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# Analysing the Impact of Major Financial Crisis on Macroeconomic Variables and Stock Prices: An Empirical Study of Stock Market of United Kingdom

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***Author's contribution***

*The sole author designed, analyzed, interpreted and prepared the manuscript.*

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## ABSTRACT

The research paper empirically tests the impact of major financial crisis of 2008 by testing the causality between five macroeconomic variables (interest rate, inflation, money supply, GDP and exchange rate), the FTSE All-Share index and its sectoral indices. Furthermore, it analyses whether the global financial crisis of 2008 affected the direction of the causality or not. For this purpose the causality tests were performed in two sections one on the data for the pre financial crisis period from 1999 to 2007 and another on the data for post financial crisis period from 2008 to 2022. The causality was tested using the quantile Granger causality test, the research findings reveal the complex causality between the UK stock market and the most prevalent macroeconomic factors. The findings of the research are suggestive that the causality between macroeconomic factors

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changed from pre-crisis period to post-crisis period. This is indicative of the event sensitivity of the stock market of UK. It was found that the direction of this causality varies according to the circumstances of the economy and across different sectors involved, and particular economic conditions at various times. The findings of this research provide important insights for policymakers, investors, and economic analysts, as they shed light on the dynamic and complex relationship between the indicators, both on an aggregate and sectoral level. The research findings also emphasise the importance of considering the variables' distribution when analysing the issue of causality.

*Keywords: Money supply; inflation; GDP; exchange rate.*

**JEL Classification:** E430 Interest Rates, G010 Financial Crisis, C190 Causality.

## 1. INTRODUCTION

The intricate and dynamic relationship between macroeconomic variables and stock prices has been a long-standing topic of investigation. Furthermore, financial crises can profoundly disturb the dynamics between macroeconomic variables and stock prices, redefining established correlations and forecasting models. This paper aims to explore this impact, focusing specifically on how the correlation between these parameters changes during periods of financial instability [1-4]. The most common theories for examining the relationship between macroeconomic factors and stock returns is the capital asset pricing model (CAPM), which was introduced by Sharpe (1964) and Lintner (1965), and the arbitrage pricing theory (APT), which was established by Ross (1976) as an alternative for the CAPM. This paper will hypothesize the APT theory because, according to Copeland et al. (2004), the APT is more robust than CAPM for several reasons. Firstly, in contrast to the CAPM, which requires an efficient market portfolio, the APT assigns no special significance to the market portfolio. Secondly, the APT is easily adaptable to a multi-period context, allowing us to consider the impact of the financial crisis period in our examination. Moreover, there are no assumptions about the distribution of asset returns in the APT. Furthermore, the APT makes a statement regarding the valuation of any group of assets, implying that it is unnecessary to evaluate all the assets in the universe in order to verify the theory, and it permits multiple factors, not just one, to influence the balanced returns of assets [5-10]. Lastly, numerous empirical studies have examined the relationship between macroeconomic variables and asset returns using the APT theory, and it is well documented for emerging and developed markets [11,12,13-19], Humpe and Macmillan, 2009; [20].

In the recent past, several countries have faced economic and financial crises. For example, the global financial crisis 2007–2008 and the Asian financial crisis in 1997 led to significant changes in the financial economy [21-24]. Several attempts have been made to explore the effects of these crises on the nature of the causality between macroeconomic variables and stock prices, and it has been concluded that stock prices responded differently prior to and after the crises [25]. For example, Caporale et al. [26] examined the impact of the 1997 Asian financial crisis on the causality between stock prices and exchange rate using daily data. In the pre-crisis sample they found a unidirectional causality from stock prices to the exchange rate in Indonesia and Thailand while the causality was bidirectional after the crisis.

## 2. LITERATURE REVIEW

The literature review section explored the relationship between selected macroeconomic variables and stock prices. Our selected macroeconomic variables are the money supply, interest rate, inflation, GDP and exchange rate. The reason for selecting these variables for discussion is that they reveal a comprehensive picture of the macroeconomic conditions and they have a significant effect on corporate earnings, which is a major factor in determining stock prices and vice versa (Abdalla and Murinde, 1997; [27,28],Granger et al., 2000; Shiller and Beltratti, 1990; Sui and Sun, 2016). Consequently, these variables are frequently employed in studies examining the association between macroeconomic variables and stock prices. Furthermore, this literature review explored the causality between these variables and stock prices, and the effect of financial crises on this causality.

Economists argue that monetary policy instruments are effective tools used by central

banks to control the money supply and affect the performance and development of businesses, the economy and stock prices [29]. Restrictive and expansionary monetary policies both have a dual effect on stock prices. By applying an expansionary monetary policy, the central bank aims to increase the money supply. Consequently, this policy can affect stock returns either positively or negatively. When the effect is positive, the increase in the money supply results in high savings available for investment, which encourages investment in stock, leading to an appreciation of stock prices. On the other hand, the effect could be negative if this increase in money supply causes inflation and an increase in the interest rate, which leads to stock price depreciation [30]. In the case of a restrictive monetary policy, reducing the money supply growth rate would result in a decrease in the supply of funds for working capital and business expansion, which causes depreciation in stock prices. However, a reduction in the money supply might result in lower inflation, hence a lower nominal interest rate. This would thus lead to higher stock prices [30].

Wongbangpo and Sharma [31] expanded their investigation to Asian economies, specifically from 1985 to 1996 prior to the advent of the Asian financial crisis. In Malaysia, Singapore and Thailand, their research observed a positive correlation. They attributed this to the amplified impacts of rising corporate profits and economic stimulus, which exceeded the inflationary effects that were caused by the rise in money supply.

Contrary to these conclusions, other research indicates a negative correlation between money supply and stock prices (Bhattacharya and Mukherjee, 2002; Nawaz and Husain, 2007; Wongbangpo and C.Sharma, 2002). For example, Nawaz and Husain's (2007) investigation on the Pakistani economy revealed a negative relationship. In addition, in Indonesia and the Philippines Wongbangpo and Sharma [31] found that an increase in the money supply resulted in a decrease in the stock market due to the negative effects of inflation, which outweighed the advantages of money supply growth.

The interest rate is a critical macroeconomic variable, and there is a consensus about its significant effect on the economy and stock prices [7,32,8,33], Shiller and Beltratti, 1990). Usually, the economic sectors need at least 12 months to reflect any response to changes in the interest rate, but the stock prices respond immediately (Hall, 2022). According to Mishkin [33], interest rates affect stock prices through two channels: cost of borrowing and economic growth. Specifically, the interest rate can affect stock prices through the cost of borrowing if interest rates increase and the cost of borrowing funds becomes greater. This results in a reduction in corporate investments and expansions, thereby decreasing potential earnings, which leads to a decline in stock prices. On the other hand, interest rates affect stock prices through economic growth if low interest rates increase economic growth by allowing borrowing to be more affordable. This raises consumption and investment, increasing business earnings and leading to a rise in stock prices. In contrast, an increase in interest rates can restrict economic growth, resulting in reduced profits for businesses and lower stock prices.

Inflation not only reflects countries' economic level, but it is also a primary factor that affects a firm's financial abilities and its stock price. In more detail, according to the Fisher effect theory proposed by Fisher [34], the relationship between inflation and stock prices can be complex and multifaceted, influenced by a variety of factors such as business earnings, interest rates and market sentiment. Specifically, inflation could affect stock prices through business earnings due to the increased cost of services and products caused by inflation; this in turn increases corporates' revenues and contributes to higher stock prices. However, this implies that businesses can transfer their higher expenses to their customers, which causes changes in stock prices. Furthermore, inflation also affects stock prices through interest rates, as when inflation rises, so do interest rates. These rises increase the cost of financing for businesses, which may have a negative effect on revenue as well as stock prices. Moreover, fixed-income securities will be more attractive than equities when interest rates are high, which causes investors to move out of the stock market to fixed-income markets, reducing stock prices. Lastly, inflation could affect stock prices through market sentiment, as high inflation may give rise to concerns over local economic and financial transactions, which can have a negative impact on confidence in the market as well as stock prices.

In contrast, according to Mankiw (2004), there are two indirect ways in which stock prices can

affect inflation. Firstly, when stock prices rise dramatically, the resulting increase in wealth can result in higher spending. This may cause higher economic activity and contribute to a rise in inflation. Secondly, an increase in stock prices may strengthen the confidence of corporates and consumers, resulting in higher investment and business expenditure. This could cause economic growth and inflation, particularly if it leads to higher salaries or production costs that are transmitted to consumers.

