The Main Determinants of Economic Growth:
An Empirical Investigation with
Granger Causality Analysis for Greece

by
Nikolaos Dritsakis[1]
Erotokritos Varelas[2]
Antonios Adamopoulos[1]

Abstract

This paper examines empirically the causal relationship among exports, gross capital formation, foreign direct investments and economic growth using a multivariate autoregressive Var model for Greece over the period 1960-2002. The results of cointegration test suggested that there is only one cointegrated vector between the examined variables, while Granger causality tests showed that there is a unidirectional causal relationship between exports and gross fixed capital formation and also there is a unidirectional causal relationship between foreign direct investments and economic growth.

Keywords*: Exports, investments, economic growth, Granger causality

JEL classification: O10, C22.

1. Introduction

There is a large part of economic theory analyzing the causal relationship between exports and economic growth. Certainly, since exports consist one of the main determinants of economic growth, an increase of exports contributes to an increase of economic growth. However, there are also some other indirect factors, which affect the causal relationship between exports and economic growth.

Ricardo in his study in 1817, notes that trade facilitates products output with a comparative advantage in a country resulting to a higher level of national wealth. Recent empirical studies are less convincing relating to the causal relationship between exports and economic growth, because the main interest focuses on which methods are used for economic growth through trade expansion.

The basic a priori argument is that exports expansion contributes to economic growth increasing the percentage of gross fixed capital formation and productivity factor.

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[1] University of Macedonia, Department of Applied Informatics
[2] University of Macedonia, Department of Economics

If there are incentives for investments growth and technology advance the marginal productivity factors are expected to be higher in exporting sector than the remain economic ones.

Since the ratio of exports to gross domestic product denotes an open economy index, a higher ratio indicates a relatively higher open economy. On the other hand a lower ratio of exports to gross domestic product reflects to a limited trade policy and a more close economy.

Solow (1956) in his study suggests that the larger the investment and saving rate are the more cumulative capital per worker is produced.

Tyler (1981) examining a sample of 55 developing countries resulted that exports and investments are the main determinants of economic growth.

New growth theories stress the importance of investments, human and physical capital in the long-run economic growth. The policies, which affect the level of growth and the investment efficiency, determine the long-run economic growth.

Theoretically, the gross capital formation affects the economic growth either increasing the physical capital stock in domestic economy directly, Plossner (1992) or promoting the technology indirectly, Levine and Renelt (1992).

Recently, many empirical studies emphasized in diversified role of private and public investments in growth process. The public investments on infrastructure, in extent in which are proved to be complementary to the private investments, can increase the marginal product of the private capital, augmenting the growth rate of a domestic economy.

Khan and Kumar (1997) supported that the effects of private and public investments on economic growth differ significantly, with private investment to be more productive than public one. Knight, Loyaza and Villanueva (1993) and Nelson and Singh (1994) confirmed that public investments on infrastructure have an important positive effect on economic growth over the period 1980-1990. Easterly and Rebelo (1993) evaluated that public investments on transportation and communications are positively correlated to economic growth, while there were negative effects of public investments of state-owned businesses on economic growth.

The effect of foreign direct investment on economic growth is dependent on the level of technological advance of a host economy, the economic stability, the state investment policy and the degree of openness. FDI inflows can affect capital formation because they are a source of financing and capital formation is one of the prime determinants of economic growth. Inward FDI may increase a host's country productivity and change its comparative advantage. If productivity growth were export biased then FDI would affect both growth and exports. A host's country institutional characteristics such as its legal system, enforcement of property rights, could influence simultaneously the extent of FDI and inflows and capital formation in that country.

Blomstoerm, Lipsey, Zejan (1994) found a unidirectional causal relationship between FDI inflows as a percentage of GDP and the growth of per capita GDP for all developed countries over the period 1960-1985.

O Zhang (1999) examines the causal relationship between foreign direct investment and economic growth with Granger causality analysis for 10 Asian countries. The results of this study suggested that there is a unidirectional causality between foreign direct investment and economic growth with direction from FDI to GDP in Hong Kong,

Japan, Singapore, Taiwan, a unidirectional causality between exports and economic growth with direction from economic growth to exports for Malaysia and Thailand, also there is a bilateral causal relationship between FDI and GDP for Kina and Indonesia, while there is no causality for Korea and Philippines.

