The effect of education on economic growth in Greece over the 1981–2009 period. Does the proxy of human capital affect the estimation?

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Abstract: This study examines the effect of education on economic growth in Greece, during the period 1981 to 2009, by applying the model introduced by Mankiw et al. (1992). Three different proxies of human capital were used, school enrolment rates in secondary education, average years of schooling and the proportion of the labour force which has received secondary education. The empirical analysis reveals that education has had a negative effect on economic growth. Specifically, the coefficients for the three proxies that were used have resulted in negative sign but only for the enrolments rates case was statistically significant. The model explained 26% up to 34% of the variation of the economic growth rate through the variation of the independent variables in different cases.

Keywords: economic growth; education; education economics development; human capital proxy; Greece.

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1 Introduction

The relationship of education and economy has been studied in economics since Smith (1776) made his inquiry into the wealth of nations. Since the Second World War, the debate concerning the various determinants of economic growth has attracted considerable attention (Solow, 1956; Schultz, 1961; Abramovitz, 1962; Becker, 1964; Denison, 1967; Mincer, 1974; etc.). Human capital theory stresses the importance of human capital as a production factor that explains economic growth and the education as the main institutional mechanism of production, accumulation and diffusion of human capital.

According to the existing literature, there are three channels through which education can impact economic growth:

1 education increases human capital inherent in labour force, which enhances labour productivity and thus transitional growth towards a higher equilibrium level of output [augmented neoclassical growth theories (Mankiw et al., 1992)]

2 education can increase the innovative power of an economy as well as knowledge on new technologies, products and processes that promote growth [theories of endogenous growth (Lucas, 1988; Romer, 1990)]

3 education facilitates the diffusion and transmission of knowledge which is needed to understand and process new information and to implement new technologies successfully, also leading to economic growth (Nelson and Phelps, 1966).

In a seminal paper, (Mankiw et al., 1992), (hereafter MRW), extended the Solow growth model by incorporating an explicit process of human capital accumulation. During the last three decades, new growth theories or endogenous growth theories, accept education as one of the primary components of human capital and the effect of education on the economies has been pointed out (Lucas, 1988; Romer, 1990), etc. Empirical studies have shown that the coefficient of the human capital variable is positive and significantly different from zero, while other studies have presented opposite findings.

The proxy of human capital is a key issue in the empirical growth model, as it would improve the performance of the growth model. Many researchers tried to approach human capital using proxies, as flow and as stock. It is very difficult to know how close proxies such as school enrolment, average years of schooling or the proportion of the labour force which has received primary, secondary or higher education, are to their conceptual equivalents, so that failure to find positive evidence could be due to poor proxies (Sianesi and Reenen, 2003).

The purpose of this study is to estimate education's effect on the growth of the Greek economy over the period 1981 to 2009. The application of Mankiw et al. (1992) model was used, by approaching three different proxies of human capital. Part of the aims of the study is to investigate whether the proxy of human capital affects the estimation.

This paper presents the review of empirical studies in Section 2. Section 3 a brief reference to Greek economy and education is displayed. Section 4 explains the methodology and discusses the model and the proxies of human capital. Section 5 introduces the empirical analysis and discusses the results. Finally, Section 6 summarises the main findings and conclusions of the study.

2 Review of empirical studies

There have been many studies on the impact of education on economic growth using different proxies of human capital. The most common proxies are school enrolment rates and the average years of schooling.

In Table 1, some major studies are presented concisely, considering the effect of education on the economic growth. These studies are categorised according to whether they are based on economic theories or educational proxies. The economic theories are the augmented neoclassical theory and the new growth or endogenous theories. Afterwards, the studies are categorised by the proxy. Specifically, in those that expressing human capital stock used the average years of schooling or the proportion of the labour force as proxy of human capital and these that expressing human capital flow used the school enrolment rates as proxy of human capital.

The category *a* present the studies that used school enrolment rates as proxy of human capital and *b* the studies that used the average years of schooling. In this study, we use one more proxy, the proportion of the labour force which has received secondary education. To our knowledge, there are no studies using this proxy in the literature. For this reason, in the following table this is not included.

Table 1 Empirical studies

Augmented neoclassical theory					
Proxy	*Studies*	*Estimated coefficient*		*Countries sample*	*Time period*
		Stat. sign	*Sign*		
a	Mankiw et al. (1992)	Significant	Positive	98 countries and OECD countries	1960–1985
	Tsamadias and Prontzas (2011)	Significant	Positive	1 country (Greece)	1960–2000
	Gemmell (1996)	Significant	Positive	96 countries	1960–1985
	Caselli e al. (1996)	Significant	Negative	98 countries	1960–1985
	Mingat and Tan (1996)	Mixed for each level of education	Mixed for each level of education	113 countries	1960–1985
b	Pritchett (2001)	Insignificant	Negative	Various countries included (total number 96)	1960–1985
	Bassanini and Scarpetta (2001)	Significant	Positive	21 OECD countries	1971–1998
	Bhaskara et al. (2010)	Significant	Positive	1 country (Guatemala)	1951–2002
	Islam (1995)	Insignificant	Negative	96 countries	1960–1985
	Soto (2002)	Significant	Positive	73 countries	1960–1990

Table 1 Empirical studies (continued)