The relationship between the real economy and stock prices has long been a subject of debate among economists and financial analysts [35], Bouri et al. 2020; [36,37]. During the period 1970–2008, the US stock price trend mirrored the movement in real GDP (Mankiw, 2010). According to Mankiw (2010) and Marques et al. (2013), there are two points of view on this relationship. The first point of view is that stock prices play a significant role in economic growth due to the wealth effect. This argument states that a rise in stock prices causes an increase in the volume of investments due to the increase in wealth. Hence, this causes an increase in consumer expenditure and then GDP growth (Marques et al., 2013) . On the other hand, the second point of view states that GDP is the most comprehensive indicator of stock prices. An increase in GDP shows a growing economy, which is typically beneficial for industries. In general, increased economic activity results in increased transactions, sales, and profits for businesses and, thus, an appreciation in stock prices (Mankiw, 2010).

Empirical studies have examined the relationship between GDP and stock prices widely (Alexius and Spang, 2018; Beck and Levine, 2004; Chakraborty, [36]; Hunjra et al. [38]; Pan and Mishra, [39]. For example, Chakraborty [16] examined the relationship in India from 1996 to 2005 using the effective techniques of cointegration and Granger causality. The author suggests that a rise in GDP in India does not always result in a rise in stock prices, as they found a negative relationship between the two variables. Moreover, this negative association is also supported by Pan and Mishra [39], who analyzed the association in the Chinese context. Utilizing the Toda-Yamamoto methodology, their study examined data from 1999 to 2015 and confirmed the negative relationship observed in earlier research. This finding was also confirmed in Pakistan by Hunjra et al. [38].

The association between exchange rates and stock prices has attracted significant attention from economists, investors and policymakers (Abdalla and Murinde, 1997; Aylward and Glen, [6]; Granger et al., 2000; Sui and Sun, 2016). According to Wong [40], exchange rates have a major impact on stock prices, and this influence comes from two channels: the effect on capital flows and the effect on imported input costs. Specifically, the effect of exchange rates on stock prices through capital flows appears when foreign investors allocate their funds in stocks. If the local currency is gaining strength, this might encourage foreign investors to expect that it will continue to appreciate. They may purchase equities in that country's stock exchange, which raises stock prices. In contrast, if the local currency continues to fall, foreign investors may attempt to prevent currency losses by selling their holdings, which could result in a decline in stock prices. For the second channel, exchange rates affect stock prices by influencing the imported input costs because for industries that depend on imported products, a weaker domestic currency results in increasing costs, which reduces earnings and then decreases stock prices.

The association between sector indices and macroeconomic variables has been examined in compelling studies across a comprehensive range of literature. Different sectors behave differently to changes in these variables, indicating the asymmetrical character of their behaviour, as is well known. This is likely because of the diverse sensitivity of sectors to macroeconomic indicator movements. A few empirical studies have provided evidence for this: Hess (2003), Maysami et al. [41], Gregoriou et al. (2009) and Bhuiyan and Chowdhury (2020).

Gregoriou et al. (2009) tested the relationship between expected and unexpected interest rate changes and stock prices at the aggregate and sectoral levels in the UK from June 1999 to March 2009, using the GMM. The sectoral indices included oil and gas, basic materials, industrials, consumer goods, healthcare, consumer services, telecommunications, utilities, financials and technology. They found that during the financial crisis, the relationship between the aggregate index and interest rates became positive. The majority (80%) of the sectors followed this pattern of relationship with interest rates, while 20% presented a negative relationship with interest rates. However, before

the crisis both had a negative relationship at both the aggregate and sectoral levels. Moreover, Hess (2003) analyzed the relationship between the macroeconomic environment and the Swiss stock indices from 1975 to 2000 using the VAR model. He revealed that the hotel sector's reaction to inflation variations was significantly more significant than that of other sectors. This may be due to the unique financial structure of the hospitality industry. In addition, it was observed that the industrial sector was significantly more sensitive to the interest rate changes, likely due to the typically high capital requirements of these businesses. Additionally, Bhuiyan and Chowdhury (2020) evaluated the interaction between various sector indices, including energy, financials, real estate, industrials, healthcare, consumer discretionary and consumer staples, and macroeconomic factors such as industrial production, money supply and the long-term interest rate in the US and Canada from 2000 to 2018, employing the VEC model. They revealed that there is no relationship between these variables and macroeconomic factors in Canada, while there are different levels of causality between sectors in the US. The money supply leads the healthcare, consumer discretionary, consumer staples, real estate, industrial, energy and financial sectors. With regard to interest rates, there is causality from them to energy and materials, but the causality between industrial production and the selected sector was not observed. Also, Maysami et al. [41] investigated the relationship between the aggregate index of Singapore, three sector indices – the finance index, property index and hotel index – and various macroeconomic indicators: CPI, IP, proxies for long- and short-term interest rates, the money supply (M2), and exchange rates. The research covered the period from 1989 to 2001, and the authors used cointegration, the VECM and Granger causality. They found a unidirectional causality directed from all the macroeconomic variables to the aggregate stock index. At the sectoral level, they observed a unidirectional causality directed from inflation rates, exchange rates, and short- and long-term interest rates to the finance sector, but there was no causality with the money supply and IP. The property sector had a strong co-movement with the overall market, reacting similarly to changes in macroeconomic variables but with a higher impact. Moreover, a unidirectional causality existed between the hotel sector and exchange rates, but there was no causality between it and the other macroeconomic variables.

## 2.1 Lead from Literature Review

Extensive literature review and a thorough analysis of prior empirical results helped in shaping the path of this research work. APT theory has suggested the presence of an association between stock returns and macroeconomic indicators, but it does not define which indicators are the most important or valuable. Reviewing the literature was useful for determining which variables needed to be included in this study. Previous empirical results relevant to the UK and other countries during various time periods, employing various indicators and methodologies applicable to this study, have been discussed in detail.

In addition, literature reveiw is a comprehensive resource for identifying recent academic gaps and deciding the appropriate statistical tests for an empirical study of the causality between macroeconomic variables and stock prices. Despite the fact that this topic has been deeply studied in different geographical areas and from different perspectives, previous studies still have various limitations. For example, some studies examine a short time frame of only around 10 years, which is not a long enough period to capture the nature of the causality between the variables (Alagidede et al., 2011; [42]; Olawale et al., 2014). Furthermore, other studies focused on only one of the macroeconomic variables and ignored the other variables, which could have a strong effect on the results [43], Granger et al. 2000; Nasseh and Strauss, 2000; Pradhan et al. 2019).

## 2.2 Justification of the Research and Methodology

A large number of empirical studies have investigated the causality between macroeconomic variables and stock prices in developed, emerging markets and these various studies investigate the causality in the UK. Despite this, the nature of this relationship is still debated among researchers (Abdalla and Murinde, 1997; Akbar et al., 2012; Alam and Uddin, 2009; Apergis and Eleftheriou, 2002; Caporale et al. 2002). For the UK, some studies have reported unidirectional causality from macroeconomic variables to stock prices, such as Azad and Serletis [44] and Peiró [8], while others found unidirectional causality in the opposite direction, such as Masuduzzaman [42] and Shirvani (2008). Some have found bidirectional causality between the variables, for

example Hasan (1999) and Cakan [45]. This difference in the results could be because of the variation in the used methodologies, selected periods and economic circumstances.

Therefore, it is important to re-examine the causality in the UK with a new perspective. All of the previous studies investigated causality at an aggregate level and used traditional econometrics models such as VAR and the standard Granger causality. However, there is still a need for further research utilizing non-traditional methods and indicators. Consequently, this research will contribute to the literature in three ways :

**First**, while most of the current studies have examined the causality between macroeconomic variables and the aggregate stock indices, a limited number of studies have examined the causality at the sectoral level in the UK. Therefore, this research fills the gap in the limited sectoral studies in the UK by using the FTSE All Share index and sectoral indices. The motivation for analysing sector indices come from the fact that the estimated impact of macroeconomic indicators on the stock market varies among different stock sectors. For instance, research conducted in Switzerland on the same topic demonstrated that the industrial sector is more sensitive to changes in macroeconomic variables than the service sector (Hess, 2003). Hence, analysing the causality at the sectoral level is helpful for investors and portfolio managers because it helps them to measure the risks and expected returns associated with their investments. **Second**, this paper tests the sensitivity of relationship between macroeconomic variables and stock indices of UK for pre financial crisis 2008 period and post financial crisis period. To assess the variability in causality across these two periods. **Third**, since most previous studies used the standard Granger causality model to test the causality between macroeconomic variables and the stock market, such as Bhattacharya and Mukherjee (2002), Ratanapakorn and Sharma (2007), Issahaku et al. [46] and Ray (2014), we cannot rely on the results of this model only because it depends on the mean of the data. Therefore, this paper will contribute to the literature by providing a deeper understanding of the causality between macroeconomic variables and stock prices in the UK using an advanced quantitative method – quantile Granger causality. The quantile approach is distinct from the classical models because it considers the distribution of the dependent variable in the analysis, which will provide more precise results (Koenker and Bassett, 1978).