Borensztein, De Gregorio and Lee (1998) highlight the role of FDI as an important vehicle of economic growth only in the case that there is a sufficient absorptive capability in the host economy. This capability is dependent on the achievement of a minimum threshold of human capital.

Moudatsou (2003) suggested that FDI inflows have a positive effect on economic growth in European Union countries both directly and indirectly through trade reinforcement over the period 1980-1996.

In the empirical analysis of this paper we use annual data for the period 1960-2002 for all variables. The remainder of the paper proceeds as follows: Section 2 describes the data and the specification of the multivariate VAR model that is used. Section 3 employs with Dickey-Fuller tests and examines the data stationarity. Section 4 presents the cointegration analysis and Johansen cointegration test. Section 5 analyses the estimations of error correction models, while section 6 summarizes the Granger causality tests. Finally, section 7 provides the final conclusions of this paper.

2. Data and specification of the model

In this study the method of vector autoregressive model (VAR) is adopted to estimate the effects of economic growth on exports, gross capital formation and foreign direct investments. The use of this methodology let us recognize the cumulative effects taking into acount the dynamic response between economic growth and the other variables (Pereira and Hu 2000).

In time series analysis the appropriate differential is significant because the most algorithms estimations fail when time series are not stationary. Also efficient benefits may exist in their 1st differences. In small samples the distributions of the coefficients (estimators) may be improved by the estimation of (VAR) vector autoregressive model in their 1st differences (Hamilton 1994). Also, the use of 1st differences in econometric studies facilitates the results explanation (interpretation), since the first differences of logarithms of initial variables represent the rate of change of these variables (Dritsakis 2003).

In order to test the causal relationships discussed above (introduction) we specify the following multivariate VAR model:

$$GDPN = f(EXPG, INVG, FDIG) \quad (1)$$

where:

$$GDPN = \frac{GDP}{N} \quad per\ capita\ GDP$$

$EXPG = \dfrac{EXP}{GDP}$ *the ratio of exports to GDP*

$INVG = \dfrac{INV}{GDP}$ *the ratio of gross capital formation to GDP*

$FDIG = \dfrac{FDI}{GDP}$ *the ratio of foreign direct investments to GDP*

N = population

The variable of economic growth (GDP) is measured by real GDP adjusted by GDP deflator. The variable of gross fixed capital formation (INV) adjusted by GDP deflator. The variable of exports is measured by real revenues of exports and is obtained by adjusting the nominal price of exports based on the database of International Financial Statistics (IFS). The variable of FDI is measured by foreign direct investments adjusted by GDP deflator. The data that are used in this analysis are annual, cover the period 1960-2002 regarding 1996 as a base year and are obtained from International Monetary Fund (IMF).

All data are expressed in logarithms in order to include the proliferative effect of time series and are symbolized with the letter L preceding each variable name. If these variables share a common stochastic trend and their first differences are stationary, then they can be cointegrated.

Economic theory scarcely provides some guidance for which variables appear to have a stochastic trend and when these trends are common among the examined variables as well. For the analysis of the multivariate time series that include stochastic trends, the Augmented Dickey-Fuller (1979) (ADF) unit root test is used for the estimation of individual time series with intention to provide evidence for when the variables are integrated. This is followed by multivariate cointegration analysis.

