali, Rehman, Yilmaz, Khan, & Afzal, 2010) concluded that equity markets were co-integrated with macroeconomic indicators and stock prices in Pakistan. However, for other macroeconomic variables, no causal relationship is known. (Kutty, 2010) used the Granger causality test to investigate the connection between stock prices and exchange rates in Mexico. He documented that stock prices and exchange rates have no long-term association between them. In the same context, (Shawtari, Salem, Hussain, Hawariyuni, & Omer, 2015) using vector error-correction models, found a long-term co-integration of macroeconomic variables including industrial production, inflation, money supply, and exchange rate with stock market prices. More recently, (Neifar M. , 2021) examined the short run and long run relationship between stock prices at Suisse stock market and a set of macroeconomic variables including Suisse exchange rate, Interest rate, and inflation for the period from 1999:1 to 2018:4. She found that the stock market price forms a co-integration relationship with considered macroeconomic variables within an ARDL framework.

"The impact of **exchange rate** changes on the economy depend to a large extent on the level of international trade and the trade balance. Hence the impact can be determined by the relative dominance of import and export sectors of the economy" (Maysami, Howe, & Hamzah, 2004).

According to experts, if the **interest rate** rises then equity returns **diminish**, and any negative news linked to interest rates badly affects the exchange rate and stock markets (Lobo, 2000).

An increase in inflation affects the stock markets' performance in a **negative** manner, while a decrease in the rate of inflation exerts a **positive** effect on the equity markets and investors' confidence will be reinstated (Omran & Pointon, 2001).

Unlike most of authors that widely theorized that stock prices are influenced by macroeconomic variables, (Lu, Metin IV, & Argac, 2010), in examining the long-term relationship between stock returns and monetary variables in an emerging market through time (for the whole research period (1988 to 1995)), by using the co-integration technique, show that there is **no co-integrating** relationship between stock prices and any of the variables or groups of variables of concern. This is consistent with the findings of (Neifar M. , 2021) in the case of Canada for the period from January 1999 to April 2018.

III. Econometric Models and Estimation

1. The data

A. Sample and data Analysis

We collect monthly data on the UK's stock price (SP) that will serve as an indicator for the stock market and macroeconomics variables (Interest rate, Consumer Price Index, Exchange rate) from January 1999 to December 2007. The descriptive analysis begins with information about macroeconomic indicators and notation are shown in **Table 1**. Except for the inflation rate, we have converted monthly data into a natural log.

Figure 1 shows the trend of LCPI, LSP, LEXC and LINT in United Kingdom's over a nine-year period (1999:1 – 2007:12). From figure 1 below, it is evident that during the whole period, CPI is characterized by a decreasing trend. It is almost the same case for the SP process. Interestingly, the SP trend decreased significantly by the end of 2002. However, it increased during the remaining period. The downward trend in SP could be attributed to the fact that until the middle of the spring of 2003, the global economy lived in the shadow of geopolitical tensions, with the uncertainties related to the Iraqi conflict continuing to foster wait-and-see behavior by agents and to tighten prices in oil markets. In addition to these international tensions, the economic disparities between the major areas persisted and even increased. The United States and, more unexpectedly, Japan showed a resumption of growth in the spring, but the euro area remained very much in decline, and most major European countries even experienced a few quarters of contraction in their activity. Overall, this growth gap was explained by a number of factors, most notably the appreciation of the euro vis-à-vis the dollar and more expansive monetary and fiscal policies on the other side of the Atlantic. The global economy reaches its low point at the beginning of 2003 in a deteriorating context marked by the outbreak of the war in Iraq, including the United Kingdom economy. Furthermore, EXC's graph showed a decline in the trend over the entire period. In addition, from 1999 to 2003, the INT trend decreased considerably. Nevertheless, and with the beginning of 2003, the INT trend took an upward until the end of the period.

Table 1 : Description of variables

Variable	Description
LSP	The market stock price (SP) in log: the price that it sells for on the open market at a given point in time.
LCPI	Consumer price index (CPI) in log, a measure that examines the weighted average of prices of a basket of consumer goods and services, such as transportation, food, and medical care.
LINT	Nominal interest rates (INT) in log.
LEXC	Nominal exchange rate (EXC) in log.
INF	Inflation rate.

Note: Monthly UK macroeconomic data are selected from International Monetary Fund (IMF). SP is selected from OCDE (Organisation de Cooperation et de Developpement Economique).

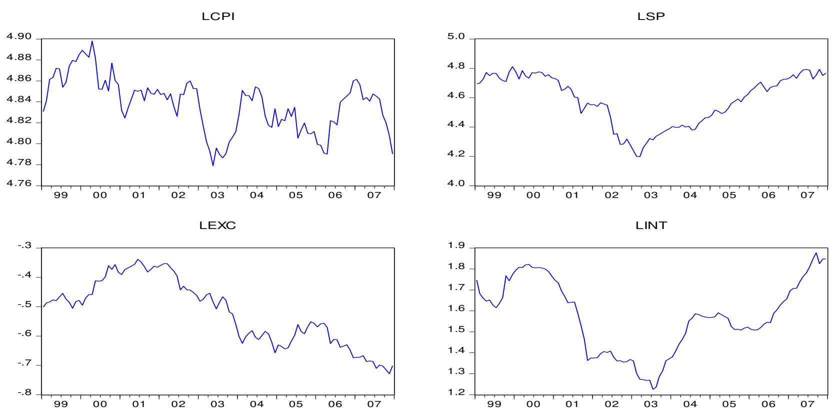

Figure 1 : Stock price, consumer price index, Exchange rate in log, and interest rate evolution from January 1999 to December 2007.

