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# Financial development and economic growth an empirical analysis for Ireland

**Antonios Adamopoulos**[1]

**Abstract**

*This study investigated the relationship between financial development and economic growth for Ireland for the period 1965-2007 using a vector error correction model (VECM). Questions were raised whether financial development causes economic growth or reversely taking into account the positive effect of industrial production index. Financial market development is estimated by the effect of credit market development and stock market development on economic growth. The objective of this study was to examine the long-run relationship between these variables applying the Johansen cointegration analysis taking into account the maximum eigenvalues and trace statistics tests. Granger causality tests indicated that economic growth causes credit market development, while there is a bilateral causal relationship between stock market development and economic growth. Therefore, it can be inferred that economic growth has a positive effect on stock market development and credit market development taking into account the positive effect of industrial production growth on economic growth for Ireland.*

**Keywords:** financial development, economic growth, Granger causality

**JEL classification:** O11, C22

## 1. Introduction

The relationship between economic growth and financial development has been an extensive subject of empirical research. The question is whether financial development causes economic growth or reversely. The main objective of this study was to investigate the causal relationship between economic growth and financial development taking into account the positive effect of industrial production index.

The recent revival of interest in the link between financial development and growth stems mainly from the insights and techniques of endogenous growth models, which have shown that there can be self-sustaining growth without exogenous technical progress and that the growth rate can be related to preferences, technology, income distribution and institutional arrangements. This provides the theoretical underpinning that early contributors lacked: financial intermediation can be shown to have not only level effects but also growth effects.

The financial repressionists, led by, McKinnon (1973) and Shaw (1973) – often re-

1. Department of Applied Informatics, University of Macedonia, Economic and Social Sciences, 34 Solonos street, P.O. 54644, Thessaloniki, Greece - email: adamant@uom.gr

ferred to as the "McKinnon-Shaw" hypothesis contend that financial liberalization in the form of an appropriate rate of return on real cash balances is a vehicle of promoting economic growth. The essential tenet of this hypothesis is that a low or negative real interest rate will discourage saving. This will reduce the availability of loanable funds for investment which in turn, will lower the rate of economic growth. Thus, the "McKinnon - Shaw" model posits that a more liberalized financial system will induce an increase in saving and investment and therefore, promote economic growth.

The endogenous growth theory has reached to similar conclusions with the McKinnon-Shaw hypothesis by explicitly modelling the services provided by financial intermediaries such as risk-sharing and liquidity provision. This theory also suggests that financial intermediation has a positive effect on steady-state growth (Greenwood and Jovanovic, 1990; Shan et al., 2001), while the government intervention in the financial system has a negative effect on economic growth (King and Levine, 1993b).

Pagano (1993) suggests three ways in which the development of financial sector might affect economic growth under the basic endogenous growth model. First, it can increase the productivity of investments. Second, an efficient financial sector reduces transaction costs and thus increases the share of savings channelled into productive investments. An efficient financial sector improves the liquidity of investments. Third, financial sector development can either promote or decline savings.

Many models emphasize that well-functioning financial intermediaries and markets ameliorate information and transactions costs and thereby foster efficient resource allocation and hence faster long-run growth (Greenwood and Jovanovic, 1990; Bencivenga and Smith, 1991; Bencivenga, Smith and Starr, 1996; King and Levine, 1993a).

In the models of Levine (1991) and Saint-Paul (1992) financial markets improve firm efficiency by eliminating the premature liquidation of firm capital, enhancing the quality of investments and therefore increasing the economic growth. Enhanced stock market liquidity reduces the disincentives for investing in long-duration and higher-return projects, since investors can easily sell their stake in the project before it matures, and is expected to boost productivity growth (Bencivenga et al., 1996).

During liquidity shocks, investors can sell their shares to another agent. Financial markets may also promote growth by increasing the proportion of resources allocated to firms. Through the diversification of productivity risk, even risk-averse investors can invest in firms. Portfolio diversification, through the stock market, may have an additional growth effect by encouraging specialization of production (Saint-Paul, 1992).

