Relationship Between Education and GDP Growth: A Bi-variate Causality Analysis for Greece

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Abstract. The aim of the paper is to investigate the long-run and the short-run relationship between human capital and economic growth in Greece over the period 1961-2006. The article uses bi-variate causality analysis, to study dynamics, by employing different methods of estimation. Specifically, the empirical results suggests that there is a positive relationship between education and GDPC and that Tertiary Education should be considered as exogenous variable, which implies that education contributed to economic growth in Greece during the estimation period.

1 Introduction

The economic crisis[1] combined with the restructuring of Greek educational system[2], demands the re-examination of the way that human capital is defined. Specifically, Greek economy has shown some major structural differences during the last 20 years and as a result the 67% of the labour force to occupy in the section of services, the 19% in the section of industry and only 9% in the section of agriculture (El. STAT., 2009).

This research tries to fill in the gap for Greece till 2006 and to conclude whether there are any structural differences. This paper differs from previous studies, since it is capturing the long-run and the short-run dynamics of this relationship and it's testing for its structural stability.

The purpose of this paper is to examine the long-run relationship between human capital and economic growth and the causal direction between them, measuring human capital in terms of quantity. The paper utilizes the technique of the vector error correction models. This is accomplished in four steps.

First, the stationarity properties of the data and the order of integration are tested. Second, the

Engle-Granger, the Phillips-Hansen co-integration tests and the Johansen maximum likelihood method are employed to search for co-integration in a education-real GDP per capita bi-variate model. Third, the vector error correction model is used to indicate the direction of Granger causality both in the long and short-run. Finally, the stability of the coefficients in the estimated relations is tested using Cusum and Cusumq tests.

The paper proceeds as follows. Section 2, briefly reviews the theoretical framework and previews studies. Section 3, presents the methodological issues and the data used in the empirical analysis Section 4, reports all the empirical results and section 5, contains concluding remarks and policy implications.

2 Theoretical backround and literature review

The interaction between human capital and economic growth has been an object of investigation for several decades, both in macroeconomic (Pereira and Aubyn, 2009; Odit *et al.,* 2010) and microeconomic literature[3] (Psacharopoulos, 1995; Bouaissa, 2009), (Ahmed, 2009). In a macroeconomic aspect, the above issue is tested mainly with two approaches: 1) (*neoclassical growth models)* of Solow (1956) and 2) (*endogenous growth*

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[1] Since 23/4/2010, Greece is under the supervision of the IMF (*International Monetary Fund*).
[2] All the educational levels are under revision by the lawmakers.

[3] Following the Mincerian wage equation (Mincer, 1974).

models)[4] of Romer (1990) and Lucas (1988), (Wilson and Briscoe, 2004).

The existing empirical literature examining the impact of education on economic growth deals with many issues. Those issues are: First the use of different types of variables as a proxy for human capital. Specifically, Maksymenko and Rabbani (2009) used the average years of schooling, Khalifa (2008), Pradhan (2009) and Chandra and Islamia (2010) the public educational expenditures and Asteriou and Agiomirgiannakis (2001) and Babatunde and Adefabi (2005) the enrolment rates in all levels of education[5] according to the data that were available[6].

Second the use of different methodological approaches. Researches such as Islam *et al.* (2007) and Dauda (2009) have used the multivariate approach, concerning physical capital and labor in their estimated model, on the contrary, Boldin *et al*. (2008) and Dananica and Belasku (2008) used the bi-variate model. Finally, the use of different approaches, concerning, human capital. There are two main approaches, the quality[7] (measured by life expectancy or infant mortality[8]) and the quantity approach of human capital, which is dive versed into the *'Stock Approach'*[9] and the *"flow approach"* (Asteriou and Agiomirgiannakis, 2001; Matsushita *et al*., 2006; Boldin *et al*., 2008; Dananica and Belasku, 2008; Huang *et al.,* 2009; Tsamadias and Prontzas, 2011), (Boccanfuso *et al*., 2009).