B. Unit root test results

Prior to the testing of co-integration, we conducted a test of order of integration for each variable using Augmented Dickey-Fuller Test (ADF) and Phillips-Perron Test (PP). The results on variables at level and at 1st difference are given in Table 2, which on the whole shows that the variables under study can be considered integrated of order one, i.e., I(1) since they are not stationary in level but stationary at 1st difference. Hence, we can pass for co-integration (Johansen, 1988) test investigation.

Table 2 : Results of non-stationary ADF test and PP test.

UNIT ROOT TESTS		**PP**				**ADF**			
At Level		LSP	LCPI	LINT	LEXC	LSP	LCPI	LINT	LEXC
With Constant (C)	t-Statistic	-0.8564	-2.2327	-1.1019	-0.2932	-0.7770	-1.9882	-0.5875	-0.1656
	Prob.	0.7984	0.1961	0.7131	0.9212	0.8212	0.2917	0.8678	0.9383
With C & Trend	t-Statistic	-0.6932	-3.1922	-0.7387	-2.3018	-0.6377	-2.8557	-0.3924	-2.2802
	Prob.	0.9706	0.0916	0.9671	0.4291	0.9745	0.1812	0.9867	0.4407
Without C & Trend	t-Statistic	0.1799	-0.3482	0.0689	-0.9230	0.1925	-0.3507	0.4798	-0.9636
	Prob.	0.7365	0.5574	0.7026	0.3145	0.7403	0.5564	0.8170	0.2977
At First Difference		ΔLSP	ΔLCPI	ΔLINT	ΔLEXC	ΔLSP	ΔLCPI	ΔLINT	ΔLEXC
With Constant (C)	t-Statistic	-9.1826	-9.9754	-7.5203	-9.0558	-9.1947	-9.9754	-7.2335	-9.0958
	Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
With C & Trend	t-Statistic	-9.3368	-9.9656	-7.7416	-9.1164	-9.3563	-9.9681	-7.4357	-9.1779
	Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Without C & Trend	t-Statistic	-9.2236	-10.0058	-7.5354	-9.0271	-9.2354	-10.0084	-7.2382	-9.0577
	Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

The matrix of correlation shows the presence of a negative linear relationship between INF and R, while a positive linear relationship between EXCG and R is suggested (see Table 3).

Table 3 : Correlation Matrix

Correlation				
Probability	**R**	**INF**	**INTG**	**EXCG**
R	1.000000			
INF	-0.204918	1.000000		
	0.0342	-----		
INTG	-0.001255	0.202155	1.000000	
	0.9898	0.0368	-----	
EXCG	0.214846	-0.493376	-0.231581	1.000000
	0.0263	0.0000	0.0164	-----

For the identification of the direction of causal association among considered variables, and to find out directional causality, we used in first stage the pairwise (Granger, 1969) causality test on stationary series (variables in first difference). Results are reported in Annex 1 Table A1.

Table A1 shows that none of the macro factors has effect on UK Stock return. More investigations are needed to get a robust result.

2. Econometric Methods

A. The Johansen multivariate co-integration procedure

We use the (Johansen, 1988) co-integration approach. The following k-dimensional VAR process with p lags

$$\mathbf{Y_t = \mu_t + \Phi_1 Y_{t-1} + \ldots + \Phi_p + Y_{t-p} + \lambda\, D2003 + \varepsilon_t}$$

can be rewritten in the VEC Model form:

$$\mathbf{\Delta Y_t = \mu_t + \Pi Y_{t-1} + \Gamma_1 \Delta Y_{t-1} + \ldots + \Gamma_{p-1} \Delta Y_{t-p+1} + \lambda\, D2003 + \varepsilon_t}$$

where $\mathbf{Y}_t$ is the vector of k = 4 considered **endogenous** variables

$$\mathbf{Y_t} = (LSP_t, LCPI_t, LINT_t, LEXC_t)',$$

$\boldsymbol{\mu}$ is a k×1 vector of real parameters; $\mu_t = \mu$ /or $\mu t = \mu + \delta\, t$ /or $\mu t = \mu + \delta\, t + \gamma t^2$, $\boldsymbol{\delta}$ **(**$\boldsymbol{\gamma}$**)** is a k×1 vector of trend coefficients, **t** is a linear time trend, $\mathbf{t^2}$ is a quadratic time trend, and D2003 is a dummy variable,

$$D2003 = 1 \text{ if } t \geq 2003 \text{ and zero if not,}$$

$$\Pi = \sum_{i=1}^{p} \Phi_i - I$$

is the **long-run matrix,** and $\Gamma_1, \ldots, \Gamma_{p-1}$ are k × k matrices of parameters

$$\Gamma_i = -\sum_{j=i+1}^{p} \Phi_j.$$

If all variables in Y_t are I (1), the matrix Π has **rank** $0 \leq r < k$, where r is the **number of linearly independent co-integrating vectors**. If the variables are co-integrated (r > 0) the **VAR in first differences** is **misspecified** as it excludes the error correction term.

