The role of the financial sector in the UK economy: evidence from a seasonal cointegration analysis

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This article empirically investigates the relationship between stock market/banking sector development and economic growth by controlling for the effects of human and physical capital factors in a seasonal cointegration framework. We use a sample of quarterly and seasonally unadjusted data which covers the period 1965Q1–2011Q4. The results suggest that: (1) the UK financial sector development is a good promoter of the domestic economy both in the long- and the short-run; (2) the supply-leading hypothesis that causality runs from stock market capitalisation and stock market volatility to real GDP per worker is confirmed; (3) stock market volatility has a negative influence on the UK's output, which may reflect economic ambiguity but may also reflect a well-functioning and efficient stock market; (4) if a country has a good infrastructure and a well-educated nation, it enhances economic growth as well as betters the financial sector (i.e. markets and banks); and (5) if a new global financial meltdown is formed, this can easily devastate the UK economy.

Keywords: financial development; economic growth; seasonal cointegration; causality; the UK economy

JEL classification: C22; C51; E44

1. Introduction

The nexus between financial development and economic growth has rekindled interest in the recent theoretical and empirical literature by drawing attention to determinants such as stock market capitalisation, stock market volatility, domestic bank credit (DC) (or deposit) and broad money stock, namely M2. Various studies have employed DC and M2 in order to investigate the relationship between financial development and real income growth for various countries – among them are Katircioglu (2010) and Soukhakian (2007) Within the current literature, different stock market development indicators have been estimated to explain some variation in growth rates across countries, whereas the effects of the banking system were also taken into account (Levine & Zervos, 1998). Based on the estimated results obtained from cross-country growth regressions, the evidence in these studies does not provide robust econometric results (Arestis, Demetriades, & Luintel, 2001). Cross-section studies also suffer from the presence of endogeneity, in which the estimated results deteriorate the effects of the financial development indicators (Harris, 1997).

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There have been various findings and views about the effects of stock market and banking development on economic growth throughout the literature, depending upon the techniques used. The issues of causality and econometric advances have been important milestones in examining the roles of both stock markets and banks between financial development and growth by applying a time series method. In this framework, a modified Augmented Solow growth model is conducted using quarterly, seasonally unadjusted data from a seasonal cointegration point of view. A developed country such as the UK with its unique market-oriented financial system presents an ideal case for analysis in terms of looking into the effects of stock market development as opposed to that of the banking sector.

The departing feature of this study is to construct an empirical model and re-examine the relationship between stock market–bank development and economic growth while controlling for the effects of human and physical capital factors in the exogenous growth modelling framework. Our main contributions to the literature are as follows. The first is to determine whether the financial sector stimulates the process of economic growth in light of the exogenous modelling framework. Second, we used seasonal integration and cointegration techniques[1] to show that previous studies in the financial development area which have employed seasonal data[2] (quarterly or monthly) could not provide important details that are hidden in the estimated results. In other words, the presence of seasonal unit roots implies that standard cointegration tests are inappropriate when seasonal data are applied. Third, we used different causality techniques from a seasonal point of view to provide useful insights and perhaps avoid inconsistency as the causal directions (i.e. supply-leading hypothesis) are determined, which have not been utilised at the same time in the previous studies (see also footnote 16 for more details as to why different causality techniques are used).

The rest of the article is organised as follows: Section 2 reviews the relevant literature on the financial development and economic growth nexus and presents recent evidence on the impacts of both stock market and banking sector development. Section 3 explains the theoretical modelling and the data. Section 4 discusses the methodology and presents the empirical results. Finally, section 5 provides some concluding remarks.

2.   Literature review

2.1.   *Financial development and economic growth*

Schumpeter (1912) asserts that financial intermediaries are crucial drivers for innovation and growth. In contrast, Robinson (1952) argues that finance does not causes growth but that instead economic growth leads to financial development as a result of the higher demand for financial services.

The evidence in the relevant literature is generally more supportive of the opinion proposed by Schumpeter (1912). This opinion was later developed by Mckinnon (1973) and Shaw (1973), also known as the M-S school of thought, and popularised by Fry (1988) and Pagano (1993). McKinnon (1973) considers physical capital and money in his model to be complementary assets where money rekindles capital formation. Shaw's (1973) framework is based upon a high interest rate that encourages more saving and more supply of credit to cause financial intermediaries to generate investment and growth by means of borrowing and lending. The studies covering the endogenous growth model are clearly modelled in favour of the positive link between financial development and economic growth in light of both McKinnon's (1973) and Shaw's (1973) frameworks.

An expansion of financial development may be encouraged by economic growth. This means that economic growth can generate demand for more financial and banking services and that both can grow with economic expansion. In this respect, economic activities improve, as there will be more demand for physical and liquid capital. This causes the real sector as well as the financial and banking sector to expand and creates competitive and efficient environment in both sectors (Berthelemy & Varoudakis, 1996).

McKinnon (1973), Shaw (1973) and Goldsmith (1969) also point to the role of capital accumulation in economic growth. Particularly, financial intermediary development reduces market friction where this situation raises domestic saving rates and brings foreign capital. In turn, financial development in terms of the intermediary level enhances capital accumulation, reduces the cost of foreign finance and boosts overall economic growth.

2.2. Stock market development, banking sector and economic growth

The evidence in the relevant literature suggests that the stock market may endorse long-term growth. The stock market also promotes specialisation, acquisition and the spreading of information (Diamond, 1984; Greenwood & Jovanovic, 1990; Williamson, 1986) and may diminish the cost of facilitating investment (Greenwood and Smith, 1997). In a well-developed stock market, corporate control can be increased by easing the principal–agent problem, where managers may increase their interest and firm value (Diamond and Verrecchia, 1982; Jensen and Murphy, 1990).

Stock markets may influence economic activities via *liquidity*. Lack of liquidity in markets may create less investment; however, liquidity in the stock market reduces risk and the costs of investing in a long time. Thus, a more liquid stock market alleviates investment and develops the allocation of capital in boosting prospects for long-term growth, whereas greater liquidity may reduce saving rates to slow growth (Bencivenga & Smith, 1991). The other vehicle provided by stock markets is *risk diversification*. Reduced risk throughout internationally integrated stock markets may lower saving rates, slow growth and decrease economic welfare (Devereux and Smith, 1994).

Stock markets may also endorse the *acquisition of information* about firms and *corporate control.* Regarding the former issue, investors are able to make money before the information becomes widely available and prices change. Thus better information about firms will enhance resource allocation and stimulate economic growth (Grossman and Stiglitz, 1980; Stiglitz, 1985). The latter issue emphasises that efficient stock markets help to sort out the principal–agent problem. Efficient stock markets also make the balance between the interest of managers and owners so well-functioning stock markets promote efficient resource allocation and growth (Diamond and Verrecchia, 1982; Jensen and Murphy, 1990).