Saint-Paul (1992) develops a model where financial markets affect technological choice. In this model, agents can choose between two technologies: One technology is highly flexible and allows productive diversification, but has low productivity; the other is rigid, more specialized, and more productive. Financial markets, in contrast, allow individuals to hold a diversified portfolio to insure themselves against negative demand shocks and, at the same time, to choose the more productive technology.

Under Saint-Paul's (1992) model, productivity growth is achieved through a broader division of labour and specialization of enterprises. Specialization, however, carries risk. Financial intermediaries support specialization by permitting investors to hedge with a diversified portfolio. Specialization in the absence of a properly functioning financial sector, however, may be too risky individual investor. If it is, financing for efficiency improving projects dries up.

King and Levine (1993b) employ an endogenous growth model in which the financial intermediaries obtain information about the quality of individual projects that is not readily available to private investors and public markets. This information advantage enables financial intermediaries to fund innovative products and productive processes, thereby inducing economic growth. Levine (1997) proposed that financial development promotes economic growth through the two 'channels' of capital accumulation and technological innovation, while King and Levine (1993b) have identified innovation as the main channel of transmission between finance and growth. Financial markets evaluate the potential innovative projects, and finance the most promising ones through efficient resource allocation.

The issue of causal relationship between financial development and economic growth has been an intensive subject of interest for many theoretical and empirical studies. Therefore, this study tries to fill the theoretical and empirical gaps created by the different economic school of thoughts related to the impact of financial development on economic growth for a developed European Union member-state such as Ireland. Ireland consists one of the most important developed countries of European Union characterized by a high rate of economic growth, a constant monetary and fiscal economic policy and very low inflation and unemployment rates, a healthy and competitive economy avoiding the negative effects of financial crisis in an unstable economic environment.

The model hypothesis predicts that economic growth facilitates financial market development taking into account the positive effect of industrial production index on economic growth.

This study has two objectives:

- To apply Granger causality test based on a vector error correction model in order to examine the causal relationships between the examined variables taking into Johansen cointegration analysis
- To examine the effect of stock and credit market development on economic growth taking into account the positive effect of industrial production index on economic growth.

The remainder of the paper proceeds as follows:

Initially the data and the specification of the multivariate VAR model are described. For this purpose stationarity test and Johansen cointegration analysis are examined taking into account the estimation of vector error correction model. Finally, Granger causality test is applied in order to find the direction of causality between the examined variables of the estimated model. The empirical results are presented analytically and some discussion issues resulted from this empirical study are developed shortly, while the final conclusions are summarized relatively.

## 2. Data and methology

In this study the method of vector autoregressive model (VAR) is adopted to estimate the effects of stock and credit market development on economic growth through the effect of industrial production. The use of this methodology predicts the cumulative effects taking into account the dynamic response among economic growth and the other examined variables Pereira and Hu (2000).

In order to test the causal relationships, the following multivariate model is to be estimated

$$GDP = f\,(SM, BC, IND) \quad (1)$$

where

GDP is the gross domestic product,
SM is the general stock market index,
BC are the domestic bank credits to private sector,
IND is the industrial production index.

Following the empirical studies of King and Levine (1993a), Vazakidis and Adamopoulos (2009b,d) the variable of economic growth (GDP) is measured by the rate of change of real GDP, while the credit market development is expressed by the domestic bank credits to private sector (BC) as a percentage of GDP.

This measure has a basic advantage from any other monetary aggregate as a proxy for credit market development. Although it excludes bank credits to the public sector, it represents more accurately the role of financial intermediaries in channeling funds to private market participants (Levine et al., 2000; Vazakidis and Adamopoulos, 2009a).