In the VEC model above, when **the rank** of **Π** is **r > 0**, it may be expressed as

$$\boldsymbol{\Pi = \alpha \beta'},$$

where α and β are (k×r) matrices of parameters of rank r. α give the speed of adjustment to equilibrium. β is the matrix of long-run coefficients that represents up to k - 1 = 3 cointegration relationship and ensures that $\mathbf{Y_t}$ s converge to their long-run steady state.[3]

The Johansen's approach is aimed to test the number r of co-integrating relationships. The test for co-integration between the Ys is calculated by looking at the rank of the **Π = αβ'** matrix via its eigenvalues.

Two test statistics for cointegration under the **Johansen approach** are considered. The **trace statistic** takes the form

$$\lambda_{trace} = -T \sum_{i=r+1}^{k} \ln(1 - \hat{\lambda}_i)$$

where λ_i are the ordered eigenvalues, and

$$\lambda_{max} = -T \ln\left(1 - \hat{\lambda}_{r+1}\right).$$

[3] A set of time-series variables are cointegrated if they are integrated of the same order and a linear combination of them is stationary.

The distributions of the test statistics are **non-standard**. (Johansen & Juselius, 1990) provide critical values for the two statistics.

If the **test statistic is greater than the critical value** from Johansen's tables, we **reject the null hypothesis** that there are **r co-integrating vectors** in favor of the alternative that there are r + 1(for λ_{trace}) or more than r (for λ_{max}).

Johansen's testing procedure is sequential. It starts with the test for r = zero co-integrating equations (a maximum rank of zero) and then accepts the first null hypothesis that is not rejected.[4]

B-Pairwise Granger causality test

Prior to the Pairwise Granger causality tests, we first conduct unit root tests to determine if the variables are stationary and to detect their order of integration.Then, we capture the interrelationships among the variables with Pairwise Granger causality tests. In testing for Granger causality, two **stationary** variables Y_t and X_t are considered in the following VAR model

$$Y_t = a + \sum_{j=1}^{p} C_{j1} Y_{t-j} + \sum_{j=1}^{p} D_{j1} X_{t-j} + \varepsilon_{t1}$$
$$X_t = b_j + \sum_{j=1}^{p} F_{j1} X_{t-j} + \sum_{j=1}^{p} E_{j1} Y_{t-j} + \varepsilon_{t2}$$

Y_t and X_t are analyzed together while testing for their interaction. X does not granger cause Y if $D_{j1} = 0$ for all j, while Y does not granger cause X if $E_{j1} = 0$ for all j.

Four results of the analyses are possible:

1) Unidirectional Granger causality from variable Y_t to variable X_t.

2) Unidirectional Granger causality from variable X_t to Y_t.

3) Bi-directional causality.

4) No causality.

C. Toda and Yamamoto Wald causality test

Besides the **Granger causality**, an important procedure was developed by (Toda & Yamamoto, 1995) to investigate significant direction of causality. This approach could be used **regardless of the integration order** and whether the indicators are simply integrated of order zero I (0) and of order one I (1).

In order to investigate (Granger, 1969) causality, (Toda & Yamamoto, 1995) developed a method based on the estimation of augmented VAR model (p+d max) where p is the optimal

[4] In case of no cointegration, (Granger & Newbold, 1974) noted that the regression results from the VAR models with non-stationary variables are spurious.

time lag on the first VAR model and d max is the maximum integrated order.[5] Toda and Yamamoto modified Wald test is then based on the **pairwise** equations:

$$Y_t = a + \left(\sum_{j=1}^{p} C_{j1} Y_{t-j} + \sum_{j=p+1}^{dmax} C_{j2} Y_{t-j} \right) + \left(\sum_{j=1}^{p} D_{j1} X_{t-j} + \sum_{j=p+1}^{dmax} D_{j2} X_{t-j} \right) + \varepsilon_{t1}$$

$$X_t = b_j + \left(\sum_{j=1}^{p} F_{j1} X_{t-j} + \sum_{j=p+1}^{dmax} F_{j2} X_{t-j} \right) + \left(\sum_{j=1}^{p} E_{j1} Y_{t-j} + \sum_{j=p+1}^{dmax} E_{j2} Y_{t-} \right) + \varepsilon_{t2}$$

where ε_{t1} and ε_{t2} are the white-noise errors.

The modified Wald test (M Wald) follows asymptotically Chi-square ($\chi 2$) distributions with the degrees of freedom are equal to the number of time lags (p). Finally, rejection of null hypothesis entails the rejection of Granger non causality.

D-ARDL specification

To explore the long- and short-run linear relationships between stock market returns and macro-economic factors, the following equation in the ARDL form will be used:

$$\Delta LSP_t = \mu(t) + \gamma_1 \, LSP_{t-1} + \gamma_2' \, X_{t-1} + \sum_{i=1}^{p} \alpha_i \, \Delta LSP_{t-i} + \sum_{i=1}^{p} \beta_i' \, \Delta X_{t-i} + \varepsilon_t, \quad (1)$$

where

$$\mu(t) = C_1 + C_2 t + \mu_1 \, D2003 + \mu_2 \, DT,$$

$$X = (LCPI, LINT, LEXC)',$$

$$\Delta X = (\Delta LCPI, \Delta LINT, \Delta LEXC)' \equiv (INF, INTG, EXCG)',$$

$$D2003 = 1 \text{ for year} \geq 2003 \text{ and zero if not},$$

and

$$DT = t \text{ if } t \geq 2003 \text{ and } 0 \text{ if not},$$

indicating significantly **change** of SP **trend by the end of 2002**, C_1 is the intercept of this equation, t is the trend, α_i and β_i represent **short**-term relationship, γ_1, and γ_2 represent **long-term** relationship (all are real parameters), p is the maximum lag to be used, and $\varepsilon_t \sim$ WN (0, σ^2).