Another important vehicle of stock markets is price volatility. Fluctuations in price weaken the capability of stock markets to stimulate an efficient allocation of investment. However, there is no certain point on the issue of volatility in recent literature (Arestis et al., 2001). Volatility, as a stock market indicator, has received significant attention in the literature. The most common way of measuring volatility is described as the moving or rolling standard deviation of the end-of-time frequency change of stock market prices, depending upon the data used.[3] The rational insight from the volatility measure is that a large amount of volatility does not necessarily suggest a particular degree of stock market development.[4] A certain degree of volatility in the stock market is clearly

desirable. However if there exists excess volatility in stock returns, this may exacerbate economic growth (De Long, Shleifer, Summers, & Waldmann, 1989; Ferderer, 1993).

Stock market capitalisation is also a centre of attraction in the literature as an indicator of stock market development. This proxy is closely related with the volume of bank business and whether an increase in the market capitalisation may go together with an increase in the volume of bank business. This indicates that the development of the stock market goes hand in hand with the development of the banking system (Arestis & Demetriades, 1997; Arestis et al., 2001).

The critical importance of the banking system in economic growth was emphasised by Bagehot (1873) and Schumpeter (1912). They pointed out the situations in which banks can actively contribute to their innovation and future growth through their function of identifying and funding productive investments. On the other hand, Robinson (1952) stated that banks have a passive role in promoting economic growth. Goldsmith (1969) also found that there is a positive relationship between the ratio of financial intermediaries' assets to GDP and per capita income and where there is rapid growth; the ratio of financial intermediaries' assets to GDP has a tendency to perform above-average as well.

In the recent empirical literature over the last five years, there has been an increasing focus on the comparison between stock market development and financial intermediary development, specifically in the banking sector. Using the data for 44 developed and emerging markets over the period 1986–1993, Demirguc-Kunt and Levine (1996) found that there are significant correlations among stock market indicators, in agreement with intuitively feasible result. Their findings also suggest that there are strong correlations between the individual indicators of stock market development and the banking sector's financial intermediary development. Consequently, they concluded, 'stock market development and bank financial intermediary development go hand in hand'.

Levine and Zervos (1996, 1998) conducted two studies, each slightly different from the other, on the role of banks and stock markets in fostering economic growth as well. In their first study, using data from 41 countries over the period 1976–1993, Levine and Zervos (1996) examined the relationship between stock market development and economic growth through cross-country regressions. As a result, after controlling for initial conditions and various economic and political factors, stock market development and bank financial intermediary development are positively associated with present and future rates of economic growth.

In their second study, using data from 47 countries from 1976 through 1993, Levine and Zervos (1998) evaluate whether individual stock market indicators (i.e. liquidity, size and volatility) and the banking development indicator (i.e. bank credit) are both robustly correlated with current and future rates of economic growth, capital accumulation, productivity growth and private savings. They concluded that stock market liquidity[5] and banking development are both good reflectors of contemporaneous and future rates of economic growth, capital accumulation and productivity growth (see also Atje & Jovanovic, 1993). In light of their findings, Levine and Zervos (1998) suggest that banks' contribution to economic growth occurs through financial services different from those of stock markets and that financial factors are inherent in an economic growth process.

3.   Theoretical modelling and data description

3.1.   *Theoretical modelling*

A number of development economists and researchers have used both the endogenous and the exogenous growth theories to emphasise the relationship between financial

development and growth. This nexus between these two issues has been well implemented by Goldsmith (1969), McKinnon (1973), Shaw (1973) and others who have produced considerable evidence that financial development correlates with growth.

Recently, many studies have provided new impetus for empirical research on the link between financial development and growth from both the endogenous and the exogenous growth modelling points of view.[6] It is worth emphasising that a number of existing empirical studies on the role of financial development have no framework with standard theoretical underpinnings.[7] Recent attention has centred on the relationship between financial development and economic growth in developing countries (See Schumpeter, 1912; Goldsmith, 1969; McKinnon, 1973; Shaw, 1973; King and Levine, 1992; Odedokun, 1996b, 1996a; Demetriades and Hussein, 1996; Levine, 1996, 1997).

In this study, we adopt the frameworks introduced by Mankiw, Romer, and Weil (1992), Knight, Loayza, and Villanueva (1992, 1993), Ghura and Hadjimicheal (Ghura & Hadjimichael, 1996) and Arestis et al. (2001) to investigate the role of stock market development, banking sector development and stock market volatility in economic growth.

Let us consider the following Cobb-Douglas production function:

$$Y_t = K_t^\alpha H_t^\beta (A_t L_t)^{1-\alpha-\beta}, \tag{1}$$

where Y is real output, K is the stock of physical capital, H is the stock of human capital, L is the raw labour, A is a labour-augmenting factor reflecting the level of technology and efficiency in the economy and the subscript t indicates time.

We assume that $\alpha + \beta < 1$, so there are constant returns to factor inputs jointly and decreasing returns separately. Raw labour and labour-augmenting technology are assumed to grow according to the following functions:

$$L_t = L_0 e^{nt} \tag{2}$$

$$A_t = A_0 e^{gt+FDP\theta}, \tag{3}$$

where n is the exogenous rate of growth of the labour force, g is the exogenous rate of technological progress, FDP is a vector of financial development policy and the other factors that can affect the level of technology and efficiency in the economy and θ is a vector of coefficients related to this policy and other variables.

In this model, variable A depends on exogenous technological improvements and the degree of stock market development and banking system development. It is obvious that A in this study differs from A used by Mankiw et al. (1992). This modification is more likely to be particularly relevant to the empirical cases of the nexus between financial development and labour productivity or economic growth in developed countries. In these countries, technological improvements are encouraged by developments in the financial and stock markets, which tend to increase economic growth (Murinde, 1996).

Furthermore, in the steady state, output per worker grows at the constant rate g (the exogenous component of the growth rate of the efficiency variable A). This outcome can be obtained directly from the definition of output per effective worker, as follows:

$$\begin{aligned} \frac{Y_t}{A_t L_t} &= (k_t)^\alpha (h_t)^\beta \\ \frac{Y_t}{L_t} &= A_t (k_t)^\alpha (h_t)^\beta \end{aligned} \tag{4}$$

Let $y_t^* = \left(\frac{Y_t}{L_t}\right)^*$

Taking logs both sides of Equation (4), we get Equation (5):
$$\ln\left(\frac{Y}{L}\right)^* = \ln A + \alpha \ln k^* + \beta \ln h^*, \ (t \text{ is omitted})$$
where $A_t = A_0 e^{(gt+FDP\theta)}$

$$\ln\left(\frac{Y}{L}\right)^* = \ln A_0 + gt + \theta \ln FDP + \frac{\alpha}{1-\alpha-\beta} \ln s^K$$
$$+ \frac{\beta}{1-\alpha-\beta} \ln s^H - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n+g+\delta) \tag{5}$$

Equation (5) indicates steady state output per worker or labour productivity where a vector of financial policy proxies and the other variables exist.

The transitional dynamics by using a log-linearisation around the steady-state give the following growth equation:

$$\ln y - \ln y(0) = g + \left(1 - e^{-\lambda t}\right)\left[\ln A_0 + gt + \theta \ln FDP + \frac{\alpha}{1-\alpha-\beta} \ln s^K\right.$$
$$\left. + \frac{\beta}{1-\alpha-\beta} \ln s^H - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n+g+\delta) - \ln y(0)\right], \tag{6}$$

where *FDP* is a vector of the financial development policy and the other factors that can affect the level of technology and efficiency in the economy and θ is a vector of coefficients related to this policy and other variables.