The general stock market index is used as a proxy for the stock market development. The general stock market index (SM) expresses better the stock exchange market, while the industrial production index (IND) measures the growth of industrial sector and its effect on economic growth (Katsouli, 2003; Nieuwerburgh et al., 2005; Shan, 2005; Vazakidis, 2006; Vazakidis and Adamopoulos, 2009b; Vazakidis and Adamopoulos, 2009c). The data that are used in this analysis are annual covering the period 1965-2007 for Ireland, regarding 2000 as a base year. All time series data are expressed in their levels and are obtained from *International Financial Statistics,* (International Monetary Fund, 2007). The linear model selected as the better for statistical estimations than a logarithmic one. The tested results of the logarithmic model proved to be statistical inferior.

**Unit root tests:** Augmented Dickey- Fuller unit root tests are calculated for individual series to provide evidence as to whether the variables are stationary and integrated of the same order. Augmented Dickey-Fuller (ADF) test involves the estimation one of the following equations respectively:

$$\Delta X_t = \delta\, X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t \quad (2)$$

$$\Delta X_t = \alpha_0 + \delta\, X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t \quad (3)$$

$$\Delta X_t = \alpha_0 + \alpha_1\, t + \delta\, X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \varepsilon_t \quad (4)$$

The additional lagged terms are included to ensure that the errors are uncorrelated. The maximum lag length begins with 3 lags and proceeds down to the appropriate lag by examining the AIC and SC information criteria.

The null hypothesis is that the variable $X_t$ is a non-stationary series ($H_0$: $\delta$=0) and is rejected when $\delta$ is significantly negative (Ha: $\delta$<0). If the calculated ADF statistic is higher than McKinnon's critical values, then the null hypothesis ($H_0$) is not rejected and the series is non-stationary or not integrated of order zero I(0). Alternatively, rejection of the null hypothesis implies stationarity (Dickey and Fuller, 1979).

In order to find the proper structure of the ADF equations, in terms of the inclusion in the equations of an intercept ($\alpha_0$) and a trend (t) and in terms of how many extra augmented lagged terms to include in the ADF equations, for eliminating possible autocorrelation in the disturbances, the minimum values of Akaike's (1973) information criterion (AIC) and Schwarz's (1978) criterion (SC) based on the usual Lagrange multiplier LM(1) test were employed. The Eviews 4.1 (2000) software package which is used to conduct the ADF tests, reports the simulated critical values based on response surfaces.

The results of the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests for each variable appear in Table 1. If the time series (variables) are non-stationary in their levels, they can be integrated with integration of order 1, when their first differences are stationary.

**Cointegration test:** Since it has been determined that the variables under examination are integrated of order 1, then the cointegration test is performed. The testing hypothesis is the null of non-cointegration against the alternative that is the existence of cointegration using the Johansen maximum likelihood procedure (Johansen and Juselious, 1990; 1992).

Johansen (1988) and Johansen and Juselius (1990) propose two test statistics for testing the number of cointegrated vectors (or the rank of Π): the trace ($\lambda_{trace}$) and the maximum eigenvalue ($\lambda_{max}$) statistics. The likelihood ratio statistic (LR) for the trace test ($\lambda_{trace}$) as suggested by Johansen (1988) is

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{p} \ln(1-\hat{\lambda}_i) \tag{5}$$

where $\hat{\lambda}_i$ is the largest estimated value of ith characteristic root (eigenvalue) obtained from the estimated Π matrix, r = 0, 1, 2,…….p-1, and T is the number of usable observations.

The $\lambda_{trace}$ statistic tests the null hypothesis that the number of distinct characteristic roots is less than or equal to *r* (where *r* is 0, 1 or 2) against the general alternative. In this statistic $\lambda_{trace}$ will be small when the values of the characteristic roots are closer to zero (and its value will be large in relation to the values of the characteristic roots which are further from zero).