3. Unit root test

The cointegration test among the variables that are used in the above model requires previously the test for the existence of unit root for each variable and especially, for per capita gross domestic product (GDP) and the ratio of exports to GDP, the ratio of gross fixed capital formation to GDP, the ratio of foreign direct investment to GDP, using the Augmented Dickey-Fuller (ADF) (1979) test on the following regression:

$$\Delta X_t = \delta_0 + \delta_1\, t + \delta_2\, X_{t\text{-}1} + \sum_{i=1}^{k}\alpha_i \Delta X_{t-i} + u_t \quad (2)$$

The ADF regression tests for the existence of unit root of X_t, namely in the logarithm of all model variables at time t. The variable ΔX_{t-i} expresses the first differences with k lags and final u_t is the variable that adjusts the errors of autocorrelation. The coefficients δ_0, δ_1, δ_2, and α_i are being estimated. The null and the alternative hypothesis for the existence of unit root in variable X_t is:

$$H_o : \delta_2 = 0 \qquad H_\varepsilon : \delta_2 < 0$$

The results of these tests appear in Table 1. The minimum values of the Akaike (AIC) and Schwartz (SC) statistics have provided the better structure of the ADF equations as well as the relative numbers of time lags, under the indication "Lag". As far as the autocorrelation disturbance term test is concerned, the Lagrange Multiplier LM(1) test has been used. The MFIT 4.0 (1997) econometric package that was used for the estimation of ADF test, provides us the simulated critical values.

Table 1 – DF/ADF unit root tests

Variables	In their levels			1st differences		
	Lag	Test statistic (DF/ADF)	LM(1)	Lag	Test statistic (DF/ADF)	LM(1)
LGDPN	1	-1.2597	4.7667 [0.029]	0	-9.2408	3.6308 [0.057]
LEXPG	0	-1.7145	2.6045 [0.107]	0	-5.4241	0.3377 [0.561]
LINVG	1	-2.5541	0.0164 [0.898]	1	-4.6952	0.7972 [0.372]
LFDIG	0	-1.6875	0.1020 [0.749]	1	-8.5286	0.11454 [0.735]

Critical value: -3.4547

The results of Table 1 suggest that the null hypothesis of a unit root in the time series cannot be rejected at a 5% level of significance in variable levels. Therefore, no time series appear to be stationary in variable levels. However, when the logarithms of the time series are transformed into their first differences, they become stationary and consequently the related variables can be characterized integrated of order one, I(1). Moreover, for all variables the LM(1) test in their first differences show that there is no correlation in the disturbance terms.

4. Cointegration and Johansen test

If the time series (variables) are non-stationary in their levels, they can be integrated with integration order 1, when their first differences are stationary. These

variables can be cointegrated as well if there are one or more linear combinations among the variables that are stationary. If these variables are being cointegrated then there is a constant long-run linear relationship among them.

Since it has been determined that the variables under examination are integrated of order 1, 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 (1988) maximum likelihood procedure Johansen and Juselious (1990, 1992). An autoregressive coefficient is used for the modelling of each variable (that is regarded as endogenous) as a function of all lagged endogenous variables of the model.

Given the fact that in order to apply the Johansen technique a sufficient number of time lags is required, we have followed the relative procedure, which is based on the calculation LR (Likelihood Ratio) test statistic (Sims, 1980). The results showed that the value $\rho=3$ is the appropriate specification for the above relationship. Further on we determine the cointegration vectors of the model, under the condition that matrix Π has an order r<n (n=4). The procedure of calculating order r is related to the estimation of the characteristic roots (eigenvalues), which are the following:

Table 2 - Johansen and Juselious Cointegration Tests

Variables LGDPN, LEXPG, LINVG, LFDIG

Maximum lag in VAR = 3

$\hat{\lambda}_1 = 0.55810$ $\hat{\lambda}_2 = 0.41975$ $\hat{\lambda}_3 = 0.27780$ $\hat{\lambda}_4 = 0.14297$

Eigenvalues			Critical Values	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r = 1	31.8501	31.7900	29.1300
r = 1	r = 2	21.2273	25.4200	23.1000

Trace Statistic			Critical Values	
Null	Alternative	Eigenvalue	95%	90%
r = 0	r > 0	71.7872	63.0000	59.1600
r ≤ 1	r > 1	39.1371	42.3400	39.3400

The results that appear in Table 2 suggest that the number of statistically significant cointegration vectors is equal to 1 and is the following one:

LGDPN = 0.23883LEXPG + 0.46903LINVG + 0.46774LFDIG

The coefficients' estimates in equilibrium relationships whch are essentially the long-run estimated elasticities relative to economic growth suggest that gross domestic product, exports, and foreign direct investments are inelastic to per capita GDP. According to the signs of the vector cointegration components and based on the basis of economic theory the above relationships can be used as an error correction mechanism in a VAR model.