F_{PSS} Test Procedure

Another way to test for co-integration and causality is the Bounds Test for Co-integration within the ARDL framework developed by (Pesaran, Shin, & Smith, 2001). This test is based on F type statistic (noted by $\boldsymbol{F_{PSS}}$) to resolves null hypothesis of no co-integration in the ARDL model. It is a bound test [with two sets of critical values (lower and upper)].

$\boldsymbol{F_{PSS}}$ test is based on the following steps:

[5] The Toda and Yamamoto, 1995 approach follows the following steps: First, we find the integration order for each series (d). If the integration order is different we get the maximum (d max). Second, we create a VAR model on series levels regardless of integration order that we found. Then, we define the order of stable VAR model (p) from lag length taken from LR, final prediction error (FPE), AIC, SC, HQ criteria.

Step 1: Testing for the unit root of LSP_t and X_t (using either ADF or PP tests, or both).

Step 2: Testing for co-integration between LSP_t and X_t (using Bounds test approach).

The null hypothesis of no co-integration is:

$$H_0: \gamma_1 = 0, \gamma_2' = 0$$

And the alternative hypothesis of co-integration is:

$$H_1: \gamma_1 \neq 0, \gamma_2' \neq 0.$$

If the $\mathbf{F_{PSS}}$ **is greater** than the upper critical bound, then the null **hypothesis is rejected**, suggesting that there is a co-integrating relationship between the variables under consideration. If the F_{PSS} falls below the **lower** critical bounds value, it suggests that there is **no co-integrating** relationship.

3. Empirical Results

A. Co-integration test

To test for co-integration and before employing causation analysis, we must specify how many lags to include in the VAR models. Therefore, in order to find out the lag length, we followed a lag length selection criterion, the AIC information criterion which suggests 2 lags for the time series data as the least value of AIC, i.e. -**20.57994** corresponds to 2 lags in the selected sample period as displayed in **Table 4**.

Table 4 : Optimum lag length for VAR specification

Lag	LogL	LR	FPE	AIC	SC	HQ
0	475.2126	NA	6.96e-10	-9.733597	-9.519901	-9.647217
1	1002.602	988.8544	1.65e-14	-20.38753	-19.74645*	-20.12840
2	1027.837	45.21363*	1.36e-14*	**- 20.57994***	-19.51146	-20.1480*
3	1039.090	19.22406	1.51e-14	-20.48105	-18.98518	-19.87639
4	1048.676	15.57702	1.74e-14	-20.34742	-18.42416	-19.57001

Note: * indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level), AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion.

In order to test the co-integration between time series we applied the Johansen test for P-1 = 1, showed at **Table 5**. The test result shows that there is no co-integration depending on the five cases.

Now, two alternatives can be considered: a VAR (1) model for stationary variables (variables in 1st difference) or an ARDL model for non-stationary variables (in level and at first difference). Here after, we see which of these alternatives is more adequate for UK stock market price during this period of study.

Table 5 : Johansen test results for P-1 = 1.

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	0	0	0	0	0
Max-Eig	0	0	0	0	0

Note: Exogenous series: D2003. Series are LSP LCPI LINT LEXC. Lags interval is 1 to 1.

B. VAR in First difference

In one hand, we recruit the impulse response function with a view to more understand our analysis. In fact, the impulse response function analysis is illustrated in the **figure 2**. The first line of graphs shows the IRF of VAR (1) module respectively of R, and monetary indicators including the inflation, exchange rate growth, and interest rate growth (INF, EXCG and INTG). From the **figure 2**, it is evident that for Return (R) there was a sharp full in the first two months. However, this is added to a **positive** impact from inflation,[6] which lasts about four months and disappears afterwards, as compared to the interest rate, which does not show any noticeable effect. Nevertheless, the graphs displays that the exchange rate has the biggest positive effect, as the UK currency depreciates as the exchange rate rises. If the UK money is appreciated, the market attract investments. This rise in demand push up the stock market level, suggesting that stock market returns will be positively correlated to the changes in the exchange rates.[7]