Alternatively, the maximum eigenvalue ($\lambda_{max}$) statistic as suggested by Johansen is

$$\lambda_{max}(r, r+1) = -T \ln(1-\hat{\lambda}_{r+1}) \tag{6}$$

The $\lambda_{max}$ statistic tests the null hypothesis that the number of r cointegrated vectors is *r* against the alternative of *(r+1)* cointegrated vectors. Thus, the null hypothesis r=0 is tested against the alternative that r=1, r=1 against the alternative r=2, and so forth. If the estimated value of the characteristic root is close to zero, then the $\lambda_{max}$ will be small.

It is well known that Johansen's cointegration tests are very sensitive to the choice of lag length. Firstly, a VAR model is fitted to the time series data in order to find an appropriate lag structure. The Schwarz Criterion (SC) and the likelihood ratio (LR) test are used to select the number of lags required in the cointegration test and suggested that the value p=3 is the appropriate specification for the order of VAR model for Ireland. Table 2 presents the results from the Johansen (1988) and Johansen and Juselius (1990) cointegration test.

**Vector error correction model:** Since the variables included in the VAR model are found to be cointegrated, the next step is to specify and estimate a vector error correction model (VECM) including the error correction term to investigate dynamic behaviour of the model. Once the equilibrium conditions are imposed, the VEC model describes how the examined model is adjusting in each time period towards its long-run equilibrium state.

The dynamic specification of the model allows the deletion of the insignificant variables, while the error correction term is retained. The size of the error correction term indicates the speed of adjustment of any disequilibrium towards a long-run equilibrium state (Engle and Granger, 1987). The error-correction model with the computed t-values of the regression coefficients in parentheses is reported in Table 3. The final form of the Error-Correction Model (ECM) was selected according to the *general to specific* methodology suggested by Hendry (Hendry and Richard, 1983; Maddala, 1992).

The general form of the vector error correction model (VECM) is the following one:

$$\Delta GDP = \beta_0 + \sum_{i}^{n} \beta_1 \Delta GDP_{t-i} + \sum_{i}^{n} \beta_2 \Delta BC_{t-i} + \sum_{i}^{n} \beta_3 \Delta SM_{t-i} + \sum_{i}^{n} \beta_4 \Delta IND_{t-i} + \lambda EC_{t-i} + \varepsilon_t \qquad (7)$$

where Δ is the first difference operator, $EC_{t-1}$ is the error correction term lagged one period, λ is the short-run coefficient of the error correction term ($-1<\lambda<0$), $\varepsilon_t$ is the white noise term.

**Granger causality tests:** Granger causality is used for testing the long-run relationship between financial development and economic growth. The Granger procedure is selected because it consists the more powerful and simpler way of testing causal relationship (Granger, 1986). The following bivariate model is estimated:

$$Y_t = a_{10} + \sum_{j=1}^{k} a_{1j} Y_{t-j} + \sum_{j=1}^{k} \beta_{1j} X_{t-j} + u_t \qquad (8)$$

$$X_t = a_{20} + \sum a_{2j} X_{t-j} + \sum \beta_{2j} Y_{t-j} + u_t \qquad (9)$$

where $Y_t$ is the dependent and $X_t$ is the explanatory variable and $u_t$ is the white noise error term in (8), while $X_t$ is the dependent and $Y_t$ is the explanatory variable in (9).

The hypotheses in this test may be formed as follows:

$H_0$: X does not Granger cause Y, i.e. $\{\alpha_{11}, \alpha_{12}, \ldots \alpha_{1k}\}=0$, if $F_c <$ critical value of F

$H_a$: X does Granger cause Y, i.e. $\{\alpha_{11}, \alpha_{12}, \ldots \alpha_{1k}\} \neq 0$, if $F_c >$ critical value of F. (10)

and

$H_0$: Y does not Granger cause X, i.e. $\{\beta_{21}, \beta_{22}, \ldots \beta_{2k}\}=0$, if $F_c <$ critical value of F.

$H_a$: Y does Granger cause X, i.e. $\{\beta_{21}, \beta_{22}, \ldots \beta_{2k}\} \neq 0$, if $F_c >$ critical value of F. (11)

(Katos, 2004, p. 1043).