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[4] According to Aghion and Howitt (1998) the role of human capital in the endogenous growth models could be divided into two approaches 1) Nelson-Phelps approach, *"N-P Approach"* (1966) and 2) Lucas approach (1988).

[5] According to Schütt (2005) this variable is the most common representing human capital.

[6] For more details about the different variables as proxies for human capital see De Muellemeester and Rochat (1995), Loening (2004), Teixeira and Fortuna (2004), Batatunde and Adefabi (2005), Islam *et al.* (2007) and Matsushita *et al.* (2006).

[7] For a further discussion on this issue see Boccanfuso *et al*. (2009).

[8] For more details see Ararat (2007) and Maksymenko and Rabbani (2009).

[9] Lin (2004) is following the stock approach.

All the above considerations are referring to the empirical results, which are mixed.

For Greece, Asteriou and Agiomirgianakis (2001) have applied the Johansen maximum likelihood procedure and their data covered the period from 1960 to 1994 and Tsamadias and Prontzas (2011), following the Mankiw model.

3 Methodological issues and data

The purpose of the empirical analysis is to examine the long-run and the short-run relationship between education and economic growth, employing co-integration analysis. In the present study the *"flow approach"* of human capita the production function of Lucas (1988) is followed.

The first step of the empirical analysis tests for the integration of the variables. Specifically, the Augmented Dickey and Fuller (1981) *(ADF)*, the Phillips and Perron (1988) *(PP)*, the Kwaitkowsky *et al*. (1992) *(KPSS)* and the Zivot and Andrews (1992) *(ZA)* test are used to investigate the degree of integration of the variables[10].

In the empirical analysis three different estimation models have been employed [(Engle-Granger (1987)[11], Phillips-Hansen (1990)[12] and Johansen maximum likekihood approach (Johansen 1988; Johansen and Juselius 1990, 1992)][13] to test for co-integration in a human capital and economic growth bi-variate model.

Also, the VECM model is used to test for the exogeneity of the variables and capturing the short-run dynamics of the variables. The Wald-test is applied to test the joint of the significance of the sum of the lags of each explanatory variable. The value of the *t*-test of the lagged error correction term will test for the Granger

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[10] For more details about the stationarity tests see Hondroyiannis and Papapetrou (2002).

[11] Or *residuals based test*.

[12] For more details see Hondroyiannis and Papapetrou (2002) και Papapetrou (2006).

[13] The use of the Johansen technique controls for endogeneity and the complicated short-run dynamics, while focusing on the long-run relationships among non-stationary variables.

exogeneity or endogeneity of the dependent variable.

Finally, the stability of the coefficients in the estimated relations is tested using Cusum and Cusumq tests.

The empirical analysis has been carried out using annual data[14] for the period 1961 to 2006[15] for Greece. Enrolment rates in Tertiary, Secondary and Primary Education are used as proxies for human capital. Moreover, an additional variable is used to capture the impact of public expenditures on education to economic growth, which is represented by real GDP per capita. Specifically, *'TTERT'* is the enrolment ratio in Tertiary Education *(measured as the percentage of the working age population)*, 'TSEC' is the enrolment ratio in Secondary Education *(measured as the percentage of the working age population)*, *'TPRIM'* is the enrolment ratio in Primary Education *(measured as the percentage of the working age population)*, *'TTOTAL'* is the enrolment ratio in all levels of education and *'EXPEND'* is the public expenditures on education relative to total public expenditures.

Finally, *'LGDPC'* is used as a proxy of economic development and represents the real gross domestic product per capita.

4 Empirical results
4.1 Unit root tests

The ADF test suggests that all the variables contains unit root in their levels but are stationary in first differences when constant is included in the estimate equation.

Although, employing Phillips-Perron test gives different lag profiles for the various time series, the critical values supports the hypothesis that all series contain a unit root.

The KPPS test does not reject the I(0) hypothesis for the first differences of the series at various levels of significance. Given the differences in the stationarity results and the form of the estimated equation, the Zivot Andrews test was estimated.

The results suggests that at a level 5% of significance none of the estimated variables are stationary, while their first difference is I(0).