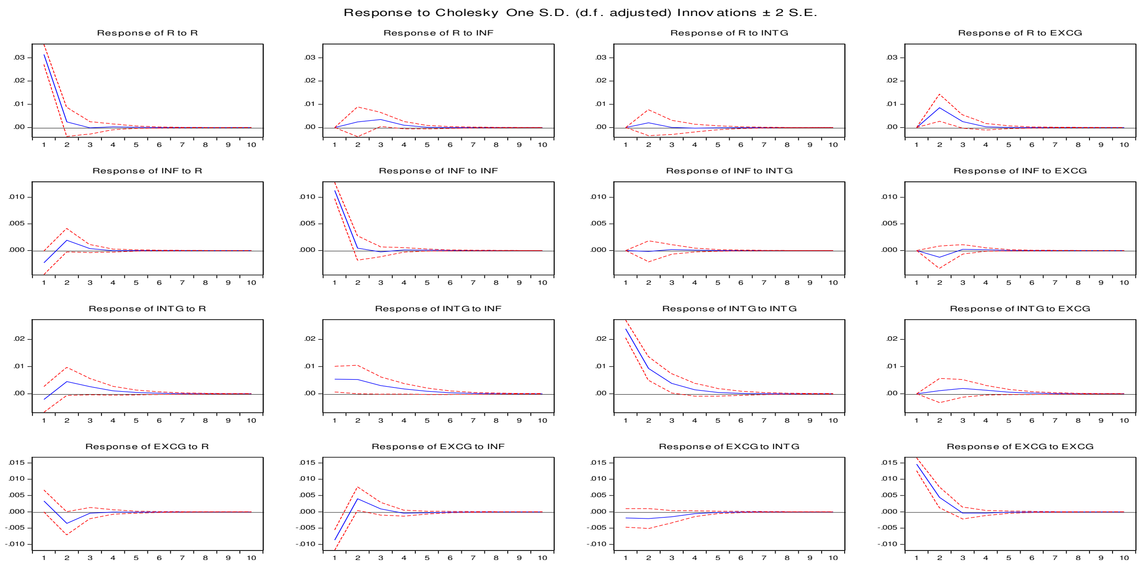

Figure 2 : Impulse response analysis from VAR (1) for variables in first difference.

[6] The results of studies by (Fama & Schwert, 1977) and (Nelson, 1976) pointed to a negative relation between inflation and stock prices (affirming that macroeconomic variables influence stock returns).

[7] Alternatively, a depreciation of the UK currency lead to an increase in demand for UK's exports and thereby increasing cash flows to the country.

In order to test the correlation between the residues of the model the Autocorrelation LM test was implied. The test ensures that the residues are uncorrelated and that they represent white noises (see **Table 6** here after).

Table 6: VAR Residual Serial Correlation LM Tests. Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	16.54385	16	0.4157	1.038344	(16, 284.8)	0.4160
2	9.923611	16	0.8706	0.615757	(16, 284.8)	0.8707

A. Granger causality/Block Exogeneity Wald Tests

For the identification of the direction of causal association among considered variables, and to find out directional causality, we used VAR Granger Causality/Block Exogeneity Wald Tests on stationary series (VAR(1) in first difference).

Table 7 shows significant bidirectional causal relations: The first is between inflation and stock return . And the second one is between the exchange rate growth and the stock return. The table reveals the existence of a unique significant one-way unidirectional causal relation from inflation to exchange rate growth at 1% significance level ($p < 0.01$) at 1 lags. However, the other pairs of variables do not have any causation in either direction as demonstrated at Table 7.

Thus Granger causality results suggest that changes in **stock return in the United Kingdom** stock market has significant **short run** effects on the **exchange rate growth** and **on the inflation .**

Table 7: VAR Granger Causality/Block Exogeneity Wald Tests from VAR (1) model in first difference variables (p = 2).

Dependent variables	test results	R	INF	INTG	EXCG	ALL	conclusion
R	Stat	_	5.174221	0.044329	12.50174	13.09507	**INF, EXCG→ R**
	P-value		**0.0229**	0.8332	**0.0004**	0.0044	
INF	Stat	4.468413	_	0.002636	1.592258	5.263613	R→ INF
	P-value	**0.0345**		0.9590	0.2070	0.1535	
INTG	Stat	4.023634	2.653359	_	0.681698	6.565712	R→ INTG
	P-value	**0.0449**	0.1033		0.4090	0.0871	
EXCG	Stat	3.686390	13.51211	1.053974	_	18.54292	R,INF→ EXCG
	P-value	**0.0549**	**0.0002**	0.3046		0.0003	

B. Toda and Yamamoto test

In second stage, we employed (Toda & Yamamoto, 1995) Wald test **Table 8** shows a significant one-way unidirectional causal relation **from exchange rate to stock price,** from stock price to interest rate, and from consumer price index to exchange rate at 5% significance level ($p < 0.05$)

Table 8: Toda and Yamamoto (TY) Modified Wald non causality test analysis

Dependent variables	Test	LSP	LCPI	LINT	LEXC	All	Conclusion
LSP	Stat	_	1.882091	0.445491	6.525639	7.415475	**LEXC→LSP**
	P-value		0.3902	0.8003	**0.0383**	0.2841	
LCPI	Stat	1.201122	_	0.673941	1.873069	4.494840	
	P-value	0.5485		0.7139	0.3920	0.6100	
LINT	Stat	8.338772	1.318868	_	0.964373	10.02974	LSP→LINT
	P-value	**0.0155**	0.5171		0.6174	0.1234	
LEXC	Stat	1.908429	15.07854	2.041639	_	21.25692	LCPI→LECG
	P-value	0.3857	**0.0005**	0.3603		0.0016	

Note: The rejection of null hypothesis at 5% ($p < 0.05$) or at 10% ($p < 0.1$). All variables are **in level**. **P+dmax=3**.
Source: Authors' calculations.

B. ARDL model results

In order to implement the ARDL model, we have to determine the appropriate lags length. To ensure comparability of results for different lag lengths, all estimations were computed over the same sample period and the selection of ARDL (11, 12, 11, 10) is based on the **lowest** value of the Akaike Information Criterion (see **Figure 3**). After deciding the optimal lags orders, the results of $\boldsymbol{F_{PSS}}$ test-statistic is reported in the table below (**Table 9**).