## 2.3 Objectives of the Research

This empirical research aims to test the APT empirically in order to explain the two-way direction causality between macroeconomic variables and stock share prices at the comprehensive and sectoral levels in the UK, using a novel quantitative method. Therefore, the following objectives have been developed:

- To analyse the long- and short-term relationship between macroeconomic variables and stock sector indices in the UK.
- To provide comprehensive results for the causality between macroeconomic variables and stock prices by analysing it for each quantile.
- To examine the impact of the 2008 financial crisis on causality at the sectoral level by testing the data for the aggregate period and before and after the financial crisis.
- To provide an in-depth evaluation of stock indices to help investors mitigate the risk of their portfolios.

## 2.4 Importance and Expected Deliverance of the Research

This paper is important for investors and policymakers for several reasons. The results will benefit investors by facilitating the forecasting of changes in stock prices and determining the direction that a fund will take if there is a change in macroeconomic variables, instead of moving out of the market. With regard to policymakers, they need to evaluate the outcomes and influences of their decisions on stock markets and the economy. Therefore, this paper will help them to manage the effects of their decisions on the stock market. In addition, the findings of this paper will make an essential contribution to the field of finance and economics research.

## 2.5 Data Description

Monthly price data are used for the stock share prices, represented by the FTSE All Share Index, and six sector indices (consumer discretionary, consumer staples, energy, industrials, materials, and utilities). All of the prices are expressed in GBP. Due to the mismatch of the frequency of

GDP and rest of the variables used in the analysis, it is converted from quarterly to monthly by assuming the uniform distribution of GDP for a month of a given quarter. For the macroeconomic variables, the inflation rate is calculated by using the CPI and the money supply (M4) expressed in GPB, in order to explore the relationship on the side of the Bank of England's actions. Furthermore, as a proxy for the interest rate, the UK Treasury bill tenders (TBRs) 3M are employed because they are always market clearing (Siklos and Wohar, 1997). GDP in GBP is employed to assess the causality by considering the real economy. Lastly, to examine the causality between foreign countries' markets and the UK markets, the exchange rate of USD to GBP is used as the foreign exchange rate. The sample includes 277 observations, and the selected variables are sourced from DataStream, except for the CPI, which is taken from The Office for National Statistics. The monthly data ranged from April 1999 to April 2022, considering the availability of data and their consistency within the accessible timeframe. All of the data are seasonally adjusted except the interest rate. GDP, M4 and stock prices are converted to the real prices using the CPI as a deflator, and all the variables are transformed into logarithm form, except inflation and the interest rate. Moreover, the study also introduces the global financial crisis 2008 as a dummy variable to capture structural breaks inherent in the data, where from 1999 to 2007 (pre-financial crisis period) and from 2008 to 2022 (After the financial crisis period). Fig. 1 presents the time series plots for the variables used in the test. It shows that each macroeconomic variable performs differently, but also that there in a certain period there is unusual behaviour – this is the previous financial crisis in 2009. For the stock share prices, it is clear that the FTSE All Share Index and the six sectors tend to increase in the long term, but the index demonstrates more fluctuations than the sectors. Moreover, stock share prices also experience a shock in the financial crisis period. Regarding the relationship between the variables, it is concluded from the figure that each macroeconomic variable is related to the stock share prices differently.

## 2.6 Model

To examine the causality between macroeconomic variables and stock share prices at the aggregate and sectoral level in two ways, we used the FTSE All Share Index and six sector indices (consumer discretionary, consumer staples, energy, industrials, materials, and utilities). For the macroeconomic variables, the inflation rate, money supply (M4), interest rate, GDP and exchange rate were employed. All of these variables are standardised as done in the literature. This allows for the comparison of variable's explanatory power.

To achieve our objectives, long-term analysis using Vector Error Correction (VEC) model is applied to explore whether there are long-term relationships between the stock price and the macroeconomic variables. In addition, short-term analyses are employed using the standard Granger causality and the quantile Granger causality provided by Troster (2018). Quantile methodology can estimate the relationship between a dependent variable and explanatory variables at different specific quantiles. It also provides a broader method for investigating the relationship between current returns and various parts of the lagged conditional returns, even when extreme values are present (Chiang and Li, 2012). The reason behind expanding the analysis of the standard Granger causality by the Quantile Granger causality is the common Granger causality results provide useful results but only a part of the insight because they analyse data based on the variables' means. To complement this, we utilise the Quantile Granger causality to investigate the causality on the conditional distribution of the variables at various quantiles.

The long-term relationships between the macroeconomic variables and stock share prices were tested utilising the following form:

$$\mathrm{SP_t} = \beta_{01} + \beta_{11}\mathrm{GDP_t} + \beta_{21}\mathrm{M4_t} + \beta_{31}\mathrm{EXC_t} + \beta_{41}\mathrm{INF_t} + \beta_{51}\mathrm{IR_t} + \varepsilon_{1t} \quad (1)$$

$$\mathrm{CS_t} = \beta_{02} + \beta_{12}\mathrm{GDP_t} + \beta_{22}\mathrm{M4_t} + \beta_{32}\mathrm{EXC_t} + \beta_{42}\mathrm{INF_t} + \beta_{52}\mathrm{IR_t} + \varepsilon_{1t} \quad (2)$$

$$\mathrm{CD_t} = \beta_{03} + \beta_{13}\mathrm{GDP_t} + \beta_{23}\mathrm{M4_t} + \beta_{33}\mathrm{EXC_t} + \beta_{43}\mathrm{INF_t} + \beta_{53}\mathrm{IR_t} + \varepsilon_{1t} \quad (3)$$

$$\mathrm{ENR_t} = \beta_{04} + \beta_{14}\mathrm{GDP_t} + \beta_{24}\mathrm{M4_t} + \beta_{34}\mathrm{EXC_t} + \beta_{44}\mathrm{INF_t} + \beta_{54}\mathrm{IR_t} + \varepsilon_{1t} \quad (4)$$

$$\mathrm{IND_t} = \beta_{05} + \beta_{15}\mathrm{GDP_t} + \beta_{25}\mathrm{M4_t} + \beta_{35}\mathrm{EXC_t} + \beta_{45}\mathrm{INF_t} + \beta_{55}\mathrm{IR_t} + \varepsilon_{1t} \quad (5)$$

$$\mathrm{UTI_t} = \beta_{06} + \beta_{16}\mathrm{GDP_t} + \beta_{26}\mathrm{M4_t} + \beta_{36}\mathrm{EXC_t} + \beta_{46}\mathrm{INF_t} + \beta_{56}\mathrm{IR_t} + \varepsilon_{6t} \quad (6)$$