Having rearranged Equation (6), we have the following equation, which indicates steady-state output per worker or labour productivity evolving around the steady-state path.

$$\ln y_{t+1} - \ln y_t = g + \left(1 - e^{-\lambda_t}\right)\left[\ln A_0 + gt + \theta \ln FDP + \frac{\alpha}{1-\alpha-\beta} \ln s_t^K\right.$$
$$\left. + \frac{\beta}{1-\alpha-\beta} \ln s_t^H - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n_t+g+\delta) - \ln y_t\right], \tag{7}$$

where $\lambda_t = (n_t + g + \delta)(1 - \alpha - \beta)$.

Equation (7) can be expressed as follows, omitting the log notation:

$$\Delta y_t = c + \mu \left[y - A_0 - A_1 FDP - A_2 T - A_3 s^K - A_4 s^H - A_5(n+g+\delta)\right]_{t-1}$$
$$\Delta y_t = c + \mu \left[y - y^*\right]_{t-1}. \tag{8}$$

Equation (8) leads an error correction mechanism, as follows:

$$\Delta \ln y_t = c_0 + \mu e_{t-1} + \sum_{i=0}^{m} \phi_i \Delta \ln s_{t-i}^K + \sum_{j=0}^{p} \eta_j \Delta \ln s_{t-j}^H$$
$$+ \sum_{k=0}^{r} \pi_i \Delta \ln(n_{t-k}+g+\delta) + \sum_{z=0}^{s} \theta \Delta \ln FDP_{t-z} + \varepsilon_t, \tag{9}$$

where $\sum FDP$ is a vector, which contains three different proxies for the financial development indicators – in turn, *FDP1*: stock market development, *FDP2*: banking sector development and *FDP3*: stock market volatility – and the rest are explained earlier in this section. It is important to mention that there might be some missing exogenous variables in our model that do not capture other important factors for the current crisis (i.e. 2008), such as the efficiency of supervision, the monetary policies of central banks, the full and complete financial disclosure of positions, inefficient corporate

governance practices and so on. However, these factors are really difficult to model within this framework under inspection.

3.2. Data description

The data we have employed in this study are quarterly seasonally unadjusted, covering the period 1965Q1–2011Q4. We have used seven variables for the UK.[8] Our variables are measured as follows. Output is measured by real GDP per number of workers, LCAP; LKR, the logarithm of real gross domestic fixed capital formation to GDP ratio, is used as a proxy for the real investment to GDP ratio (investment share in GDP); LHR, the third level (or tertiary) enrolment rate is compiled as a proxy which refers to the ratio of the number of students enrolled at universities; LNGD is the empirical counterpart of log $(n_{1+}g + \delta)$ – that is, the log of the sum of the labour (or worker) growth rate plus the estimation of technological progress rate plus the depreciation rate $(g + \delta = 0.05$ is assumed)[9]. The vectors of financial development policy variables are as follows: stock market development by the logarithm of the stock market capitalisation ratio, LMC, is defined as the ratio of stock market value to nominal GDP; banking sector development by the logarithm of the ratio of DC to nominal GDP is LBC; and stock market volatility is measured by a moving eight-quarter standard deviation of the end-of-quarter change of stock market prices, LV[10] (see also Arestis & Demetriades, 1997).

4. Econometric framework, methodology and empirical results

4.1. Econometric framework

We initially investigated the stationary properties of our data-set, employing the seasonal integration test proposed by Hylleberg et al. (HEGY) (1990). This technique permits simultaneous testing for the existence of unit roots in the zero and seasonal frequencies. We then applied the seasonal cointegration and seasonal error correction modelling framework proposed by Engle, Granger, Hylleberg, and Lee (1993) in order to capture the seasonal effects at all possible frequencies. To confirm the results obtained from the seasonal cointegration test, we conducted an extended version of Johansen's (1988) and Johansen and Juselius's (1992) methods as modified by Lee (1992) to assess the number of cointegrating vector(s) from a seasonal point of view. Accordingly, an exogeneity test is conducted to find out whether the variables used on the right-hand side of the model are weakly exogenous (see Johansen, 1992).

The final step is to examine the Granger causality (GC) issue in regard to whether there is a causal relationship among the relevant variables under study. In order to investigate this, we first use the 'Final Prediction Error' (FPE) criteria to determine the optimal lag-length for the variables in the bivariate VAR model. After following the formal GC testing procedure, we also employ the Holmes-Hutton (HH) procedure to confirm the GC test results by using the usual asymptotic χ^2-distribution and F-distribution, respectively.

4.2. Methodology and empirical results[11]

In light of the modelling derived in the previous section, we apply the seasonal cointegration and seasonal error correction modelling framework to investigate the relationship between financial development determinants and economic growth in the following model, represented by Equation (10).

$$\text{LCAP}_t = a_0 + a_1 T + a_2 LKR_t + a_3 LHR_t + a_4 \text{LNGD}_t + a_5 VFPDV_t + u_t, \quad (10)$$

where VFPDV is the vector of the financial development policy variables LMC, LBC and LV. LKR, LHR and LNGD are physical capital, human capital and number of labourers, respectively, which are defined in the previous section. a_0, a_1, a_2, a_3, a_4 and a_5 are estimated parameters, u_t is a serially uncorrelated random disturbance term and L denotes the natural logarithm.

Initially, we examine the stationary properties of the variables under inspection by conducting the HEGY test. This test provides different steps for the presence of unit roots at the seasonal frequencies as well as at the zero frequency. The test statistics are for unit roots at frequencies of 0 (i.e. long run), ½ – two cycles per year (i.e. at biannual frequency), and ¼ – one cycle per year (i.e. at annual frequency), respectively. The HEGY test is based upon the following regression:

$$\Delta_4 X_t = \sum_{i=1}^{k} \prod_i Y_{i,t-1} + \sum_{i=1}^{k} \delta_i \Delta_4 X_{t-i} + \varepsilon_t. \tag{11}$$

Under the null hypothesis of stochastic seasonality, Π_i are zero, and the $Y_{i,t}$ are obtained from X_t via the filter factors $(1+L)$ $(1+L^2)$, $(1−L)$ $(1+L^2)$, L $(1-L)$ $(1+L)$ and $(1-B)$ $(1+B^2)$. More specifically, we can mention about this test as follows:

$$\Delta_4 X_t = \prod_1 X_{1,t-1} + \prod_2 X_{2,t-1} + \prod_3 X_{3,t-2} + \prod_4 X_{3,t-1} + \sum_{j=1} \beta_j \Delta_4 X_{t-j} + \varepsilon_t, \tag{12}$$

where

$\Delta_4 X_t = (1 − L^4) X_t,$
$X_{1,\,t-1} = (1+L+L^2+L^3) X_{t-1} = X_{t-1}+X_{t-2}+X_{t-3}+X_{t-4},$
$X_{2,\,t-1} = −(1-L+L^2-L^3) X_{t-1} = -(1-L) (1+L^2) X_{t-1} = -X_{t-1}+X_{t-2}-X_{t-3}+X_{t-4},$
$X_{3,\,t-2} = −(1+L^2) X_{t-2} = -(1-L) (1+L) X_{t-2} = --X_{t-2}+X_{t-4},$
$X_{3,\,t-1} = −(1+L^2) X_{t-1} = - X_{t-1}+X_{t-3},$ and ε_t is a normally and independently distributed error term with zero mean and constant variance.[12] Deterministic components which include an intercept, three seasonal dummies and a time trend are included in equation (12), which can be estimated by ordinary least squares. The three null and alternative hypotheses to be tested are as follows:

(1) $H_0 : \Pi_1 = 0,$ $H_I : \Pi_1 < 0$
(2) $H_0 : \Pi_2 = 0,$ $H_I : \Pi_2 < 0$
(3) $H_0 : \Pi_2 = \Pi_3 = 0,$ $H_I : \Pi_3 \neq 0$ and / or $\Pi_4 \neq 0.$

The HEGY test involves the use of the t-test for the first two hypotheses and an F-test for the third hypothesis. If the first hypothesis is not rejected, there is a unit root at the zero frequency (i.e. a non-seasonal unit root in the series). Non-rejection of the second hypothesis implies that there is a seasonal unit root at the semi-annual frequency. Lastly, if the third hypothesis is not rejected, then there is a seasonal unit root at the annual frequency.

The outcomes of the HEGY tests are shown in Table 1. HEGY tests suggest that the first, second and third null hypotheses are not rejected at the 5% level. This means that the variables in question have no unit roots at the zero, biannual and annual frequencies, and the relevant series are integrated of order 1 at the seasonal frequencies ½ and ¼ as well as zero. In addition to this, we notice that the results estimated are not sensitive to the removal of deterministic seasonality. This implies that the seasonal components of the variables seem to be stochastic rather than deterministic.

Table 1. Seasonal unit roots test (1965Q1–2011Q4).

Variables	Deterministic Components	$t(\Pi_1)$	C.V.	$t(\Pi_2)$	C.V.	$t(\Pi_3)$	C.V.	$t(\Pi_4)$	C.V.	$F(\Pi_3 \cap \Pi_4)$	C.V.
						Auxiliary Regression					
$\mathbf{LCAP_t}$	C, SD, T	−8.31	−3.51	−9.07	−2.92	−9.66	−3.43	−5.31	−1.93	74.55	6.60
$\mathbf{LBC_t}$	C, SD, T	−5.58	−3.51	−5.68	−2.92	−5.95	−3.43	−2.24	−1.93	89.70	6.60
$\mathbf{LMC_t}$	C, SD, T	−7.13	−3.51	−7.29	−2.92	−6.34	−3.43	−3.84	−1.93	85.01	6.60
$\mathbf{LV_t}$	C, SD, T	−6.76	−3.51	−7.26	−2.92	−6.72	−3.43	−4.02	−1.93	71.65	6.60
$\mathbf{LKR_t}$	C, SD, T	−5.26	−3.51	−6.16	−2.92	−5.21	−3.43	−3.32	−1.93	73.51	6.60
$\mathbf{LHR_t}$	C, SD, T	−5.43	−3.51	−5.76	−2.92	−6.42	−3.43	−3.91	−1.93	79.14	6.60
$\mathbf{LNGD_t}$	C, SD, T	−6.03	−3.51	−6.23	−2.92	−6.44	−3.43	−3.02	−1.93	82.65	6.60

Notes: The reported critical values at 5% significance level are obtained from Hylleberg et al. (1990). It is worth noting that the critical values for 172 numbers of observations do not exist in the relevant table that is tabulated by Hylleberg et al. (1990). Hence, we have calculated the reported critical values approximately for 172 numbers of observations by using the relevant table. Dependent variables in the table are in the seasonal differences, C intercept; SD seasonal dummies; and T trend. Source: Authors' analysis.

The next step is to test for seasonal cointegration between the relevant variables, which should be in the same order. Since the series are seasonally unadjusted, the Hylleberg et al. (1990) seasonal cointegration test is used. The presence of seasonal unit roots implies that standard cointegration tests are inappropriate. The static cointegration regression does not necessarily give consistent estimates due to the presence of seasonal unit roots, as shown in Engle, Granger and Hallman (1989). The problem of the standard cointegration technique in this context motivates an alternative approach to testing for cointegration in the presence of unit roots at other seasonal frequencies. Engle, Granger, Hylleberg, and Lee (1993) has also extended the theory of cointegration to allow for cointegration at both zero and seasonal frequencies. If $LCAP_t \sim I(1)$, $LKR_t \sim I(1)$, $LHR_t \sim I(1)$, $LNGD_t \sim I(1)$, $LBC_t \sim I(1)$, $LM2_t \sim I(1)$, $LMC_t \sim I(1)$ and $LV_t \sim I(1)$, the cointegrating regressions at frequencies 0, ½, ¼ are respectively given by the following regressions:

$$Z_1(y_t) = \alpha_0 + \alpha_1 Z_1(X_t) + u_t \tag{13}$$

$$Z_2(y_t) = \beta_0 + \beta_1 Z_2(X_t) + v_t \tag{14}$$

$$Z_3(y_t) = \gamma_0 + \gamma_1 Z_3(X_t) + \gamma_2 Z_3(X_{t-1}) + w_t \tag{15}$$

Cointegration is established at all frequencies if u_t, v_t, and w_t are stationary. Testing for stationary of these residuals is carried out on the basis of the following auxiliary regressions:

$$\Delta u_t = \varphi u_{t-1} + \sum_{i=1}^{k} \varphi_i \Delta u_{t-i} + \varepsilon_{1,t}, \tag{16}$$

$$v_t + v_{t-1} = \varphi(-v_{t-1}) + \sum_{i=1}^{k} \varphi_i(v_{t-i} + v_{t-1-i}) + \varepsilon_{2,t}, \tag{17}$$

$$w_t + w_{t-2} = \lambda_1(-w_{t-2}) + \lambda_2(-w_{t-1}) + \sum_{i=1}^{k} \varphi_i(w_{t-i} + w_{t-2-i}) + \varepsilon_{3,t}. \tag{18}$$

For the auxiliary regressions (16) and (17), the test statistics t ratios of ϕ and the critical values are tabulated in Engle and Granger (1987) and Engle and Yoo (1987). Testing for unit root in w_t is not straightforward since it contains complex roots. In this case, the test statistics are the t ratios of λ_1 and λ_2 and F statistics for λ_1 and λ_2, whose critical values are tabulated in Engle et al. (1993). In Engle and Yoo (1987, Table 2, p. 157), critical values are, however, not valid for seasonal cointegration at annual frequency since they are complex conjugates. Engle et al. (1993) provides the asymptotic t-statistics (see Tables A1–A5 in Engle et al. 1993, pp. 293–297) for a cointegration relationship at the annual frequency.