5. A VAR model with an error correction mechanism

After determining that the logarithms of the model variables are cointegrated, we must estimate then a VAR model in which we shall include a mechanism of error correction model (MEC). The error correction model arises from the long-run cointegration relationship and has the following form:

$\Delta LGDPN_t$ = lagged ($\Delta LGDPN_t$, $\Delta LEXPG_t$, $\Delta LINVG_t$, $\Delta LFDIG_t$) + λ u_{t-1} + V_t (3)

where Δ is reported to first differences of variables
u_{t-1} are the estimated residuals from the cointegrated regression (long-run relationship) and represents the deviation from the equilibrium in time period t.

$-1 < \lambda < 0$ short-run parameter

V_t white noise disturbance term.

One difficulty, which a researcher faces with the estimation of an autoregressive VAR model, is the appropriate specification of the model. Specially, the researcher has to decide which deterministic components should be included and which number of lags should be used as well.

Since arbitrarily selected specifications of the autoregressive VAR model are possible to produce unreliable results, we use the selection criterion of a database model in order to specify the autoregressive VAR model for Greek economy. Among the different selection criteria of the model the one that was suggested by Schwartz (1978), known as Schwartz Bayesian information criterion seems to outperform other alternative solutions (Mills and Prasad 1992). Therefore, the specification of the autoregressive VAR model is based on the Schwartz Bayesian information criterion. Also, first order specification of the model VAR (1) is selected with a constant and a time trend.

The final form of the Error-Correction Model was selected according to the approach suggested by Hendry (Maddala 1992). The initial order of time lag for the

model is 2 because it is large enough to enclose the system's short-run dynamic. We also apply a number of diagnostic tests on the residuals of the model. We apply the Lagrange test for the residuals' autocorrelation, the heteroscedasticity test and the Bera-Jarque normality test. We also test the functional form of the model according to the Ramsey's Reset test. Error correction model is appeared in table 3.

Table 3. Error Correction Model

$$\Delta LGDPN_t = \ 0.00166 + 0.03324\Delta LEXP_{t-1} + 0.0993\ \Delta LINVG_{t-2} + 0.03158\Delta LFDIG_{t-1}$$

$$\qquad\qquad (0.3444)\quad (0.6400) \qquad\quad (1.7021) \qquad\qquad\quad (1.9501)$$

$$\qquad\qquad [0.733]\quad\ [0.526] \qquad\quad\ [0.098] \qquad\qquad\quad\ [0.059]$$

$$\qquad\qquad - 0.48911\ u_{t-1}$$

$$\qquad\qquad\ (-3.5030)$$

$$\qquad\qquad\quad [0.001]$$

$$\overline{R}^2 = 0.4054 \qquad\qquad F(4,34) = 7.4809 \qquad DW = 2.0946$$

$$\qquad\qquad\qquad\qquad\qquad [0.000]$$

$$A:X^2[1] = 0.2796 \qquad\qquad B:X^2[1] = 0.0082$$

$$\qquad\ [0.597] \qquad\qquad\qquad\qquad\ [0.927]$$

$$C:X^2[2] = 2.4048 \qquad\qquad D:X^2[1] = 2.3628$$

$$\qquad\ [0.300] \qquad\qquad\qquad\qquad\ [0.124]$$

Notes:

Δ: Denotes the first differences of the variables.

$\overline{R}^2$ = Coefficient of multiple determination adjusted for the degrees of freedom (d.f).

DW= Durbin-Watson statistic.

F(n, m)= F-statistic with n,m d.f respectively.

A: X^2(n) Lagrange multiplier test of residual serial correlation, following x^2 distribution with n d.f.

B: X^2(n) Ramsey's Reset test for the functional form of the model, following x^2 distribution with n d.f.

C: X^2(n): Normality test based on a test of skewness and kurtosis of residuals, following x^2 distr with n d.f.