In order to test the above hypotheses the usual Wald F-statistic test is utilised, which has the following form

$$F = \frac{(RSS_R - RSS_U)/q}{RSS_U/(T-2q-1)}$$

where $RSS_U$= is the sum of squared residuals from the complete (unrestricted) equation,

$RSS_R$= the sum of squared residuals from the equation under the assumption that a set of variables is redundant, when the restrictions are imposed, (restricted equation)

T = the sample size and q = is the lag length.

Examining this model the following cases can be distinguished

1. If $\{\alpha_{11}, \alpha_{12}, \ldots \alpha_{1k}\} \neq 0$ and $\{\beta_{21}, \beta_{22}, \ldots \beta_{2k}\} = 0$, there exists a unidirectional causality from X to Y, denoted as X→Y
2. If $\{\alpha_{11}, \alpha_{12}, \ldots \alpha_{1k}\} = 0$ and $\{\beta_{21}, \beta_{22}, \ldots \beta_{2k}\} \neq 0$, there exists a unidirectional causality from Y to X, denoted as Y→X
3. If $\{\alpha_{11}, \alpha_{12}, \ldots \alpha_{1k}\} \neq 0$ and $\{\beta_{21}, \beta_{22}, \ldots \beta_{2k}\} \neq 0$, there exists a bilateral causality between Y and X, denoted as X↔Y.

(Seddighi et al., 2000, p. 310).

The validity of the test depends on the order of the VAR model and on the stationarity or not of the variables. The validity of the test is reduced if the variables involved are non-stationary (Geweke, 1984). The results related to the existence of Granger causal relationships among economic growth, stock market development, credit market development and productivity appear in Table 4.

## 3. Empirical results

The observed t-statistics fail to reject the null hypothesis of the presence of a unit root for all variables in their levels confirming that they are non-stationary at 1% and 5% levels of significance (Table 1). However, the results of the DF and ADF tests show that the null hypothesis of the presence of a unit root is rejected for all variables when they are transformed into their first differences (Table 1). Therefore, all series that are used for the estimation of ADF equations are non-stationary in their levels, but stationary in their first differences (integrated of order one I(1)). Moreover, the LM(1) test shows that there is no correlation in the disturbance terms for all variables in their first differences. These variables can be cointegrated as well, if there are one or more linear combinations among the variables that are stationary.

The number of statistically significant cointegration vectors for Ireland is equal to 1 (Table 2) and is the following:

$$GDP_t = 1.15\ SM_t + 0.05\ BC_t + 0.42\ IND_t \quad (12)$$

The cointegration vector of the model of Ireland has rank r<n (n=3). The process of estimating the rank r is related with the assessment of eigenvalues, which are the following for Ireland: $\hat{\lambda}_1 = 0.63$, $\hat{\lambda}_2 = 0.20$, $\hat{\lambda}_3 = 0.07$, $\hat{\lambda}_4 = 0.02$.

For Ireland, critical values for the trace statistic defined by (6) are 39.89 and 45.58 for Ho: r = 0 and 24.31 and 29.75 for Ho: $r \leq 1$, 12.53 and 16.31 for Ho: $r \leq 2$ at the significance level 5% and 1% respectively as reported by Osterwald-Lenum (1992), while critical values for the maximum eigenvalue test statistic defined by (7) are 23.80 and 28.82 for Ho: r = 0, 17.89 and 22.99 for Ho: $r \leq 1$, 11.44 and 15.69 for Ho: $r \leq 2$ (Table 2).

It is obvious from the above cointegrated vector that stock market development, credit market development and industrial production index have a positive effect on economic growth in the long-run. According to the signs of the vector cointegration components and based on the basis of economic theory the above relationship can be used as an error correction mechanism in a VAR model for Ireland respectively.