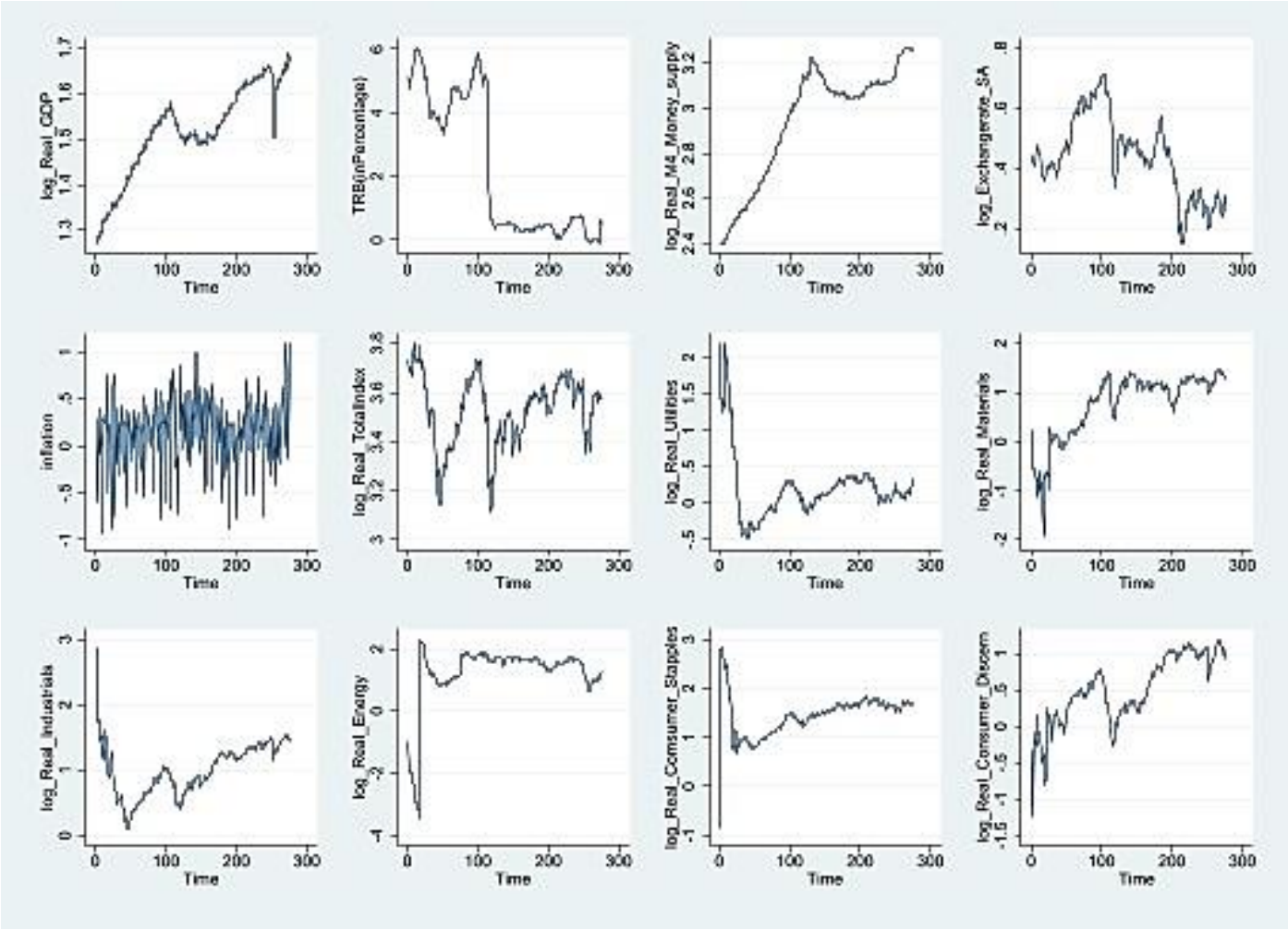


**Fig. 1. Prices for macroeconomic variables and FTSE All-share index and six sectors**

$$MAT_t = \beta_{07} + \beta_{17}GDP_t + \beta_{27}M4_t + \beta_{37}EXC_t + \beta_{47}INF_t + \beta_{57}IR_t + \varepsilon_{7t} \quad (7)$$

Where SP represents the logarithm of the real FTSE All Share Index prices, GDP represents the logarithm of the real GDP, M4 represents the logarithm of the real money supply, EXC represents the logarithm of the exchange rate which is defined as the number of USD per GBP, INF represents inflation, IR represents the UK Treasury bill tender 3M, and $\boldsymbol{\varepsilon}$ represents the residual term. For the stock indices, CS = the consumer staples sector, CD = the consumer discretionary sector, ENR = the energy sector, IND = the industrial sector, UTI = the utilities sector and MAT = the materials sector.

The Johansen cointegration test (1988) method is used to establish the number of cointegrating vectors with trend and constant. Specifically, the trace and the max statistics were employed to determine the number of cointegrating vectors. For the lag length, due to the variation in lag values obtained from different lag length selection criteria, the test was applied based on various lag lengths, and the best lag length was specified by the number of lag lengths that the cointegration relationship was fairly consistent over. Then, to explore the short-term relationships between the variables, the standard Granger causality test was used, considering the same VAR model as that used in the cointegration, and the quantile Granger causality test, also considering 19 quantiles.

Table 1 shows the descriptive statistics of the selected variables. It can be seen that the highest mean price is the FTSE All Share Index, followed by M4, TRB, GDP, consumer staples, the energy sector, industrial sector, materials sector, consumer discretionary sector, exchange rate, utilities sector and inflation. The maximum price is for TRB, followed by the FTSE All Share Index, M4, industrial sector, consumer staples, energy sector, utilities sector, GDP, the materials sector, consumer discretionary sector, inflation and the exchange rate. The minimum price is the highest for the FTSE All Share Index followed by M4, GDP, the exchange rate, industrial sector, TRB, utilities sector, consumer staples, inflation, consumer discretionary sector, materials sector and energy sector. The standard deviation of prices is the highest for TRB followed by the energy sector, materials sector, consumer discretionary sector, utilities sector, consumer staples, industrial sector, inflation, M4, FTSE All Share Index, exchange rate and GDP.

To solve spurious regression problems which may arise when the variables are non-stationary at levels without having any cointegration, all of the variables are subjected to the augmented Dickey-Fuller (ADF) unit root test (Dickey and Fuller, 1979) and the Phillips and Perron (1988) test. They are conducted to check the stationarity of the series. These are conventional and regular tests carried out for stationarity. Moreover, they are carried out by various cases of the test equations, depending on how the data behaved:

a. When the time series is flat and potentially slow-turning around a non-zero value, the following test equation is used:

$$\Delta z_t = a_0 + \theta z_{t-1} + a_1\Delta z_{t-1} + a_2\Delta z_{t-2} + \cdots \ldots \ldots \ldots + a_p\Delta z_{t-p} + u_t$$

Note that this equation has an intercept term in it but no time trend. The number of augmenting lags is determined by minimizing the Akaike information criterion (AIC). The t-statistic is then used the θ coefficient to test whether the data need to be differentiated to make it stationary or not. Notice that the test is left-tailed.

b. When the time series has a trend in it (either up or down) and is potentially slow-turning around a trend line, we draw through the data and the following test equation is used:

$$\Delta z_t = a_0 + \theta z_{t-1} + \delta t + a_1\Delta z_{t-1} + a_2\Delta z_{t-2} + \cdots \ldots \ldots \ldots + a_p\Delta z_{t-p} + u_t$$

Note that this equation has an intercept term and a time trend. The number of augmenting lags is determined by minimizing the AIC. The t-statistic is then used the θ coefficient to test whether the data need to be differentiated to make it stationary or we need to put a time trend in your regression model to correct for the variables deterministic trend. Note that the test is left-tailed.

## 2.7 Hypothesis

The hypotheses of the ADF are as follows:

$H_0: \theta = 0$

$H_1: \theta < 0$

The null hypothesis suggests that the series had a unit root, which means that the series is not stationary at level.

From the results according to the ADF test with a constant (or with trend), log of Real M4, log of Exchange rate, TRB, and log of real GDP are at stationary at their first difference, while inflation is stationary at level. These results are consistent using the PP test for both kinds of specification. (p-value close to zero, leading the rejection of the null hypothesis of unit root).

For sectors CD, CS, energy, and utilities, the prices (in their natural log forms) are stationary at levels. This can be seen using both ADF and PP tests for both types of specification, with constant and trend. Prices for sector for materials is stationary at level, concluded using ADF and PP tests. Finally, the log of FTSE is stationary at its first difference. This is established using PP and ADF tests both.

Despite some of the variables in our analysis are stationary at level, the Johansen Cointegration test is still used to analyze whether there is a long run relationship amongst the variables or not. This is in consistency with the reasoning given by Johansen (1997) where he mentions that some of the variables that are stationary at level can still be included in the test, given there is a reasonable explanation for their inclusion (Stavarek, 2005).

## 3. RESULTS

### 3.1 The Long Run Results

The results for both the trace and max test statistics reveal that there is a long-term relationship between the macroeconomic variables namely GDP, Exchange rate, Inflation, Real M4, TRB and the FTSE All Share Index and each sector. To the best of knowledge, according to the statisticians, if the trace and maximum tests provided different results, the preference will be for the trace test result (Johansen, 1988). It must be noted that despite some of the variables being stationary at level, the Johansen Cointegration test is conducted for checking the long run relationship. This is in consistency with Johansen (1997), according to whom the selection of variables to be included in the cointegration test should be based on the economic reasoning. This means the inclusion of stationary variables is allowed only if it is reasonable. However, it is required to have at least two variables to be non-stationary at level.

Though the results from the Johansen cointegration test suggest more than two cointegrating relationships in some cases, only one cointegrating relationship is considered. This is done not only for the sake of simplicity, but also as per the research question where the analysis is done to see the impact of macroeconomic variables on stock prices. This is done through the normalization of the stock index variables and hence, the effect of each of the macroeconomic variables is estimated on the dependent variable (the stock indices).