D: X^2(n): Heteroscedasticity test, following x^2 distribution

( )= We denote the t-ratio for the corresponding estimated regression coefficient.

[ ]= We denote prob. levels.

We do not reject the estimations, which are based on the results of table 3 according to the statistical and diagnostic tests in 10% level of significance (except the variable of exports). The percentage of the total variation of the dependent variable that is described in our model is high enough (40%). The Error-Correction Term is statistically significant and has a negative sign, which confirms that the long-run equilibrium relation between the independent and dependent variablesin 5% level of significance. Their relative price denotes 0.48912 (-3.5030) a satisfactory convergence rate to equilibrium point per period.

From the results of table 3 we can infer that in the long-run an increase of 1% on ratio of exports to GDP will lead to an increase of 0.033% on per capita GDP, an increase

of 1% on the ratio of gross fixed capital formation to GDP will lead to an increase of 0.09% on per capita GDP, while increase of 1% on ratio of foreign direct investment to GDP will lead to an increase of 0.031% on per capita GDP.

6. Granger causality test

The model that was estimated in the previous section was used in order to examine the Granger causal relationships between the variables under examination. As a testing criterion the F statistic was used. With the F statistic the hypothesis of statistic significance of specific groups of explanatory variables was tested for each separate function. The results relating to the existence of Granger causal relationships between the variables: the per capita GDP, the ratio of exports to GDP, the ratio of gross fixed capital formation to GDP, the ratio of foreign direct investment to GDP appear in Table 4.

Table 4 – Granger causality tests

Dependent variable	Testing hypothesis	F1	F2
LGDPN	LEXPG there is no causality (LGDPN $\neq$ LEXPG)	0.323	2.480
	LINVG there is no causality (LGDPN $\neq$ LINVG)	2.894	0.457
	LFDIG there is a unidirectional relationship (LGDPN $\Leftarrow$ LFDIG)	6.171	0.740
LEXPG	LINVG there is a unidirectional relationship (LEXPG $\Leftarrow$ LINVG)	6.468	1.970
	LFDIG there is a unidirectional relationship (LEXPG $\Rightarrow$ LFDIG)	1.986	3.652
LINVG	LFDIG there is no causality (LINVG $\neq$ LFDIG)	0.007	0.100

Critical value: 3,07

From the results of table 4 we can infer that:

There is a unidirectional causal relationship between the ratio of foreign direct investments to GDP and the per capita GDP with direction from foreign direct investments to per capita GDP, a unidirectional causal relationship between the ratio of exports to GDP and the ratio of gross fixed capital formation to GDP with direction from gross fixed capital formation to exports and final a unidirectional causal relationship between the ratio of exports to GDP and the ratio of foreign direct investments to GDP with direction from exports to foreign direct investments. Also, there is no causal relationship between the per capita GDP and the ratio of exports to GDP, between the ratio of gross fixed capital formation to GDP and the per capita GDP and between the ratio of gross fixed capital formation to GDP and the ratio of of foreign direct investments to GDP.

6. Conclusions

In this paper an effort was made in order to examine the relationship among the per capita GDP, the ratio of exports to GDP, the ratio of gross fixed capital formation to GDP, the ratio of gross fixed capital formation to GDP and the ratio of of foreign direct investments to GDP, using annual data over the period 1960-2002.

The empirical analysis suggested that the examined variables present a unit root. On this basis the Johansen cointegration test analysis was used to lead to long-run equilibrium relationships among these variables. Then the methodology of error correction model was applied to estimate the short-run and the long-run relationships. The selected cointegrated vectors gave us the appropriate error correction terms, which proved to be statistically significant at a 5% level of significance during their inclusion to the short-run dynamic equations.

Final, through Granger causality test we can infer that there is a unidirectional causal relationship between the ratio of foreign direct investments to GDP and the per capita GDP with direction from foreign direct investments to per capita GDP, between the ratio of exports to GDP and the ratio of gross fixed capital formation to GDP and between the ratio of exports to GDP and the ratio of foreign direct investments to GDP as well.