From Table 3, it can be seen that there exists a cointegration relation at both the seasonal frequencies (i.e. biannual and annual) and the long run (zero) frequency, since all variables are integrated of order (1). Here we have conducted the residual-based cointegration test (or residual-based ADF test as suggested by Engle & Granger, 1987). This test can be carried out in two steps; in the first step, the long run relationship is estimated by OLS (e.g. equations [16], [17], and [18]), and in the second step, the residuals (u_t, v_t, w_1 and w_2) from equations (16), (17) and (18) are taken and then the ADF test is applied for stationary of estimated residuals. Hypotheses are conducted as follows:

Table 2. Cointegration test at frequency 0: the long run.

Cointegration Regression			Auxiliary Regression		Calculated ADF Residuals
Equation	R^2	**Deterministic Components**	Deterministic Part	Augmentation	**ADF, t(Φ)**
$LCAP_{1t} = f (LKR_{1t}, LHR_{1t}, LNGD_{1t}, LBC_{1t}, LMC_{1t}, LV_{1t})$	0.96	C,T	–	1, 2	−4.69

Notes: The tests are based upon the ordinary ADF regression $\Delta u_t = \pi_1 u_{t-1} + \sum_{i=1}^{k} b_i \Delta u_{t-i} + e_t$ where u_t is the residual from the cointegration regression. The critical value is –4.28 at 5% significance level obtained from Engle and Yoo (1987), Engle and Granger (1987) and Mackinnon (1991). It is worth noting that deterministic components (i.e. trend and intercept) are included for the equation in the table above.
Source: Authors' analysis.

Table 3. Cointegration test at frequency ½ : biannual.

Cointegration Regression			Auxiliary Regression		Calculated ADF Residuals
Equation	R^2	**Deterministic Components**	Deterministic Part	Augmentation	**ADF, t(Φ)**
$LCAP_{2t} = f (LKR_{2t}, LHR_{2t}, LNGD_{2t}, LBC_{2t}, LMC_{2t}, LV_{2t})$	0.97	C, T	–	1, 2	−7.52

Notes: The tests are based upon the auxiliary regression $V_t + V_{t-1} = \varphi(-V_{t-1}) + \sum_{i=1}^{k} \rho_i (V_{t-i} + V_{t-1-i}) + \varepsilon_t$ where V_t is the residual from the cointegration regression. The critical value is –4.28 at 5% significance level obtained from Engle and Yoo (1987), Engle and Granger (1987) and Mackinnon (1991). It is worth noting that deterministic components (i.e. trend and intercept) are included for the equation in the table above. Source: Authors' analysis.

H_0: ϕ and $\lambda = 0$ (Residuals are non-stationary)
H_I: ϕ and $\lambda < 0$ (Residuals are stationary)

The residual-based ADF test statistics for u_t, v_t, w_1 and w_2 ensure that we can reject the null hypothesis of non-stationary (or no seasonal cointegration) at the 5% significance level for the equations mentioned above.

The results of testing for seasonal cointegration are presented in tables 2, 3 and 4. The results demonstrate the presence of cointegration at both ½ and ¼ frequencies as well as at the zero frequency. In other words, we can reject the null hypothesis of no seasonal cointegration at the zero, biannual and annual frequencies at the 5% significance level. Hence, we can conclude that the data exhibit seasonal cointegrating relationships at all seasonal frequencies.

Based upon the cointegration results, it is possible to estimate the seasonal error correction model since cointegration is established at all seasonal frequencies, and the seasonal differencing is adequate to achieve stationary. We then specify a seasonal error correction model, as shown below.[13]

$$\Delta_4 x_t = \alpha + \sum_{i=1}^{k} \beta_i \Delta_4 x_{t-i} + \sum_{i=0}^{k} \delta_i \Delta_4 Y_{t-1} + \gamma(X_{t-4} - Y_{t-4}) + \varepsilon_t, \tag{19}$$

Table 4.   Cointegration test at frequencies ¼ and ¾: annual.

Cointegration Regression			Auxiliary Regression		HEGY Test		
Equation	R^2	**Deterministic Components**	Deterministic Part	Augmentation	$t\lambda_1$	$t\lambda_2$	$F\lambda_1 \cap \lambda_2$
$LCAP_{3t} = f$ $(LKR_{3t},$ $LHR_{3t},$ $LNGD_{3t},$ $LBC_{3t},$ $LMC_{3t}, LV_{3t})$	0.94	C, T	–	1, 2	−5.73	−3.25	19.34

Notes: The tests are based upon the auxiliary regression, $w_t + w_{t-2} = \lambda_1(-w_{t-2}) + \lambda_2(-w_{t-1}) + \sum_{i=1}^{k} \rho_i(w_{t-i} + w_{t-2-i}) + \varepsilon_t$ where w_t is the residual from the cointegration regression. The critical values are at 5% significance level t: $\lambda_1 = -3.22$, t: $\lambda_2 = -2.13$, and F: $\lambda_1 \cap \lambda_2 = 7.01$, obtained from Engle et al. (1993). Note that deterministic components (i.e. trend and intercept) are included for the relevant equation. Source: Authors' analysis.

where $\varepsilon_t \sim NID(0, \delta_\varepsilon^2)$, $X_{t-4} - Y_{t-4}$ is the error correction term which is taken from the OLS cointegrating relationship in tables 2, 3 and 4.

Table 5 reports the estimates of error correction models in restricted form. We allow four lags on the differences of all variables until we get the most significant lagged differenced terms in the models (i.e. the parsimonious specification). The error correction terms are negative and statistically significant at the 1% level. This indicates that outputs adjust to their equilibria levels, and the error correction terms provide further evidence that the variables in the equilibrium regressions are cointegrated. To put it differently, the magnitudes of corresponding coefficients show that 25%, 21% and 19% of last period's disequilibria are corrected after four quarters in the seasonal differences. These results also reflect a reasonable short run effect and adjustment to deviation from the long run equilibrium condition and provide some evidence for both the effect of stock market capitalisation and volatility on economic growth.

One can say that the causal impact of one variable on another should take place in an ECM – the impact of lagged changes in the explanatory variables. The results presented in Table 5 indicate unidirectional causality running from physical capital, human capital, market capitalisation and volatility to economic growth, whereas no causal relationship was found between economic growth and banking sector development.[14] This supports the supply leading hypothesis, which posits a causal relationship from financial development to economic growth. This phenomenon is supported by the works of Levine, Loayza, and Beck (2000), Odedokun (1996a), King and Levine (1993a, 1993b), Jao (1976) and Mckinnon (1973). These results need further investigation to be justified by using different causality techniques to eliminate any doubt about the direction of causality. Before applying the causality techniques, it is worth noting that the results obtained from the seasonal cointegration should be confirmed using the maximum likelihood approach of Lee (1992) (i.e. the extension work of Johansen & Juselius, 1990). We have, therefore, decided to conduct the non-seasonal framework and the seasonal framework proposed by Johansen (1988) and Johansen and Juselius (1990) and extended by Lee (1992).

Table 6 reports the maximum likelihood test results, confirming the unique cointegrating vector among the relevant variables in all seasonal frequencies and the zero frequency. The table shows that the null hypothesis of no cointegration is rejected for all cases by the λ-max and trace statistics with four lags. Our results are consistent

Table 5. Seasonal error correction models.