Next, after establishing that there exists a cointegrating relationship amongst the variables, the Vector Error Correction Model test (VECM) is estimated and the corresponding results for the long-term relationship amongst the variables through the cointegrating equations. The cointegrating relationship that is estimated through the normalization of FTSE all share index, shows that all the macroeconomic variables (GDP, inflation, Exchange rate, M4, and TRB) are all statistically significant at 1% level. Moreover, GDP, Inflation, and exchange rate affect the FSTE all share index negatively and these are consistent with the previous studies such as Florackis et al. (2014), David E. Rapach (2002) and Nguyen (2019), while money supply and TRB affect the overall index positively which supported by Gregoriou (2009) and Chukwuani and Paul's (2018).

The other cointegrating relationships which are estimated for each sector, also show that all the macroeconomic variables, except for GDP for its impact on consumer discretionary prices, are statistically significant, all at 1% level of significance. The utilities, industrials, consumer discretionary and consumer staples indices follow the main index in its relationship with the macroeconomic variables, which show a negative relationship with the GDP, inflation and exchange rate and a positive with the money supply and interest rate. However, materials and energy indices have inverse movement than the main index, which have a positive relationship with the GDP, inflation and exchange rate and a negative with the money supply and interest rate.

### 3.2 The Short Run Results

#### 3.2.1 Granger causality test

This analysis presents the causality between the selected macroeconomic indicators and the FTSE All-share index and its sector indices from 1999 to 2022, investigates the impact of the

Global financial crisis 2008 on the direction of the causality by dividing the periods for 1999-2007 (before the crisis) and 2008-2022 (after the crisis) and contributes to the literature by examining the causality at sectoral level in the UK.

#### 3.2.2 For the aggregate period from 1999 to 2022

The Granger causality test is used to check causality between the variables. To the best of our knowledge, previous studies examined the causality between the variables at aggregate level in the UK, but this study is the first in studying the causality at sectoral level. The results show that there is no causality directed from GDP to stock prices at aggregate and sectoral levels except Consumer discretionary index shows bidirectional causality. While the GDP is granger caused by the FTSE All-share, Consumer discretionary and industrials indices and this finding is aligned with several studies conducted examined the UK such as Shirvani (2008), Thornton (1993), Masuduzzaman [22] and Nasseh and Strauss (2000). For the inflation, there is bidirectional causality between the inflation and the FTSE All-share index, and this result is consisting with Cakan (2012) analysis, while the sector indices observed various results. In particular, there is bidirectional causality between the inflation and industrials index, unidirectional causality from the inflation to materials and Consumer discretionary indices. In the opposite direction, there is a unidirectional causality from utilities index to the inflation. Interestingly for money supply, there is no causality between itself and stock prices at aggregate and sectoral levels except the Consumer discretionary index Grange causing the money supply. These results diverge from the results reported by most of the studies such as Thornton, 1993, which found unidirectional causality from stock prices to the money supply. With the regard to the exchange rate, it does not cause changes in the stock prices overall and, but it is affected by the FTSE All-share index and the sector indices (Industrials, Materials and Utilities). These results are supported by Caporale et al. [43], Ajayi and Mougoue (1996). Lastly, for the interest rate, it Granger causes only the Consumer discretionary index, but it caused by the FTSE All-share index and industrials index while most of studies found unidirectional causality from interest rate to the main index such as Mohapatra and Rath, 2015 and Peiro, [47].

#### 3.2.3 Before the financial crisis period from 1999 to 2007

Before the global financial crisis from 1999 to 2007 using the Granger causality test. The results observed that there is no causality between GDP and stock prices before the Global financial crisis 2008 with the exception of two sector indices (energy and consumer staples), which they are caused by the GDP. For the inflation, there is a bidirectional causality between the inflation and the FTSE All-share index, but the varying results are observed with the regards of sectors. Bidirectional with the industrials index, causality is directed from the inflation to materials index and causation directed from utilities to the inflation. There is no causality for the rest of the sectors in either direction. Still there is no causality between money supply and the FTSE All-share index. But regarding the sectors, there is unidirectional causality from the money supply to the indices (energy, materials and consumer staples. For the exchange rate, there is no causality at the aggregate level, but the exchange rate Granger causes energy, materials, utilities and consumer staples but not vice versa. Lastly, for the interest rate, FTSE All-share index and most of the sector indices granger cause the interest rate. Conversely, the interest rates cause changes only in energy and utilities indices.

#### 3.2.4 After the financial crisis period from 2008 to 2022

After the global financial crisis from 2008 to 2022 using the Granger causality test. It is found that stock prices at the aggregate and the sectoral levels Granger cause the GDP but not vice versa. For the inflation, similar to the previous investigated periods, there is bidirectional causality between the inflation and the FTSE All-share index. Varying results are observed regarding the sectors with bidirectional causality with the Consumer discretionary index, unidirectional causality to materials index and unidirectional causality from energy index to the inflation. Money supply Granger causes the FTSE All-share and materials indices, but not vice versa. For the exchange rate, no causality is directed from the exchange rate to stock prices. Conversely, only materials and utilities indices Granger cause the exchange rate. For the interest rate, bidirectional causality is found between the interest rate and the FTSE All-share index, while various results found regarding the sectors.

### 3.2.5 Quantile Granger causality test

Using the Quantile Granger causality test, we contribute to the literature by expanding the standard Granger causality analysis results for the period from 1999 to 2022. Then, we investigate the impact of the Global financial crisis of 2008 on the direction of the causality by examining the periods from 1999 to 2007 (before the Global financial crisis) and from 2008 to 2022 (After the Global financial crisis). Overall, the Quantile Granger causality results suggest that the causality between macroeconomic variables and the FTSE All-share index and its various sectors depends on the quantile under consideration. This sheds light into the importance of considering the specific characteristics of each sector index and each quantile of the variables in the causality examination. Therefore, this test provides a deeper understanding of the causality between macroeconomic variables and stock prices. The following sections demonstrate the results in particular.

### 3.2.6 For the aggregate period from 1999 to 2022

The analysis of the causality from GDP and interest rate to the FTSE All-share index and its sector indices showed that both GDP and interest rate strongly Granger cause the stock prices, but the causality to the FTSE All index is observed in fewer quantiles than the indices. In contrast, the results show highly significant causality from stock prices to the two indicators in most of quantiles. For the money supply, there is significant causality in the upper quantiles to all index and sector indices at 1%, while the significance of the causality become less in the lower quantiles at 5% level. On the other hand, the analysis of the causality from stock prices to the money supply shows that the causality from the FTSE All-share index is centralised only in the lower quantiles, while sector indices Grange cause the money supply in most of the quantiles. For the inflation, the causality from inflation to the FTSE All-share index is found in the quantiles 0.2-0.6, 0.85 and 0.9, while the causality to sector indices presents uniform pattern which is found in the quantiles 0.05, 0.4,0.45, 0.7, 0.75 and 0.95. Conversely, the causality from the FTSE All-share index to the inflation found in the middle and lower quantiles, while sector indices significantly predict the inflation in most of the quantiles at 1%. For exchange rate, the causality from exchange rate to stock prices in the FTSE All-share index and its sector indices found in the upper quantiles. However, the causality from the FTSE All-share index to the exchange also found in the upper quantiles, but is observed in sector indices in most of the quantiles.

### 3.2.7 Before the financial crisis from 1999 to 2007

It is found that causality from the GDP to stock prices exists throughout all quantiles for the FTSE All-Share index and sector indices. At the aggregate level, the index causes changes significantly in the GDP in most quantiles. However, sector indices show causality to the GDP, but less significance than the index and lower quantiles, which it exists in the upper, middle and the last quantiles. For the interest rate, it is observed that interest rate Granger causes the FTSE All-share index and its sectors in the majority of the quantiles, but they vary based on the quantile. For example, in the quantile 0.55, interest rate cause changes in the FTSE All-share index and three sector indices (Energy, Material and Consumer Staples), but it does not cause Utilities and Industrial indices. On the other hand, the FTSE All-share index and its sector indices follow similar trend in their causations on the interest rate. The causality appears only in the quantiles 0.3, 0.35, 0.6, 0.65 and 0.85, but there is no causality in the rest of the quantiles.