The results of the estimated vector error correction model suggested that a short-run increase of stock market index per 1% induces an increase of economic growth per 0.08% in Ireland and also an increase of bank lending per 1% induces an increase of economic growth per 0.007% in Ireland, while an increase of productivity per 1% induces an increase of economic growth per 0.2% in Ireland) (Table 3).

The estimated coefficient of $EC_{t-1}$ is statistically significant and has a negative sign, which confirms that there is not any problem in the long-run equilibrium relation between the independent and dependent variables in 5% level of significance, but its relative value (-0.02) for Ireland shows a satisfactory rate of convergence to the equilibrium state per period (Table 3).

In order to proceed to the Granger causality test the number of appropriate time lags was selected in accordance with the VAR model. According to Granger causality tests there is a bilateral causality between stock market development and productivity, a bilateral causality between stock market development and economic growth, a unidirectional causal relationship between economic growth and credit market development with direction from economic growth to credit market development, a unidirectional causal relationship between productivity and credit market development with direction from productivity to credit market development, and a unidirectional causal relationship between stock and credit market development with direction from credit market development to stock market development (Table 4). Therefore, it can be inferred that a well functioning financial system accelerates economic growth taking into account the positive effect of industrial production growth.

## 4. Discussion

The model of financial system is mainly characterized by the effect of stock market development and credit market development. However, credit market development is determined by the banking growth through the size of bank lending directed to private sector at times of low inflation rates. Stock market development is determined by the trend of general stock market index. The significance of the empirical results is dependent on the variables under estimation.

The results of this paper are consistent with the studies of Levine and Zervos (1998), Nieuwerburgh et al. (2005) and Shan (2005). Guiso et al. (2004) found that financial development has a positive effect on economic growth for 14 European Union member states including Ireland. King and Levine (1993) suggested that financial development leads to economic growth for a sample of 80 countries using a cross country analysis, while Hondroyannis et al. (2004) found a bilateral causal relationship between financial development and economic growth for Greece applying time series analysis.

The results of many empirical studies examining the relationship between financial development and economic growth differ relatively to the sample period, the examined countries, the measures of financial development and the estimation method. The direction of causal relationship between financial development and economic growth is regarded as an important issue under consideration in future empirical studies. However, more light should be shed on the comparative analysis of empirical results for the rest of European Union members-states.

## 5. Conclusions

This paper concerns the relationship between financial development and economic growth for Ireland, using annually data for the period 1965-2007. The empirical analysis suggested that the variables that determine economic growth present a unit root. Once a cointegrated relationship among relevant economic variables is established, the next issue is how these variables adjust in response to a random shock. This is an issue of the short-run disequilibrium dynamics. The short run dynamics of the model is studied by analysing how each variable in a cointegrated system responds or corrects itself to the residual or error from the cointegrating vector. This justifies the use of the term error correction mechanism. The error correction (EC) term, picks up the speed of adjustment of each variable in response to a deviation from the steady state equilibrium. The VEC specification forces the long-run behaviour of the endogenous variables to converge to their cointegrating relationships, while accommodates the short-run dynamics. The dynamic specification of the model suggests deletion of the insignificant variables while the error correction term is retained.

The results of Granger causality tests indicated that there is a bilateral causal relationship between economic growth and stock market development and a unidirectional causal relationship between economic growth and credit market development with direction from economic growth to credit market development, a unidirectional causality between credit market development and stock market development with direction from credit market development to stock market development for Ireland. Therefore, it can be inferred that stock market development has larger effect on economic growth than credit market development in Ireland.