Explanatory Variables ECT	Dependent Variable Δ_4LCAP		
C	0.04***	0.05***	0.03***
	(3.21)	(3.32)	(4.17)
ECT$_{1t}$ (-1)	−0.25***	-	
	(−5.14)		
ECT$_{2t}$ (-1)	−	−0.21***	
		(−4.31)	
ECT$_{3t}$ (-1)	−	−	−0.19***
			(−2.59)
Δ_4LCAP(-1)	0.54***	0.61***	0.49***
	(7.03)	(4.58)	(3.83)
Δ_4LBC(-1)	0.04^	0.06^	0.08^
	(1.54)	(1.59)	(1.61)
Δ_4LMC(-1)	0.03*	0.14*	−
	(1.71)	(1.77)	
Δ_4LMC(-2)	−	−	0.14***
			(2.81)
Δ_4LV(-1)	−	−0.11*	−
		(−1.93)	
Δ_4LV(-2)	−0.19**	−0.21*	−0.15*
	(−2.27)	(−1.68)	(−1.72)
Δ_4LHR(-1)	0.35***	0.37**	−0.13**
	(3.09)	(2.24)	(2.19)
Δ_4LKR(-1)	0.43***	0.41**	0.44***
	(3.15)	(2.07)	(2.94)
Δ_4LNGD(-2)	−0.17*	−0.18*	−0.21*
	(−1.64)	(−1.66)	(−1.65)

Notes: ECT(-1) is the residual series from the OLS cointegrating regression in tables 2, 3 and 4. Numbers in the parentheses are t values. ***, **, * indicate 1%, 5%, and 10% level of significance respectively and ^ shows that they are not insignificant at the conventional levels. All diagnostic passes at 5% level of significance. Source: Authors' analysis.

with the findings of Reimers (1997), who found one cointegration vector at the seasonal frequencies (i.e. ½, ¼ and ¾) as well as at the zero frequency in investigating the nexus between real income and financial wealth for the German economy (see also Christopoulos & Tsionas, 2004).

In the next step, we conducted a weak exogeneity test in two ways: first, to find out the long run causality between the output and its determinants referring to the statement pointed out by Hall and Milne (1994);[15] second, to examine whether the variables used on the right-hand side of the model are weakly exogenous or not.

Each vector was normalised on the output in each case where we found evidence of error correction that is negative and significant. The cointegrating vector shows a positive relationship between the output and banking system, as well as market development. The results in Table 7 provide clear evidence for the weak exogeneity of each of the explanatory variables to the system (i.e. LKR$_t$, LHR$_t$, LNGD$_t$, LBC$_t$, LMC$_t$ and LV$_t$). In the long run (or zero frequency), the vector exhibits that causality runs from stock market capitalisation and stock market volatility to GDP per worker. Utilising the same rationale, there is also sufficient evidence, albeit mixed, that causality runs from the banking system development to real GDP per worker in the same period as well as in biannual and annual frequencies compared to the results estimated in Table 5. In the same periods, there is a flow of causality from stock market development to real GDP per worker.

Table 6.   Johansen Maximum Likelihood (ML) procedure cointegration likelihood ratio (LR) test to determine the number of cointegration vectors (r) based upon Maximal Eigen value of the stochastic matrix, and trace of the stochastic matrix from a seasonal point of view suggested by Lee (1992).

Cointegration Regression	Null Hypothesis	Alternative Hypothesis	λ_{max}	Critical Value at 5%	λ_{trace}	Critical Value at 5%
Long run: (0)	r = 0	r = 1	76.25	43.61	122.99	115.85
	r <= 1	r = 2	35.26	37.86	86.31	87.17
	r <= 2	r = 3	23.55	31.79	56.47	63.00
LCAP_{1t} = f (LKR_{1t},	r <= 3	r = 4	21.72	25.42	38.17	42.34
LHR_{1t}, LNGD_{1t}LBC_{1t},	r <= 4	r = 5	10.35	19.22	18.21	25.77
LMC_{1t}, LV_{1t})	r <= 5	r = 6	4.82	12.39	4.82	12.39
Biannual: ½	r = 0	r = 1	72.88	43.61	135.88	115.85
	r <= 1	r = 2	30.43	37.86	87.00	87.17
	r <= 2	r = 3	28.17	31.79	61.57	63.00
LCAP_{2t} = f (LKR_{2t},	r <= 3	r = 4	23.46	25.42	35.67	42.34
LHR_{2t}, LNGD_{2t}LBC_{2t},	r <= 4	r = 5	11.51	19.22	23.02	25.77
LMC_{2t}, LV_{2t})	r <= 5	r = 6	9.42	12.39	9.42	12.39
Annual: 1/3 (or ¾)	r = 0	r = 1	82.43	43.61	136.59	115.85
	r <= 1	r = 2	36.29	37.86	83.85	87.17
	r <= 2	r = 3	26.79	31.79	57.06	63.00
LCAP_{3t} = f (LKR_{3t},	r <= 3	r = 4	21.15	25.42	38.76	42.34
LHR_{3t}, LNGD_{3t}LBC_{3t},	r <= 4	r = 5	18.39	19.22	22.48	25.77
LMC_{3t}, LV_{3t})	r <= 5	r = 6	9.08	12.39	9.08	12.39

Notes: r indicates the number of cointegrating vectors. λ_{max} is the maximum eigenvalue statistics, λ_{trace} is the trace statistics. VAR 4 based on a common practise in which four lags are used due to quarterly data (see Bahmani-Oskooee and Shabsigh (1996). The unrestricted constant and restricted trends are not rejected in all cases. The critical values are obtained from Osterwald-Lenum (1992). Source: Authors' analysis.

Table 7.   Testing for weak exogeneity using Johansen approach from a seasonal point of view.

Relation	Variables	Test for Weak Exogeneity	
		Test Statistics	**Conclusion/Loading factor/p-value**
	LBC_{1t}	$\chi^2(1) = 3.73$ (.04)	Accept /0.08/0.05
Long Run	**LMC_{1t}**	$\chi^2(1) = 0.42$ (.54)	Accept/0.10/0.04
Or	**LV_{1t}**	$\chi^2(1) = 2.39$ (.12)	Accept/-0.12/0.05
Zero Frequency	**LKR_{1t}**	$\chi^2(1) = 2.73$ (.10)	Accept/0.25/0.02
Normalised on LCAP_{1t}	**LHR_{1t}**	$\chi^2(1) = 1.32$ (.25)	Accept/0.21/0.01
	LNGD_{1t}	$\chi^2(1) = 0.45$ (.51)	Accept/-0.16/0.10
	LBC_{2t}	$\chi^2(1) = 0.06$ (.80)	Accept/0.11/0.06
Biannual	**LMC_{2t}**	$\chi^2(1) = 1.33$ (.26)	Accept/0.13/0.03
Or	**LV_{2t}**	$\chi^2(1) = 1.99$ (.44)	Accept/-0.12/0.07
½ Frequency	**LKR_{2t}**	$\chi^2(1) = 0.06$ (.80)	Accept/0.29/0.01
Normalised on LCAP_{2t}	**LHR_{3t}**	$\chi^2(1) = 2.57$ (.11)	Accept/0.22/0.03
	LNGD_{1t}	$\chi^2(1) = 3.82(.05)$	Accept/-0.09/0.08
	LBC_{3t}	$\chi^2(1) = 0.10$ (.75)	Accept/0.09/0.05
Annual	**LMC_{3t}**	$\chi^2(1) = 0.05$ (.90)	Accept/0.14/0.03
Or	**LV_{3t}**	$\chi^2(1) = 3.81$ (.05)	Accept/-0.11/0.07
¼ (and ¾) Frequency	**LKR_{3t}**	$\chi^2(1) = 0.78$ (.37)	Accept/0.31/0.02
Normalised on LCAP_{3t}	**LHR_{3t}**	$\chi^2(1) = 3.80$ (.04)	Accept/0.19/0.03
	LNGD_{3t}	$\chi^2(1) = 2.75$ (.15)	Accept/-0.11/0.09