The combined results from all tests confirm the stationarity of the first differences of all the variables at different levels of significance[16].

4.2 Co-integration analysis

Since, all variables are integrated of the same order the next step involves the application of the co-integration tests.

The empirical results using the two-step Engle Granger co-integration method Suggest that the hypothesis of no co-integration between the education variables and GDP growth can be rejected[17]. To verify the results, the Phillips–Hansen method was applied - fully modified ordinary least squares estimator of Phillips Hansen- *(FMOLS)*.

The combined results from the previous estimation techniques suggest the existence of a long-run relationship between human capital and economic growth.

The next step involved a co-integration analysis among the two variables using the Johansen maximum likelihood approach employing both the maximium eigenvalue and trace statistic. The results of co-integration tests with enrolments in various levels of education (except Primary Education), public educational expenditures and real GDPC, indicate that there is one co-integrating vector.[18]

The combined results of the co-integration analysis from the three estimation techniques imply that there is a positive long-run

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[14] All the data are obtained from EL. STAT. (Greek statistics of education, various volumes) and (Greek Statistical Yearbook, various volumes) and the Ameco database.

[15] Since, there is no data available for the educational variables after 2006.

[16] All the results are available from the author upon request.

[17] The results are not presented here for the economy of space and are available from the author upon request.

[18] The differentials in the empirical results concern the fact that Johansen- Juselius co-integration analysis is more appropriate for the estimation of a multi-variatiate analysis and not a bi-variate.

relationship between human capital and economic growth.

4.3 Error Correction Models

Having verified that the variables are co-integrated, vector error-correction models *(VECM)* can be applied. The findings for the endogeneity of human capital and economic growth, based on the error correction equations from the estimation of Engle Granger cointegration analysis are reported below.

Estimations of the parameters show, (*Tertiary Education)* that the error correction term measuring the long-run disequilibrium has the right sign and is statistically significant for the real GDP equation. This implies that the real GDPC has a tendency to restore equilibrium and take the brunt of any shock to the system. The *t*-test for the error correction term indicates, at the 1% level of significance, that real GDPC is not weakly exogenous variable. The significance levels associated with the Wald-test of joint significance of the sum of the lags of the explanatory variable and the error correction term provide more information on the impact of the educational variables on economic variables and vice versa. For the real GDPC the results imply the Granger-endogeneity of the variable.

The VECM results from the estimation of Secondary and Primary education equations are as follows: the *t*-tests for the error correction terms indicate, at the 10% level of significance that secondary education is not weakly exogenous variable and that primary education is weakly exogenous variable.

Finally, the estimation of public educational expenditures equation indicate that, public educational expenditures is weakly exogenous variable and that real GDPC has a tendency to restore equilibrium and take the brunt of any shock to the system.

Next, the results for the endogeneity of human capital and economic growth, based on the error correction equations from the estimation of Phillips Hansen cointegration analysis indicate that, all the estimations for each bi-variate model (Primary, Secondary, Tertiary education and public educational expenditures), verify the previous results from the Engle-Granger technique, which means that the conclusions are qualitatively the same. But, the estimations based on the error correction equations from the estimation of Johansen and Juselius co-integration analysis give different results. Specifically, the main differences occurred in all bi-variate models except Tertiary education. Finally, the stability of the coefficients was estimated using Cusum and Cusumq tests[19]. The results imply that coefficients are stable.

4.4 Summary of the estimated Granger causality results

Table 1, summarizes the findings for the long-run, the short-run and the Granger causality of the variables. At the second, third and fourth column of the table, all the estimated coefficients of the independent variables are presented employing the three co-integration methodologies[20]. All the estimated coefficients are statistically significant at 1% level of significance and have a positive sign. The combined results of all methodologies indicate that for all estimated bi-variate models there is one co-integrating vector. The findings of the existence of a positive long-run relationship between human capital and economic growth are in line with previous researchers such as Pereira and Aubyn (2009) for Portugal, Babatunde and Adefabi (2005) for Nigeria and Asteriou and Agiomirgianakis (2001), for Greece.