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## Appendix

**Table 1: DF/ADF unit root tests**

| Variables | In levels | | | | | In first differences | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | lag eq_f | adf_ test stat | cr_val 1% 5% 10% | SBC AIC | LM [prob] | lag eq_f | adf_ test stat | cr_val 1% 5% 10% | SBC AIC | LM [prob] |
| GDP | (p=1) (1) | 3.20 [0.99] | -2.62 -1.94 -1.61 | -4.95 -5.04 | 0.32 [0.72] | (p=0) (1) | -3.25 [0.00] | -3.24 -3.15 -3.04 | -4.41 -4.56 | 0.32 [0.72] |
| BC | (p=0) (2) | 5.05 [1.00] | -3.59 -2.93 -2.60 | -2.45 -2.54 | 0.20 [0.81] | (p=0) (1) | -4.06 [0.01] | -3.94 -3.52 -3.19 | -2.27 -2.40 | 0.50 [0.60] |
| SM | (p=1) (1) | 1.93 [0.98] | -2.62 -1.94 -1.61 | -2.25 -2.34 | 1.66 [0.20] | (p=0) (1) | -2.95 [0.00] | -2.62 -1.94 -1.61 | -2.25 -2.29 | 0.40 [0.66] |
| IND | (p=1) (2) | 1.02 [0.91] | -2.62 -1.94 -1.61 | -4.75 -4.83 | 0.12 [0.88] | (p=0) (1) | -5.38 [0.00] | -2.66 -1.95 -1.60 | -4.24 -4.29 | 0.14 [0.86] |

Notes:
Eq_f = equation form
Cr_val = critical values
AIC = Akaike criterion
SBC = Schwarz Bayesian criterion,
LM = Langrage Multiplier test

**Table 2: Johansen and Juselious Cointegration Tests (GDP, BC, SM, IND)**

| Country | Ireland | | | |
|---|---|---|---|---|
| Testing Hypothesis | Johansen Test Statistics | | | |
| | $\lambda_{trace}$ | Cr_v 5% 1% | $\lambda_{max}$ | Cr_v 5% 1% |
| $H_0$: r = 0 and r=1 | 53.89 | 39.89 45.58 | 40.58 | 23.80 28.82 |

| | | | | |
|---|---|---|---|---|
| $H_0$: r ≤ 1 and r=2 | 13.31 | 24.31<br>29.75 | 9.31 | 17.89<br>22.99 |
| $H_0$: r ≤ 2 and r=3 | 4.00 | 12.53<br>16.31 | 3.04 | 11.44<br>15.69 |
| **Cointegrated vectors** | 1 | | 1 | |

Notes: Cr_v = critical values

**Table 3: Vector Error Correction Model**

| Independent Variable | Estimated coefficients |
|---|---|
| Constant | 0.001[0.06] |
| $\Delta GDP_{t-1}$ | 0.17[0.37] |
| $\Delta SM_{t-1}$ | 0.08[0.04] |
| $\Delta BC_{t-1}$ | 0.007[0.87] |
| $\Delta IND_{t-1}$ | 0.20[0.11] |
| $ECT_{t-1}$ | -0.02[0.002] |
| $R^2$ | 0.88 |
| DW | 2.28 |
| **Diagnostics tests** | |
| Serial Correlation | 8.53[0.003] |
| Functional Form | 2.48[0.11] |
| Normality | 76.23[0.00] |
| Heteroskedasticity | 0.74[0.38] |

Notes:
[ ]= Denotes the probability levels,
Δ= Denotes the first differences of the variables.
$R^2$ = Coefficient of multiple determinations adjusted for the degrees of freedom (d.f),
DW= Durbin-Watson statistic

**Table 4: Granger causality tests**

| Countries | Dependent variable | Independent variable | F1 | F2 | Causal relations |
|---|---|---|---|---|---|
| Ireland | GDP | SM | 8.30 | 16.24 | GDP ⇔ SM |
| | | BC | 0.39 | 3.96 | GDP ⇒ BC |
| | | IND | 2.85 | 2.01 | No causality |
| | SM | BC | 5.99 | 0.86 | BC ⇒ SM |
| | | IND | 5.69 | 3.95 | SM ⇔ IND |
| | BC | IND | 3.40 | 0.22 | IND ⇒ BC |

Critical values: 3.25 for Ireland
Estimated lags = 3