Notes: Table 7 indicates the results that the hypothesis of weak exogeneity cannot be rejected at 5% level. The tabulated test statistics of $\chi^2(1)$ is 3.84. Source: Authors' analysis.

Unlike the results produced by Arestis et al. (2001), our findings are consistent with the view that capital market-based financial systems may be stronger promoters of the domestic economy than bank-based ones in the case of the UK (see Arestis et al., 2001).

In the next stage, we especially applied different causality techniques[16] to make clearer the causality debate which began with Patrick (1966). This ongoing debate is still unresolved after three decades in the empirical literature. First, we used Akaike's Minimum FPE criterion with Hsiao's synthesis to choose the optimal lag lengths in the seasonal differences (see Giles, Giles, & Mccann, 1993). Second, having applied FPE, we employed Wald and Sims LR tests, not only to justify the results obtained from the different techniques but also to determine the direction of causality.

Table 8 shows the optimal lag lengths for the relevant variables and also the FPE (m^*) and FPE (m^*, n^*) values reported where these values suggest that there is a unidirectional causality from the capital (i.e. KR and HR) and stock market development (i.e. MC and V) sector to real GDP per worker. These findings support the results estimated using Johansen's method for the long run relationship (i.e. zero frequencies) (see Table 7).

To obtain the results which are reported in Table 9, we followed the formal GC and HH causality testing procedures. We then employed Wald, Sims LR and HH multiple-rank F-test statistics to get the usual asymptotic χ^2 distribution and degrees of freedom for the HH multiple-rank F-test (see Giles et al., 1993). Accordingly, we used a simple logarithmic transformation converting Wald Statistics into LR test statistics in order to obtain the results for the Sims LR test. This transformation is also asymptotically χ^2 (see Giles et al., 1993, p. 202; Sims, 1980, p. 17).

As can be seen in Table 9, the evidence of causality runs from physical capital, human capital, stock market capitalisation and stock market volatility to economic growth. This confirms the results obtained from Arestis et al. (2001), in which they found the flow of causality from financial system to GDP per worker. The table also shows that the results from each causality technique confirm each other in indicating the same causality direction at non-seasonal and seasonal frequencies as well as seasonal differences (i.e. short run) (see also Table 10 for a summary of causality direction). Given the results of the causality tests, our findings are consistent with those of Luintel and Khan (1999); however, they are not consistent with those of Arestis and Demetriades (1997) for the US experience, Ang and Thangavelu (2004) for the Australian experience and Ang and McKibbin (2007) for Malay experience, where the flow of causality runs from growth to financial development.

Table 8. Selection of lag lengths using fFPE.

Dependent Variable	Independent Variable	m^*	n^*	FPE (m^*)	FPE (m^*, n^*)
D_4LCAP	D_4LBC	5	1	0.151×10^{-3}	0.163×10^{-3}
D_4LBC	D_4LCAP	5	1	3.175×10^{-3}	3.331×10^{-3}
D_4LCAP	D_4LMC	5	1	0.1619×10^{-3}	0.1612×10^{-3}
D_4LMC	D_4LCAP	5	1	18.37×10^{-3}	18.42×10^{-3}
D_4LCAP	D_4LV	5	1	0.2119×10^{-3}	0.2114×10^{-3}
D_4LV	D_4LCAP	5	1	19.54×10^{-3}	19.65×10^{-3}
D_4LCAP	D_4LHR	5	1	0.1726×10^{-3}	0.1719×10^{-3}
D_4LHR	D_4LCAP	5	1	2.31×10^{-3}	2.39×10^{-3}
D_4LCAP	D_4LKR	5	1	0.563×10^{-3}	0.561×10^{-3}
D_4LKR	D_4LCAP	5	1	4.21×10^{-3}	4.48×10^{-3}

Notes: If FPE (m^*, n^*) < FPE (m^*), Y Granger-causes X.
m^* denotes maximum lag on dependent variable.
n^* denotes minimum lag on independent variable. Source: Authors' analysis.

Table 9.   Vector autoregression models; GC and HH tests.

Dependent Variable	Independent Variable	Degrees Of freedom[a]	Wald Test	Sim's LR Test	m^*	n^*	HH Multiple-rankF-test	Causal Inference
D_4LCAP	D_4LBC	1	0.029	0.031	5	1	0.168 (1.128)[b]	NC
D_4LBC	D_4LCAP	1	0.056	0.059	5	1	0.006 (1.128)	NC
D_4LCAP	D_4LMC	1	11.21[*]	11.89[*]	5	1	5.06[*] (1.128)	MC → CAP
D_4LMC	D_4LCAP	1	3.31	3.34	5	1	1.25 (1.128)	NC
D_4LCAP	D_4LV	1	7.24[*]	7.43[*]	5	1	4.52[**] (1.128)	V → CAP
D_4LV	D_4LCAP	1	2.31	2.47	5	1	3.27 (1.128)	NC
D_4LCAP	D_4LHR	1	6.84[*]	6.89[*]	5	1	3.86[**] (1.128)	HR → CAP
D_4LHR	D_4LCAP	1	3.77	3.81	5	1	3.45 (1.128)	NC
D_4LCAP	D_4LKR	1	5.55[*]	5.86[*]	5	1	4.18[**] (1.128)	KR → CAP
D_4LKR	D_4LCAP	1	3.82	3.83	5	1	3.29 (1.128)	NC

Notes: *indicates significance at the 1% level.
**indicates significance at the 5% level.
[a]χ^2 degrees of freedom for both Wald and Sims' LR tests.
[b]degrees of freedom for HH multiple-rank F-test.
NC no causality. Source: Authors' analysis.

Table 10.   Summary of causality results χ^2-Test.

Seasonal Differences		
FPE	χ^2-Test	HH Multiple-Rank F-Test
CAP – BC(NC)	CAP – BC(NC)	CAP – BC(NC)
BC – CAP(NC)	CAP – BC(NC)	CAP – BC(NC)
CAP – MC(NC)	CAP – MC(NC)	CAP – MC(NC)
MC → CAP	MC → CAP	MC → CAP
CAP – V(NC)	CAP – V(NC)	CAP – V(NC)
V → CAP	V → CAP	V → CAP
CAP – HR(NC)	CAP – HR(NC)	CAP – HR(NC)
HR → CAP	HR → CAP	HR → CAP
CAP – KR(NC)	CAP – KR(NC)	CAP – KR(NC)
KR → CAP	KR → CAP	KR → CAP

Notes: CAP; Real GDP per worker, BC; Domestic bank credit, MC; Stock market capitalisation, V; stock market volatility, HR; human capital or tertiary enrolment rate, KR; physical capital or fixed capital formation and NC; No causality. Source: Authors' analysis.