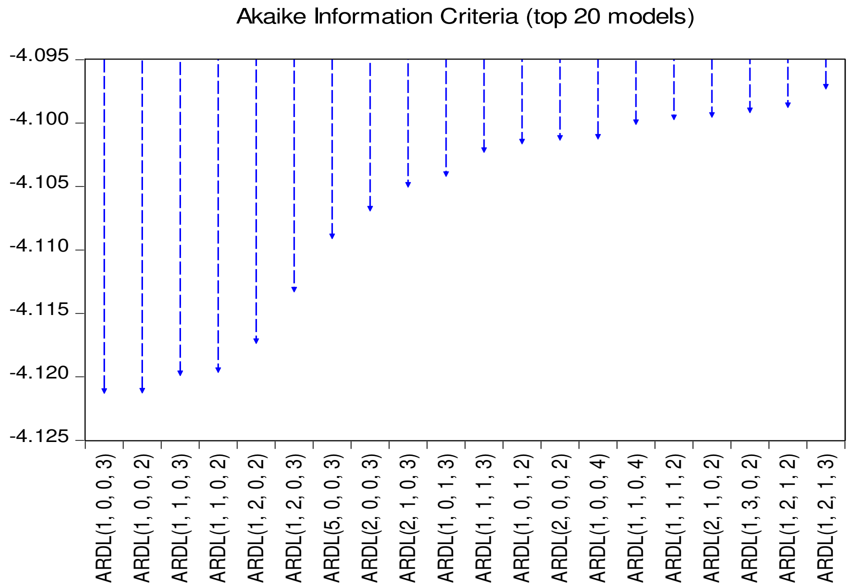

Figure 3 : ARDL selection based on optimal AIC.

The $\mathbf{F_{PSS}}$-statistic for joint significance is above the upper bound critical value at 5% level of significance (5.07). This result confirm the existence of **long-run** equilibrium relationship between macroeconomic variables and UK Stock market Prices pre GFC (see **Table 9**).

Table 9: F_{PSS}- Statistic of Cointegration between Macro Variables and Stock Prices

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n = 1000	
F-statistic	**12.125668**	10%	3.47	4.45
K	3	5%	**4.01**	**5.07**
		2.5%	4.52	5.62
		1%	5.17	6.36

We further go to the long run stability relation and the short run dynamics. The results of the long run coefficients are presented in **Table 10**. It implies that Consumer Price Index (CPI in log), interest rate (INT in log) and exchange rate (EXC in log) affect positively the UK stock price in the long run.

Table 10: Long run relationship results.

ECT= LSP	-(0.898776*LCPI	+ 0.171244*LINT	+1.053271*LEXC)
	(0.439729)	(0.053462)	(0.12356)
	[**0.0468**]	[**0.0025**]	[**0.0000**]

Note: (.) and [.] are respectively the standard deviation and the p- value.

In order to capture the short-run dynamics of the model, error correction mechanism was applied and the results are reported in the **Table 11**. The results show that the ECM term, has negative sign **(-1.557087)** and is statistically significant at 5 percent level, ensuring that long-run equilibrium can be attained in the case of UK stock market.

Since the co-integration results show that stock prices are co-integrated with LCPI, LINT and LEXC, the following Error Correction Model (ECM) will be used in testing the long run causal relationship;

$$\Delta LSP_t = \mu_1(t) + \delta_1 ECT_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta LSP_{t-i} + \sum_{i=1}^{p} \beta_i \Delta X_{t-i} + \varepsilon_t \qquad (2)$$

Then, there is a long-run causal relationship between LSP and X = (LCPI, LINT, LEXC)′. Precisely, $\boldsymbol{\delta_1}$ indicates a causality from X = (LCPI, LINT, LEXC) ′ to LSP that implying that X = (LCPI, LINT, LEXC) ′ drives LSP toward long-run equilibrium.

Table 11: Error Correction model of LSP for the UK Stock Market

Variable	ECM_{-1}	C_l	t	TD	D2003
Coefficient	**-1.557087**	1.101887	0.017267	-0.032140	-1.611587
Std. Error	0.216479	0.155528	0.002433	0.004509	0.230761
t-Statistic	-7.192791	7.084836	7.098104	-7.127912	-6.983782
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000

To ascertain the goodness of fit of the selected ARDL model, the stability and the diagnostic tests are conducted. **Table 12** shows that, the selected ARDL model fulfils the conditions of no specification errors. Considered Diagnostic test statistics are serial non correlation tests and homoskedasticity test at 5% level.

The structural stability test is conducted by employing the cumulative sum of recursive residuals (CUSUM).

Figure 4 presents plot of the CUSUM test statistics that fall inside the critical bounds of 5% significance. The stability tests further confirm the stability of the estimated coefficients.