For the money supply, it is reported that money supply predicts the FTSE All-share index in the quantiles 0.2, 0.45-0.65 and 0.85-0.95. But when we look at the sector indices, it observed a causality from money supply to the sectors in the majority of the quantiles. However, in the direction from stock prices to the money supply, the Quantile test results are consistent with the standard Granger causality in observing the absence of causality except in the quantile 0.6, which shows causality from the FTSE All-share index and the indices (Consumer Staples, Utilities, Material and Industrial) to money supply. For inflation, there is causality from the inflation to the FTSE All-share index at 5% in various quantiles. However, the causality at sectoral level is observed in the majority of the quantiles in the whole sectors indices. Contrary, the analysis of the causality from stock prices to inflation showed that the causality is missing in the most of FTSE All-share index's quantiles except the upper and lowest ones, while it is missing in the whole sector indices across all quantiles except the utilities index observed high significant

causality at 1%. For exchange rate, the causality from exchange rate to the FTSE All-share index is centralised in the middle and the lower quantiles, while majority of the quantiles showed causality from exchange rate to sector indices. In contrast, the test showed an absence of the causality from the stock prices except the 0.1 quantile.

#### 3.2.8 After the financial crisis from 2008 to 2022

The results observe that GDP Granger causes the overall stock market (at aggregate and sectoral levels) randomly among different quantiles. Particularly, it is shown that the FTSE All-share index is caused significantly by the GDP in the quantiles 0.15, 0.25, 0.5 and the 0.85. While at the sectoral level, surprisingly the causality between the Material, Utilities sectors indices and GDP does not show stable level of significance among all quantiles, indicating that GDP demonstrates a precise impact on these specific sectors. On the other hand, the opposite direction of the analysis show that the FTSE All-share index and all sectors' indices Granger cause the GDP significantly almost among all the quantiles except the 0.4, 0.45 and the 0.95, where the causality is missing in these quantiles. For the interest rate, the table shows that the control of interest rate on the FTSE All-share index and its sectors is found only in a few quantiles most of them centralised in the upper quantiles. However, the index and the sectors granger cause the interest rate significantly in most quantiles except in the 0.5 and 0.55. For money supply, the causality from money supply to the FTSE All-share index and the sector indices is found random trend of causality across the quantiles. For instance, in the quantile 0.15, there is causality to the FTSE All-share index and the indices (Energy, Industrial and Consumer discretionary), while in the quantile 0.35 there is a causality only to Energy index. On contrast, the causality from the FTSE All-share index and its sector indices shows similar pattern. Specifically, there is a strong causality from the FTSE All-share index and all the indices to the money supply in the quantiles 0.1, 0.3, 0.35 and 0.7-0.9. For inflation, the causality to the FTSE All-share index is limited only in three quantiles 0.25, 0.5 and 0.85, while it is showed in the upper quantiles in the sector indices. On the other hand, the FTSE All-share index granger cause the inflation in three quantiles 0.3, 0.9 and 0.95, while the sectors showed highly significant causality to the inflation except the Utilities sector. For exchange rate, the causality from exchange rate to the FTSE All-share index and its sector indices is found randomly across quantiles. For instance, in the quantile 0.25, there is a causality to all the index and sector indices except the utilities, while there is no causality in the quantile 0.3 except in Consumer discretionary. On the other hand, there is a uniform pattern of the causality from stock prices to exchange rate. Specifically, the causality is found in the 0.15-0.25, 0.45, 0.9 and 0.95 quantiles in the whole market (index and sector indices).

## 4. DISCUSSION AND IMPLICATIONS

### 4.1 Long Run Relationship

In the long run, concentrating on the aggregate level, a positive impact is indicated by rises in the Money Supply and Interest Rate. This implies that expansionary policies could have a positive impact on stock prices. However, the surprising result in this analysis is the positive association between the interest rate and stock prices because usually the increase in interest rate causes an increase in firms' cost which leads to a decline in the stock prices, which is a negative relationship. However, this result could be observed due to the investors' behaviour or the prediction of economic stability over periods of higher interest rates.

In addition, the analysis showed that sectors may have separate behavior than the main index, this implies the importance of examining the specific sector indices' response to the macroeconomic indicators to achieve precise predictions. For instance, the effect of the exchange rate on the share prices of different sectors varies. While for sectors like utilities, industrials, consumer discretionary, and consumer staples, the effect is negative, which means as the GBP appreciates (~USD depreciates), the share prices for the mentioned sectors decrease. The economic reasoning for this relationship can be tied with the exports which fall after the rise in GBP value against USD. This decrease in demand for exports for these sectors could contribute to a fall in prices. This requires further research on how the sectors are outward-oriented in terms of trade. On the other hand, the effect is exactly the opposite for the materials and energy sectors, having a positive relationship with the exchange rate. Concerning GDP, its negative relationship with the indices of utilities, industrials, consumer discretionary and consumer staples can be explained through the monetary mechanism. The

reason for this result might be because, according to statistics, the service sector makes the greatest contribution to the UK GDP (Bank World, 2022). This implies that when the GDP increases, it leads to inflationary pressures in the economy forcing the central banks to contract the money supply, which in turn decreases the liquidity, and hence, causes a fall in stock prices. However, the long-term relationship between GDP and the sectoral prices of materials and energy have positive relationships with GDP. This positive relationship can be attributed to the income effect.

## 4.2 Causality

The examination highlighted the complex nature of the economic dynamics, and for policymakers and investors it yielded significant implication regarding the causality between the selected macroeconomic variables and stock prices. The results are presented in the following sections.

### 4.2.1 The causality between GDP and stock share prices

From 1999 to 2022 in the aggregate sample, the traditional Granger causality analyses revealed that GDP had an impact on the FTSE All-Share index only in the consumer discretionary sector. Nevertheless, the FTSE All-Share index and two sectors (industrial and consumer discretionary), caused changes in the GDP. This indicates that the FTSE All-Share index and the indices of these sectors may be valuable indicators for predicting changes in GDP. The standard Granger causality test revealed a limited insight, whereas the Granger causality test for quantiles went deeper and showed that GDP had a bidirectional causal effect on the FTSE All-Share index and all sectors at distinct quantiles. This indicated the possibility of different levels of predictability in different economic circumstances. This complexity demonstrates that decision makers and investors should take into account the distribution of the variables in evaluating their portfolios.

The sample was divided into before and after the 2008 financial crisis. Before the crisis from 1999 to 2007, the traditional Granger causality test revealed that GDP led the consumer staples and energy sectors, but there were no causation effects from stocks to GDP. However, the Granger causality test for quantiles suggested a more pervasive effect of GDP across various distributional quantiles and vice versa, suggesting that stock prices also cause changes in the GDP, particularly in the upper and middle quantiles of the distribution. This differed from the results of the standard Granger causality test, highlighting the importance of considering causality among quantiles.

After the financial crisis, from 2008 to 2022, the traditional Granger causality analyses indicate that GDP did not predict the FTSE All-Share index or any of its sector indices. However, the index and its sectors (except the materials sector) caused significant changes in GDP. The more in-depth analyses of the quantile Granger causality tests revealed a significant causality from the FTSE All-Share index and its sectors to GDP in the majority of quantiles, in addition to causality from GDP to stock prices, but in fewer quantiles. The two tests agreed on the extreme effect of stock prices on GDP, but they were dissimilar regarding causality in the other direction. The implication of this is that while the classical Granger causality test implies that the FTSE All-Share index is not predicted by the GDP, the quantile Granger causality suggests causality in certain circumstances. Therefore, investors should rely solely on macroeconomic variables such as GDP to forecast stock market changes.

### 4.2.2 The causality between interest rates and stock share prices

In the period from 1999 to 2022, the standard Granger causality test revealed that on the whole, the interest rate did not cause changes in the stock market. The exceptions were the consumer discretionary sector and the interest rate, which were affected by the FTSE All-Share index and the industrials sector. However, the quantile Granger causality reported bidirectional causality across the interest rate and all of the stock market across quantiles except in the middle quantiles, indicating the ability of the quantile approach to capture a broader causality.

For the period from 1999 to 2007, prior to the global financial crisis, the traditional Granger causality analyses indicate that variations in interest rates predicted the stock prices just for the energy and utilities indices, and that the interest rates were affected by the FTSE All-Share index and its sectors, except for the energy and consumer discretionary sectors. However, the quantile Granger causality results provided a broader picture of the causality

between interest rates and stock prices. These demonstrated bidirectional causality between interest rates and the index and all sectors, but the level of the quantiles are differed depending on the market conditions. For example, the interest rate Granger cause the main index and the sectors in most of the quantiles, while the stock prices Granger cause the interest rate only in the middle and the lower quantiles. This highlights the significance of the quantile Granger causality test for investigating causal relationships in various portions of the distribution.