Moreover, there is no causal relationship between the per capita GDP and the ratio of exports to GDP, between the ratio of gross fixed capital formation to GDP and the per capita GDP and between the ratio of gross fixed capital formation to GDP and the ratio of foreign direct investments to GDP.

References

Akaike, H. (1973). *Information Theory and an Extension of the Maximum Likelihood Principle,* In: Petrov, B. and Csaki, F. (eds) 2nd International Symposium on Information Theory. Budapest: Akademiai Kiado.

Blomstoerm, M., Lipsey, R., Zejan, M. (1994). *What explains the growth of developing countries? Convergence of Productivity,* Oxford University Press, Oxford.

Borenstein De Gegorio, J, and Lee, J, (1998). How does foreign direct investment affect economic growth?, *Journal of International Economics*, 45, 115-135.

Dickey, D.A., & Fuller W.A. (1979). Distributions of the estimators for auto-regressive time series with a unit root, *Journal of American Statistical Association,* 74, 427 - 431.

Dritsakis, N, (2003). Hungarian macroeconomic variables – reflection on causal relationships, *Acta Oeconomica*, 53(1), 61-73.

Easterly, W., and Rebelo, S. (1993). Fiscal policy and Economic Growth: An empirical investigation, *Journal of Monetary Economics,* 32, 417-458

Granger, C. W, (1988). Some Recent Developments in a Concept of Causality, *Journal of Econometrics*, 39, 199 – 211.

Hamilton, J. D, (1994). *Time Series Analysis,* New Jersey: Princeton University Press.

International Monetray Fund (IMF) (2003). *International Financial Statistics Yearbook,* 2003, Washington DC: Various Years.

Johansen, S (1988). Statistical Analysis of Cointegration Vectors, *Journal of Economic Dynamics and Control,* 12, 231 – 254.

Johansen, S and Juselious, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for the Money, *Oxford Bulletin of Economics and Statistics, 52, 169-210.*

Johansen, S., and Juselius, K. (1992). Testing Structural Hypotheses in a Multivariate Cointegration Analysis at the Purchasing Power Parity and the Uncovered Interest Parity for the UK , *Journal of Econometrics*, 53: 211 – 244.

Knight, M., Loyaza, N., and Villanueva, D. (1993). Testing the neoclassical theory of economic growth, *IMF Staff Papers,* 40, 512-541.

Khan, M, and Kumar, M. (1997). Public and private investment and the growth process in developing countries, *Oxford Bulletin of Economics and Statistics,* 59, 69-88.

Levine, R and Renelt, D. (1992). A sensitivity analysis of cross-country growth regressions, *American Economic Review*, 82, 942-963.

Nelson, M., and Singh, R. (1994). The deficit growth connection: Some recent evidence from developing countries, *Economic Development and Cultural Change,* 43, 167-191.

Maddala, G.S. (1992). *Introduction to Econometrics*, 2nd Edition, Prentice Hall, New Jersey.

MFIT 4.0 (1997). *Quantitative Micro Software*, *Interactive Econometric Analysis*. Oxford University Press.

Mills, J. and Prasad, K., (1992). A Comparison of Model Selection Criteria, *Econometric Reviews,* 11, 201-233.

Moudatsou, A (2003). Foreign direct investment and economic growth in the European Union, *Journal of Economic Integration*,18(4), 689-707

Pereira A., & Xu, Z. (2000). Export growth and domestic performance. *Review of International Economics, 8 (1), 60-73.*

Plossner, C. (1992). The search for growth in policies for long-run economic growth, Federal Reserve Bank of Kansas City, Kansas City, MO.

Schwartz, R. (1978): Estimating the Dimension of a Model, *Annuals of Statistics, 6, 461-*

464.

Sims, C. (1980). Macroeconomics and Reality, *Econometrica,* 48, 1-48

Solow, R. (1956). A contribution to the theory of economic growth*, Quarterly Journal of Economics,* 50, 65-94.

Tyler, W. (1981). Growth and export expansion in developing countries: Some empirical Evidence, *Journal of Development Economics,* 9, 121-310.

Zhang, H (1999). FDI and economic growth: evidence from ten East Asian Economies, *Economia Internationale*, 7(4), 517-535.