Table 12: diagnostic of ARDL model (Breusch-Godfrey Serial Correlation LM Test)

F-statistic	1.406155	Prob. F(2,43)	**0.2561**
Obs*R-squared	5.893215	Prob. Chi-Square(2)	0.0525

Heteroskedasticity Test: ARCH

F-statistic	1.091755	Prob. F(1,93)	**0.2988**
Obs*R-squared	1.102293	Prob. Chi-Square(1)	0.2938

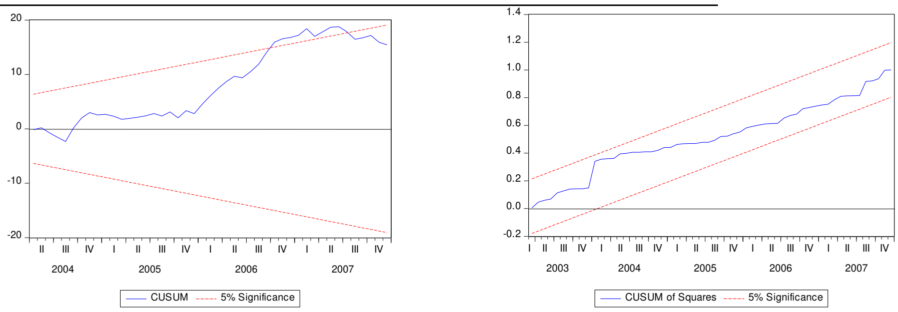

Figure 4 : Plot of cumulative sum of recursive residuals

IV. Conclusion

The role of macroeconomic monetary variables in the relationship with the share prices of stocks has become a critical and fascinating subject for academics and financial economics practitioners. The **efficient** market hypothesis suggests that all the relevant information currently known about changes in macroeconomic variables (such as money supply and interest rate) are fully reflected in current stock prices, so that investors will not be able to earn **abnormal profit** through **prediction** of the future stock market movements.

This study examines the relationship between stock prices and a set of macroeconomic variables, which comprises interest rate, inflation, consumer price index and the exchange rate, using data from the United Kingdom stock market for the period **Pre 2008 GFC**; from January 1999 to December 2007. This study employs a time series technique comprised of VAR, cointegration, Error Correction Modelling, and Granger causality tests to reach empirical evidence of the nature of relations between stock prices and macroeconomic variables. **ARDL** findings revealed that the UK market formed significant relationships with all macroeconomic variables included in this study.

Following these successive steps, the study concludes:

First, the impulse response graphs from the VAR (1) model on stationary series (variables in first difference) show **temporary** effects on stock return.

Second, the VAR Granger non Causality/Block Exogeneity Wald Tests results show that both inflation (INF) and exchange rate growth (EXCG) **Granger cause** the stock market Return of the United Kingdom.

Third, from the (Toda & Yamamoto, 1995) Wald non causality test on **non-stationary** series (variable in level), Show that only exchange rate (EXC) as macroeconomic factor which has **effect** on UK stock market prices.

Fourth, the **Johansen's** co-integration test reveals **no co-integration** between the macro economic factors and the United Kingdom stock market price.

And then, it's the **ARDL** model which implies the existence of a stable **long run** equilibrium relationship between macroeconomic variables and the stock market price. The results of the ECM representation confirm that all considered macroeconomic factors X = (LCPI, LINT, LEXC) ′ drives UK stock price (LSP) toward long-run equilibrium at a fast speed.

This study would guide UK policy makers toward reassessing their policies regarding those macroeconomic variables and their influence on the stock market. They should be aware that any changes in their policies regarding the macroeconomic variables would have affect the stock market.

Finally, further analysis can considered to use a wider dataset, including the time from 2008 global financial crisis to nowadays, and more macroeconomic factors, which may lead to more significant results in the relationship between UK stock prices (returns) and UK economic environment.

Annex 1: Test Toda and Yamamoto (TY) results

Table A 1 : Pairwise Granger causality test results.

Null Hypothesis:	Obs	Conclusion	F-Statistic	Prob.
INF ↛R	105		0.41283	0.6629
R ↛ INF			1.39199	0.2534
EXCG ↛ R	105		1.84045	0.1641
R ↛ EXCG			2.13843	0.1232
INTG ↛ R	105		0.64080	0.5290
R ↛ INTG		R→INTG	5.94337	**0.0036**
EXCG ↛ INF	105		1.39358	0.2530
INF ↛ EXCG		INF→EXCG	7.67881	**0.0008**
INTG ↛ INF	105		0.06672	0.9355
INF ↛ INTG			0.49165	0.6131
INTG ↛ EXCG	105		0.84674	0.4319
EXCG ↛ INTG			0.30055	0.7411

Note: **↛: does not Granger Cause. →: Granger cause.**

Table A2 : Johansen test results.

	Log Likelihood by Rank (rows) and Model (columns)				
0	1096.365	1096.365	1096.757	1096.757	1101.796
1	1106.146	1108.424	1108.723	1111.540	1116.535
2	1113.153	1116.031	1116.270	1123.471	1126.310
3	1113.874	1120.955	1121.155	1128.887	1131.726
4	1114.080	1121.555	1121.555	1132.073	1132.073
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	-20.38425	-20.38425	-20.31617	-20.31617	-20.33577
1	-20.41785	-20.44196	-20.39100	-20.42528	-20.46293
2	-20.39910	-20.41569	-20.38245	-20.48058	-20.49642*
3	-20.26178	-20.33878	-20.32367	-20.41296	-20.44766
4	-20.11471	-20.18029	-20.18029	-20.30327	-20.30327
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	-19.98222*	-19.98222*	-19.81363	-19.81363	-19.73273
1	-19.81481	-19.81379	-19.68745	-19.69660	-19.65887
2	-19.59505	-19.56138	-19.47789	-19.52576	-19.49135
3	-19.25670	-19.25833	-19.21809	-19.23200	-19.24157
4	-18.90862	-18.87369	-18.87369	-18.89617	-18.89617