Next, referring to the empirical results of the short-run dynamics (Granger- causality in the strict sense), the Wald-tests indicate that there is a relationship between Primary education and real GDPC and that enrolment rates in all levels of education should be considered as an endogenous variable.

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[19] Cusum and Cusumq tests are not presented here for the economy of space and are available from author upon request.

[20] Coefficient(1) is referring to the Engle-Granger co-integration test, coefficient(2) to the Phillips-Hansen co-integration test and finally Coefficient(3) to the Johansen and Juselius methodology.

Table 1. Summary of the results for the long-run, the short-run and the Granger causality of the variables.

	Short-Run relationship			Long-Run relationship					
Methodology	OLS	Phillips-Hansen	Johansen-Juselius	Strict exogeneity			Weak exogeneity error correction term)		
	Coefficient (1)	*Coefficient (2)*	*Coefficient (3)*	OLS	P-H	J-J	OLS	P-H	J-J
TPRIM → GDPC	0.130***(τ)	0.134***(τ)	-0.091	YES	YES	---	-0.12*	-0.12	---
GDPC →TPRIM				NO	NO	---	0.68	0.76	---
TSEC → GDPC	0.052*** (τ)	0.042***(τ)	0.524***(τ)	YES	YES	---	-0.06	-0.08*	0.02***
GDPC →TSEC				YES	YES	---	0.99*	0.89	0.16***
TTERT → GDPC	0.294***	0.288***	0.198***	YES	YES	YES	-0.10***	-0.10***	-0.11***
GDPC → TTERT				YES	YES	YES	0.21	0.21	0.10
TTOTAL → GDPC	0.048***(τ)	0.045***(τ)	0.195***(τ)	YES	YES	---	-0.07	-0.07	0.04***
GDPC → TTOTAL				YES	YES	---	1.78	1.66	0.70***
EXPEND → GDPC	0.029***	0.031***	0.020***	YES	YES	---	-0.09***	-0.08***	-0.08***
GDPC → EXPEND				YES	YES	---	1.05	-1.41	1.11

Methodology	Strong exogeneity			
	OLS	P-H	J-J	
TPRIM → GDPC	YES	YES	---	absence
GDPC →TPRIM	NO	NO	---	causality
TSEC → GDPC	YES	YES	---	absence
GDPC →TSEC	NO	NO	---	causality
TTERT → GDPC	NO	NO	NO	causality
GDPC → TTERT	YES	YES	YES	absence
TTOTAL → GDPC	YES	YES	---	absence
GDPC → TTOTAL	NO	NO	---	causality
EXPEND → GDPC	NO	NO	---	causality
GDPC → EXPEND	YES	YES	---	absence

*Note: T is the Time trend in the long-run relationship. ***,** and * indicate significance at 1%, 5% and 10% level.*

The combined results of all methodologies indicate that the real GDPC depends on Tertiary education and the public expenditures on education, while Primary education is affected by economic growth.

5 Conclusions and policy implications

In this paper we examined the causal relationship between education and economic growth for Greece covering the period from 1961 to 2006, using a bi-variate approach based on human capital theory.

Empirical results suggests that in the long-run period real GDP per capita is affected by changes in primary, secondary, tertiary education and educational public expenditures.

The empirical results using the error-correction estimation indicate that the direction of causality runs from Tertiary Education and public educational expenditures to real GDP per capita and that both variables should be considered as exogenous variable. As for the primary and secondary education, the findings reveal that causality runs through the opposite direction, from real GDPC to the levels of education. All the estimations have shown the existence of a uni-direction causality between human capital and economic growth in Greece.

The findings have important policy implications for Greece because of the economic uncertainty, which affects all sectors and every aspect of human activity, including education. Conclusions drawn from this analysis could be useful for educational policy makers to invest in education. Specifically, there is a motivation for the government to increase the public expenditures on education and to expand the number of students in Tertiary education, since that cause economic growth. Further investigation for a multivariate approach is an open issue, since there are some difficulties with the availability of the data.

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