For the period from 2008 to 2022, after the financial crisis, a bidirectional causality was found between interest rates and the main stock index. However, the quantile Granger causality outcomes presented a different scenario. There was a significant causal relationship from interest rates to the index and all sectors, but only with high market conditions. Conversely, stock prices predicted changes in interest rates in the majority of market conditions. For investors, this implies that the causality between interest rates and stock prices fluctuates, depending on market circumstances. Therefore, investment strategies should be applied to particular market circumstances, such as high or low market conditions. Moreover, as the analysis revealed an important causal relationship during high market conditions, investors should also consider individual sectors to evaluate the causality between the interest rate and stock prices. Policymakers should acknowledge that the efficacy of interest rate changes may vary based on the prevailing market conditions. Hence, they have to implement policies that are flexible to hedge against the market changes.

#### 4.2.3 The causality between money supply and stock share prices

In the period from 1999 to 2022, the Granger causality results indicate the money supply did not Granger cause the stock market, except in the consumer discretionary sector, where a unidirectional causality was found from the money supply to the sector. Nevertheless, the inverse analysis of the causality found that changes in the FTSE All-Share index and its sectors don not predict the money supply. However, the quantile Granger causality test found that the level of causality from money supply to stock prices varied across percentiles. In particular, at the $30^{th}$ and $70^{th}$ to $75^{th}$ percentiles, a significant causal relationship was clearly observable. This indicates that a variation in the money supply had a significant effect on the median and lower percentiles of the stock prices. On the other hand, in the opposite direction the outcomes were notably different from those derived from the standard Granger causality results. A significant causality across the majority of quantiles was observed, except for the median (0.5) quantile. This may mean that variations in stock prices have an impact on the distribution of the money supply, differing from the outcomes of the standard Granger causality test when the mean is examined.

Prior to the financial crisis, from 1999 to 2007, the conventional Granger causality analysis revealed that the money supply Granger caused indices (energy, materials, and consumer staples), whereas it did not cause changes in the FTSE All-Share index. This indicates that sector indices-specific causations cannot be captured by examining the aggregate market index. Employing the quantile Granger causality test showed that the majority of quantiles were similarly affected by changes in the money supply, but that this effect was seen in the whole stock market, not in certain sector indices. Nonetheless, in the 60th percentile, there was a significant causal relationship from the FTSE All-Share index and all its sector indices to the money supply, indicating that high fluctuations in stock prices could impact the money supply.

After the financial crisis period from 2008 to 2022, the traditional Granger causality test showed unidirectional causality from the money supply only to the FTSE All-Share index and the materials sector, but there are no causations between money supply and other indices. However, the quantile Granger causality analyses provided a deeper understanding of the causality; they indicated strong causality from the FTSE All-Share index and all the sector indices to money supply in the upper, middle, and lower quantiles. Given that quantile causality depends on varying market dynamics, portfolio managers should diversify their portfolios and develop strategies to mitigate the risks arising from future changes in the money supply. For policymakers, the significant impact of the FTSE All-Share index and all sector indices on the money supply over quantiles indicates that stock market movements could be used by the central bank as a useful indicator of the money supply.

#### 4.2.4 The causality between inflation and stock share prices

Taken together from 1999 to 2022, the findings indicate a bidirectional causality between inflation and stock prices, indicating a dynamic and complex relationship. At the sectoral level, the effect of inflation on sector indices, and the causality in the opposite direction, varied, indicating that sectors react in diverse ways to inflation. The variation among sectors is due to the variation in the economic fundamentals of their interactions with macroeconomic factors. In addition, the quantile Granger causality analysis showed a comprehensive picture of the causality between the variables. The outcomes indicate that the causality is consistent among all percentiles, meaning that inflation affects stock prices in the same way over all the stock distributions.

Considering the period prior to the financial crisis (1999–2007), the classical Granger causality analyses reveal that inflation had a limited effect on stock prices, with a bidirectional causality between the main index and the industrials index. Conversely, the quantile Granger causality analyses show more in-depth results, with inflation demonstrating a significant impact on stock prices in various market conditions, except for certain sectors at times of low prices. This result implies that, because inflation has diverse effects on stock prices through sectors and market circumstances, investors should mitigate the inflation risks by diversifying their portfolios' assets.

The post-financial crisis period (2008–2022) suggests that the complexity of the causation between inflation and the stock market is greater than that which can be observed with classical Granger causality analysis. As indicated by the quantile Granger causality test, the causality seems to be state-dependent because of the various impacts of inflation among the economic channels in different economic circumstances.

#### 4.2.5 The causality between exchange rates and stock share prices

Over the period from 1999 to 2022, the standard Granger causality test indicates that there was no causal relationship from exchange rates to the overall stock market. However, there was a causal relationship from certain sectors to the exchange rates. In contrast, the quantile Granger causality test observed causality from the exchange rate to the stock market across quantiles, highlighting the importance of employing more advanced econometric approaches to investigate deeper causality. Moreover, the outcomes of the standard Granger causality analysis show that policymakers and investors cannot consider exchange rate fluctuations as reliable indicators of the overall stock market movements. However, there may be certain market conditions (e.g., specific percentiles) in which exchange rates present useful information regarding stock market changes.

Prior to the financial crisis, from 1999 to 2007, the standard Granger causality analysis found that the exchange rate had a greater effect on some sectors than on others. On the other hand, the finding of the quantile Granger causality analysis revealed that the exchange rates had an asymmetric influence on the overall stock market, implying that the standard Granger causality test was incapable of capturing the causality in depth. In addition, the outcomes highlighted the heterogeneity among indices and the importance of analysing all the distributions. This implies that examining these conditions can help investors and portfolio managers to develop deeper strategies for their investments. Particularly in times of anticipated currency volatility, decisions over asset allocation can be influenced by the knowledge of which sectors could be affected by exchange rate fluctuations.

After the financial crisis, from 2008 to 2022, the standard Granger causality test presents a unidirectional causality directed from only two sector indices to the exchange rate. Conversely, the quantile Granger causality findings showed bidirectional causality at various distribution levels, indicating the influence of the exchange rate on the overall market. The dynamics of the causality changed after the global crisis. This indicates that the economy and the market as a whole are still undergoing structural changes, with these indices playing a major role in the dynamics of the foreign exchange market. Furthermore, it can be essential for investors to comprehend bidirectional causality. Those who previously had only considered the exchange rate's effect on stock prices may now need to account for how fluctuations in stock prices impact exchange rates, which may affect a broader range of investments.

To sum up, these results indicate that the causality between macroeconomic variables and

stock prices is not consistent. The direction of this causality varies based on the economic situation, the selected sectors, and certain economic circumstances at various times. Moreover, the results shed light on the crucial of examining the distribution of the variables when investigating the relationship between macroeconomic variables and stock prices to achieve deeper understanding. These findings provide important implications for economic analysts, policymakers, and investors because they shed light on the dynamic and multifaceted causality between macroeconomic factors and stock prices in the United Kingdom on an aggregate and sectoral level.

## 5. CONCLUSION

This empirical chapter examines the causality between macroeconomic indicators and stock share prices in the UK. To the best of our knowledge, this is the first study to consider the issue at the sectoral level in the UK using the causality in quantiles. Moreover, this chapter investigates whether the global financial crisis of 2008 changed the direction of the causality. The research finding suggest that sensitivity of UK stock market changed across the periods i.e. it changed from pre-crisis period to post-crisis period. To achieve our objectives, we performed long-term analysis using the VECM test and short-term analysis using Granger causality. We then expanded the standard Granger causality analysis by applying the Granger causality test for quantiles, to provide deeper understanding of our issue.

In the long term, the relationship between the macroeconomic indicators and the FTSE All-Share index varies depending on the selected indicators. Some sector indices follow the main index in their relationship with the indicators, while others behave differently from the main index. This implies the importance of considering the individual behaviour of each sector index when evaluating the stock prices for investment purposes.

For the short term, the standard Granger causality test was employed, and again expanded by the quantile Granger causality test. The results indicate that the causality between the macroeconomic variables and stock prices is not consistent. The direction of this causality varies based on the economic situation, the selected sectors, and certain economic circumstances at different times. Moreover, the results shed light on the importance of examining the distribution of the variables when investigating the relationship between macroeconomic variables and stock prices to achieve a deeper understanding. These findings provide important implications for economic analysts, policymakers, and investors because they shed light on the dynamic and multifaceted causality between macroeconomic factors and stock prices in the United Kingdom on an aggregate and sectoral level. In the future, researchers could examine why certain sectors are more sensitive to changes in each macroeconomic variable than others, as well as why the predictive potential of macroeconomic variables varies according to market conditions and time periods.

## COMPETING INTERESTS

Author has declared that no competing interests exist.