Table A3 : Model Residual Diagnostics

Lag	LRE* stat	Df	Prob.	Rao F-stat	df	Prob.
1	18.40812	16	0.3005	1.159085	(16, 284.8)	0.3008
2	29.32587	32	0.6026	0.914922	(32, 329.8)	0.6036

Annex 2: VAR (1) for variables in 1st difference

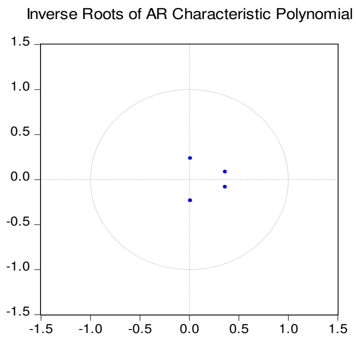

Figure B 1 : VAR (1) stability condition of level variables

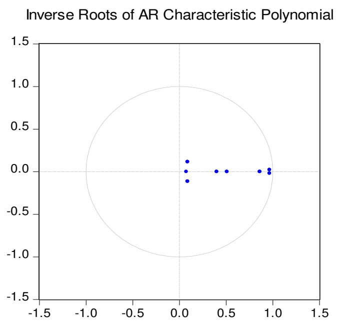

Figure B 2 : VAR (3) stability condition of level variables, application of TY test

Table A 4 : VAR (3) stability condition in application of LY test.

Root	Modulus
0.967244 - 0.021558i	0.967484
0.967244 + 0.021558i	0.967484
0.862437	0.862437
0.510876	0.510876
0.402018	0.402018
0.088500 - 0.115411i	0.145437

No root lies outside the unit circle.
VAR satisfies the stability condition.

Annex 3: ARDL

Table A5: The rest of the ARDL results.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LSP(-1))	1.029530	0.179575	5.733149	0.0000
D(LSP(-2))	0.913293	0.190470	4.291842	0.0000
D(LSP(-3))	1.020127	0.153869	5.817175	0.0000
D(LSP(-4))	0.678808	0.163381	4.072734	0.0000
D(LSP(-5))	0.779443	0.156360	5.477089	0.0000
D(LSP(-6))	0.649211	0.166157	4.898012	0.0000
D(LSP(-7))	0.379170	0.165426	3.445784	0.0018
D(LSP(-8))	0.332353	0.157248	2.968869	0.0066
D(LSP(-9))	0.320530	0.151887	2.695358	0.0099
D(LSP(-10))	0.314194	0.155853	2.515596	0.0155
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCPI)	-0.695262	0.483337	-0.438462	0.4572
D(LCPI(-1))	-1.572790	0.500371	-2.144731	0.0101
D(LCPI(-2))	-1.194359	0.499529	-2.389085	0.0059
D(LCPI(-3))	-0.392510	0.457007	-1.858870	0.1290
D(LCPI(-4))	0.921695	0.461454	1.997372	0.0519
D(LCPI(-5))	-0.025873	0.470584	-0.054981	0.9564
D(LCPI(-6))	0.644562	0.452469	1.424544	0.1612
D(LCPI(-7))	0.846362	0.454736	1.861216	0.0693
D(LCPI(-8))	1.049598	0.428252	2.450888	0.0182
D(LCPI(-9))	0.539272	0.482646	1.117324	0.2698
D(LCPI(10))	-0.122227	0.367559	-0.332536	0.7410
D(LCPI(11))	-0.242715	0.328941	-0.737869	0.4644
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LINT)	-0.069881	0.193412	-0.361304	0.7196
D(LINT(-1))	0.017256	0.196850	0.087661	0.9305
D(LINT(-2))	0.114213	0.204081	0.559645	0.5785
D(LINT(-3))	-0.105740	0.162589	-0.650351	0.5188
D(LINT(-4))	-0.190288	0.167473	-1.136229	0.2619
D(LINT(-5))	0.263049	0.176810	1.487746	0.1438
D(LINT(-6))	-0.243755	0.167986	-1.451043	0.1537
D(LINT(-7))	-0.199583	0.174128	-1.146184	0.2578
D(LINT(-8))	0.156505	0.175152	0.893540	0.3763
D(LINT(-9))	0.137257	0.170044	0.807183	0.4238

D(LINT(10))	0.298772	0.168035	1.778030	0.0822
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LEXC)	-0.155570	0.281069	0.153495	0.8589
D(LEXC(-1))	-0.644041	0.281995	-3.283874	0.0012
D(LEXC(-2))	-1.484706	0.284821	-3.701792	0.0007
D(LEXC(-3))	-0.007620	0.273794	-4.027833	0.0000
D(LEXC(-4))	-0.569111	0.287412	-1.980122	0.0538
D(LEXC(-5))	-0.018343	0.307786	-3.059595	0.0026
D(LEXC(-6))	-0.137006	0.296800	-1.461611	0.0959
D(LEXC(-7))	-0.131901	0.283702	-1.464929	0.2440
D(LEXC(-8))	0.249631	0.279565	1.608326	0.3189
D(LEXC(-9))	0.424058	0.294342	1.440702	0.0525

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