5.   Conclusion

In this study, we used financial development indicators as well as some control variables to empirically investigate their role on the economic growth of the UK by utilising a variety of econometric techniques. A sample of quarterly and seasonally unadjusted data for the period 1965Q1–2011Q4 was used. Many macroeconomic time series contain

important seasonal components, and it is a common belief that modellers need to pay specific attention to the nature of seasonality rather than essentially ignoring it. As an alternative to the deterministic approaches based on seasonal dummies, stochastic models based on seasonal differencing have been proposed in recent years. Integration and cointegration implicitly assume that integrated or cointegrated series contain unit roots at the long run or zero frequency; however, if the series are seasonally I(1), most unit root tests have very low power and tend to accept the null hypothesis of a unit root with no consideration of seasonal structure. The reason for this is that seasonally integrated processes contain roots not only at zero but also at the seasonal frequencies, and omitting the seasonality is likely to give spurious results and specification errors (Robinson, 1994). We thus used the seasonal integration and cointegration procedures that make it possible in the present study to avoid specification errors, inconsistent estimates, and spurious results, as quarterly data were employed in light of the exogenous modelling framework.

The variables used were integrated of order (1) at seasonal and non-seasonal frequencies, whereas seasonal and non-seasonal cointegration relationships were found. We then confirmed that there is a unique cointegrating vector both in the long run (zero frequency) and at the seasonal frequencies, where the Johansen method modified by Lee (1992) was conducted. The exogeneity test was also applied to obtain a causal long run or seasonal frequencies relationship between stock market development (or banking sector development) and real GDP per worker. The test indicates that mix causal relationship found between banking sector development and output at the zero frequency and seasonal frequencies, whereas there exists a flow of causality from physical capital, human capital, stock market capitalisation and stock market volatility to real GDP per worker. At seasonal frequencies, the only flow of causality is from stock market development to real GDP per worker.

Finally, we employed the formal GC, HH, Wald and Sim's LR testing procedures to confirm the findings obtained in the previous test and provide more reliable results for the causal debate initiated by Patrick (1966) as to whether the direction of causality runs from financial to economic development or other way around. The tests' results evidence that causality runs from stock market development to real GDP per worker at the seasonal difference (i.e. short run effect). These test results confirm the earlier findings obtained by conducting the seasonal error correction models.

On the basis of the results obtained, the following conclusions can be deducted. First, our findings suggest that the UK financial market development sector is more likely to be a good promoter of domestic economic growth than banking sector development. Second, stock market volatility has a negative influence on the UK's output and suggests that volatility in stock prices may reflect economic ambiguity; however, the presence of volatility in stock prices may sometimes reflect a well-functioning and efficient stock market. Our findings do not support the latter statement, which is consistent with the findings of Aizenman and Marion (1996), who found that volatility has a negative real effect. Third, in the UK economy, where the economy seems very dependent on the finance sector as well as the banking sector, economic problems can hit hard. The banking system can virtually collapse, and the government may borrow from the IMF and other neighbours to try and rescue the economy. Fourth, if a new global financial meltdown is formed, this can easily devastate the UK economy, and the financial problems will not be able to be avoided in a short run period due to its dependence on both the finance and banking sectors.

Finally, the results can be interpreted in favour of the 'finance causes growth' hypothesis (i.e. supply-leading). The results also show that if a country has a good infrastructure and a well-educated nation, it enhances economic growth as well as financial development systems (i.e. markets and banks).[17]

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. Wallis (1974) points out that the existence of seasonality can severely distort properties of time series even if the data are seasonally adjusted.
2. Charemza and Deadman (1997) mention that omitting seasonality is likely to have produced fragile or spurious results. This implies that regression analysis makes sense only for data which are not subject to a trend.
3. For example, Demirguc-Kunt and Levine (1996) and Levine and Zervos (1998) used a 12-month rolling standard deviation estimate, while Arestis and Demetriades (1997) and Arestis, Demetriades and Luintel (2001) used eight quarter moving standard deviation of the end-of-quarter change of stock prices.
4. High volatility might represent stock market development through the quick revelation of information about firms in a well-functioning stock market.
5. Harris (1997) found out that liquidity does not have any impact on economic growth.
6. See King and Levine (1992), Murinde (1996), Odedokun (1996b), Berthelemy and Varouda-kis (1996) and others.
7. See Odedokun (1996b) for more detail.
8. Stock market data such as price index and market value were obtained from the online information system Datastream International. DC and the others were obtained from International Financial Statistics (IMF, IFS).
9. We follow Mankiw et al. (1992) in assuming that $(g+\delta)$ is equal to 0.05.
10. We first calculated the logarithmic first differences of the end-of-quarter stock market price index. We then computed a moving eight-quarter standard deviation as a measure of stock market volatility.
11. All of our empirical tests were carried out using Microfit 40 (Pesaran & Pesaran, 1997.
12. See Engle et al. (1993) for more details about polynomial distribution.
13. See Davidson, Hendry, Srba, and Yeo (1978) and Moosa and Choe (1998) for more details.
14. Robinson (1952) stated that banks have a passive role in propelling economic growth.
15. Hall and Milne (1994) interpret that weak exogeneity in a cointegrated system is equivalent to the meaning of long run causality.
16. Granger (1988) argues that causality tests based on traditional time series techniques (i.e. Granger and Sim's tests) can reach incorrect conclusions about causality when time series are cointegrated. Bahmani-Oskooee and Alse (1994, p. 536) also emphasise that standard Granger or Sims' tests are only valid if the original time series, say X and $Y,$ are not cointegrated. The Granger model is premised on the maintained hypothesis of correct functional form (i.e. linear), homoscedasticity and normality of the error term. Holmes and Hutton (HH) (1988) argue that violation of these conditions can influence causality conclusions. They thus suggest an alternative procedure for causality testing based on the rank ordering of each variable. That is, they recommend ranking each variable and using the rank value of each observation in causality testing. The causality conclusion, achieved by using the Granger testing procedure applied to the rank ordering of the variables, is robust over the alternative distribution of the error structure and is invariant to monotonic transformations of the variables.
17. However, what we are facing now (i.e. crisis) is the outcome of sophisticated and well-educated financial engineers. The sub prime loans, collaterised debt obligations and all other related derivative instruments are created by these guys, in a way creating a bubble in the housing sector, especially in the US. The inefficiency of credit rating companies, the lack of supervising by the government and greediness contributed to the crisis and spread all over the world from

sophisticated markets to less sophisticated markets. Therefore, a well-educated population and good infrastructure do not always create economic growth. The developed countries having these characteristics are the ones which are in trouble economically the most, but sometimes it seems that countries that are less educated and that have poor infrastructure are affected less by crises.

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