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# APPENDICES

**Table 1. Summary Statistics of the variables**

| Variables | P-value | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| Log Real GDP | 0.00000 | 1.517091 | 0.0994406 | 1.270506 | 1.687389 |
| log_Exchangerate_SA | 0.00043 | 0.4362756 | 0.1327114 | 0.1481605 | 0.715 |
| Inflation | 0.00000 | 0.1767883 | 0.3586138 | -0.9350685 | 1.093873 |
| log_Real_M4 | 0.00000 | 2.946189 | 0.2550803 | 2.397593 | 3.269305 |
| TRBinPercentage | 0.00000 | 2.206225 | 2.211852 | -0.118469 | 6.04649 |
| log_Real_Consumer_Discern | 0.00000 | 0.5081752 | 0.470163 | -1.225 | 1.19893 |
| log_Real_Comsumer_Stapples | 0.00000 | 1.455 | 0.4040541 | -0.8743037 | 2.819788 |
| log_Real_Energy | 0.00000 | 1.220059 | 1.044503 | -3.469704 | 2.309684 |
| log_Real_Industrials | 0.00000 | 1.000108 | 0.3914243 | 0.0919715 | 2.863293 |
| log_Real_Materials | 0.00000 | 0.7606131 | 0.6644137 | -1.92377 | 1.486562 |
| log_Real_Utilities | 0.00000 | 0.192633 | 0.4264471 | -0.4905497 | 2.191378 |
| log_Real_totalindex | 0.00000 | 3.529139 | 0.1408721 | 3.115309 | 3.798793 |

**Table 2. Granger causality test for the aggregate period**

| **Panel A: Causality from macroeconomic variables to stock share prices** | | | | | | |
|---|---|---|---|---|---|---|
| **VAR** | **Dependant variables** | **Independent values** | | | | |
| | | **GDP** | **Inflation** | **M4** | **Exchange rate** | **TRB** |
| 5 | FTSE All-share index | 0.814 | 0.003*** | 0.298 | 0.93 | 0.394 |
| 5 | Energy | 0.944 | 0.300 | 0.45 | 0.925 | 0.791 |
| 5 | Industrials | 0.553 | 0.001*** | 0.578 | 0.814 | 0.062 |
| 5 | Materials | 0.448 | 0.017** | 0.062 | 0.098 | 0.302 |
| 5 | Utilities | 0.9560 | 0.5510 | 0.9700 | 0.6210 | 0.3280 |
| 3 | Consumer discretionary | 0.043** | 0.006*** | 0.030** | 0.047 | 0.004*** |
| 4 | Consumer stapples | 0.426 | 0.188 | 0.91 | 0.064 | 0.279 |
| **Panel B: Causality from stock share prices to macroeconomic variables.** | | | | | | |
| **VAR** | **Independent variables** | **Dependant values** | | | | |
| | | **GDP** | **Inflation** | **M4** | **Exchange rate** | **TRB** |
| 5 | FTSE All-share index | 0.001*** | 0.001*** | 0.469 | 0.016** | 0.000*** |
| 5 | Energy | 0.705 | 0.004*** | 0.111 | 0.086 | 0.372 |
| 5 | Industrials | 0.008** | 0.006*** | 0.998 | 0.021** | 0.035** |
| 5 | Materials | 0.708 | 0.062 | 0.213 | 0.024** | 0.258 |
| 5 | Utilities | 0.158 | 0.008*** | 0.332 | 0.023** | 0.613 |
| 3 | Consumer discretionary | 0.000*** | 0.101 | 0.526 | 0.321 | 0.067 |
| 4 | Consumer stapples | 0.576 | 0.431 | 0.590 | 0.068 | 0.115 |

*Panel A represent the causality from macroeconomic variables to stock share prices. Panel B represent the causality from stock share prices to macroeconomic variables. The Bold values represent the p-values ** and *** denote statistical significance at the 5% and 1% level respectively*

**Table 3. Granger causality test for before the financial crisis period**

| Before financial crisis | | | | | | |
|---|---|---|---|---|---|---|
| **Panel A: Causality from macroeconomic variables to stock share prices.** | | | | | | |
| **VAR** | **Dependant variables** | **Independent variables** | | | | |
| | | **GDP** | **Inflation** | **M4** | **Exchange rate** | **TRB** |
| 5 | FTSE All-share index | 0.899 | **0.024**** | 0.424 | 0.051 | 0.436 |
| 5 | Energy | 0.001*** | 0.088 | 0.001*** | 0.000*** | 0.000*** |
| 5 | Industrials | 0.570 | 0.034** | 0.828 | 0.080 | 0.708 |
| 5 | Materials | 0.304 | 0.049** | 0.011** | 0.026** | 0.306 |
| 5 | Utilities | 0.179 | 0.496 | 0.180 | 0.01*** | 0.001*** |
| 3 | Consumer discretionary | 0.342 | 0.722 | 0.186 | 0.244 | 0.322 |
| 4 | Consumer stapples | 0.016** | 0.247 | 0.04** | 0.008*** | 0.086 |
| **Panel B: Causality from stock share prices to macroeconomic variables.** | | | | | | |
| **VAR** | **Independent variables** | **Dependant variables** | | | | |
| | | **GDP** | **Inflation** | **M4** | **Exchange rate** | **TRB** |
| 5 | FTSE All-share index | 0.123 | 0.021** | 0.078 | 0.502 | 0.000*** |
| 5 | Energy | 0.091 | 0.009** | 0.201 | 0.714 | 0.090 |
| 5 | Industrials | 0.132 | 0.031** | 0.798 | 0.005*** | 0.045** |
| 5 | Materials | 0.144 | 0.229 | 0.162 | 0.338 | 0.029** |
| 5 | Utilities | 0.08 | 0.011** | 0.240 | 0.348 | 0.027** |
| 3 | Consumer discretionary | 0.602 | 0.398 | 0.576 | 0.377 | 0.177 |
| 4 | Consumer stapples | 0.222 | 0.170 | 0.169 | 0.234 | 0.016** |

*Panel A represent the causality from macroeconomic variables to stock share prices before the financial crisis. Panel B represent the causality from stock share prices to macroeconomic variables before the financial crisis. The Bold values represent the p-values ** and *** denote statistical significance at the 5% and 1% level respectively*

**Table 4. Granger causality test for after the financial crisis period**

| After the financial crisis | | | | | | |
|---|---|---|---|---|---|---|
| **Panel A: Causality from macroeconomic variables to stock share prices.** | | | | | | |
| **VAR** | **Dependant variables** | **Independent variables** | | | | |
| | | **GDP** | **Inflation** | **M4** | **Exchange rate** | **TRB** |
| 5 | FTSE All-share index | 0.236 | 0.026** | 0.011** | 0.669 | 0.022** |
| 5 | Energy | 0.459 | 0.099 | 0.121 | 0.611 | 0.576 |
| 5 | Industrials | 0.536 | 0.112 | 0.153 | 0.984 | 0.047** |
| 5 | Materials | 0.965 | 0.012** | 0.019** | 0.999 | 0.236 |
| 5 | Utilities | 0.875 | 0.95 | 0.573 | 0.314 | 0.007*** |
| 3 | Consumer discretionary | 0.354 | 0.011** | 0.170 | 0.725 | 0.000*** |
| 4 | Consumer stapples | 0.259 | 0.340 | 0.196 | 0.264 | 0.001*** |
| **Panel B: Causality from stock share prices to macroeconomic variables.** | | | | | | |
| **VAR** | **Independent variables** | **Dependant variables** | | | | |
| | | **GDP** | **Inflation** | **M4** | **Exchange rate** | **TRB** |
| 5 | FTSE All-share index | 0.001*** | 0.013** | 0.258 | 0.151 | 0.000*** |
| 5 | Energy | 0.002*** | 0.000*** | 0.234 | 0.982 | 0.129 |
| 5 | Industrials | 0.000*** | 0.266 | 0.944 | 0.387 | 0.001*** |
| 5 | Materials | 0.699 | 0.135 | 0.178 | 0.014** | 0.000*** |
| 5 | Utilities | 0.016** | 0.474 | 0.257 | 0.045** | 0.438 |
| 3 | Consumer discretionary | 0.000*** | 0.033** | 0.653 | 0.411 | 0.134 |
| 4 | Consumer stapples | 0.002*** | 0.168 | 0.698 | 0.368 | 0.364 |

*Panel A represent the causality from macroeconomic variables to stock share prices after the financial crisis. Panel B represent the causality from stock share prices to macroeconomic variables after the financial crisis. The Bold values represent the p-values ** and *** denote statistical significance at the 5% and 1% level respectively*



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