New growth theory					
Proxy	*Studies*	*Estimated coefficient*		*Countries sample*	*Time period*
		Stat. sign	*Stat. sign*		
a	Barro (1991)	Significant	Positive	98 countries	1960–1985
	Levine and Renelt (1992)	Significant	Positive	119 countries	1960–1989
	Murphy et al. (1991)	Insignificant	Positive	91 countries	1970–1985
	Englander and Gumey (1994)	Significant	Positive	OECD countries	1960–1990
	Asteriou and Agiomirgianakis (2001)	Significant	Positive	1 country (Greece)	1960–1994
	Bils and Klenow (2000)	Significant	Positive	85 countries	1960–1990
b	Barro (1997)	Significant	Positive	100 countries	1960–1990
	Hanushek and Kimko (2000)	Significant	Positive	31 countries	1960–1990
	Benhabib and Spiegel (1994)	Insignificant (growth rate)	Negative	78 countries	1965–1985
		Significant (levels)	Positive		
	De la Fuente and Domenech (2000)	Significant	Positive	OECD countries	1960–1990
	Lin (2003)	Significant	Positive	1 country (Taiwan)	1965–2000
	Topel (1999)	Significant	Positive	111 countries	1960–1990
	Krueger and Lindahl (2001)	Significant	Positive	78 countries	1965–1985
	Tallman and Wang (1994)	Significant	Positive	1 country (Taiwan)	1965–1989

The basic findings can be summarised as follows: for both theories, the studies have found that the impact of human capital, as flow and as stock, varies considerably in statistical significance and sign. However, most studies have found that a significant positive effect of human capital is present in the economic growth, especially, when the proxy of enrolment rates is used.

3 A brief reference on Greek economy and education during the period 1981 to 2009

This period has been of great importance for Greece since two major events took place, influencing the country's economic and political situation:

a The accession to the European Economic Community (EEC). The induction agreement came into force in January 1981. Greece, as an EEC member participated in all stages of European integration, including the single European Act and the signing of the Maastricht Treaty.

b The accession to the European Monetary Union (EMU) and the adoption of the new euro-currency (1 January 2001).

During this period, a number of structural and functional reforms and adjustments, in both economy and education, were materialised, with varying success.

In Greece, the average growth rate of GDP per worker was at 0.3% in the 1980s, 1.7% in the 1990s and 2.2% in 2000s. The average growth rate was approximately 1.4% during the examined period. Greece, also achieved a satisfactory employment rate. The average unemployment rate was recorded at 7.1% in the 1980s, 9.7% in 1990s, and 9.1% in 2000s. On the other hand, the country suffered from high inflation, especially during the period 1980 to 1995. More specifically, inflation from an annual average 19.5% in the 1980s, later decreased to 9.1% in the1990s and finally fell down to 4% in the year 2000s. The fiscal deficit equalled 2.6% of GDP in the fiscal year 1980, 14% in 1990 and 3.7% in 2000 to 15.4% in 2009. The 1980s and 1990s recorded high inflation and fiscal deficits rates with significant variation caused by exogenous factors (e.g., oil crisis) as well as the political cycle. At the same period, the trade deficit varied from 7.92% in 1980, 9.82% in 1990, and 13.5% in 2000 to 14% in 2009. In this period, public debt as percentage of GDP increased significantly from 22% in 1980, 71% in 1990, and 103% in 2000 to 128% in 2009.[1]

The Greek economy, passed on to the 21st century, facing a number of unsolved problems: high fiscal deficits and public debt, trade deficits and mainly low competitiveness. The need for fiscal discipline was compelling as was the adoption of institutional, structural and functional reforms in order to adapt to the euro-zone environment.

Education in Greece constitutes a responsibility of the state and is offered for free by public educational institutions at all levels. The Greek educational system has always been a very centralised one. Social demand for education increased, during the period 1981 to 2009, and the public educational structures of all levels have at the same time expanded. In the case of higher education, at the beginning of the 1980s only 14 universities operated in the country while in 2009 this number increased to 24 universities and 16 Technological Educational Institutions.

Starting from the first half of the 1990s, a new system of post-secondary vocational education and training was adopted (through the operation of public and private centres). Greek education, especially at the secondary level, has to a great extent been oriented towards general schooling. The milestone in the history of national education in Greece has been year 1975, when nine-year compulsory education has been constitutionally established. The period 1975 to 1977 stands out for the establishment of mandatory nine-year education (six-year primary and three-year secondary education). Since then, efforts have been made to reform and modernise educational structures of this level but progress has been slow. Educational qualifications in Greece are considered prerequisites for a successful professional career, both in the public and the private sector. The Greek educational system entered the 21st century facing a series of problems such as the low quality and low effectiveness of education at all levels, graduate unemployment, massive

student exodus abroad, brain drain, misallocation of resources, regressive social transfers, reduced human capital investment.

4 Methodology and model of MRW

The Solow (1956) model assumes an aggregate production function, with arguments effective labour and the stock of capital. Technological progress, population growth and capital depreciation take place at constant, exogenous rates. Mankiw et al.'s (1992) work tested the Solow model augmented with human capital. They assumed a Cobb-Douglas production function with constant returns to scale and decreasing returns to capital, augmented with the exogenous level of technological progress and human capital. The principal assumptions of their model included country specific constant rates (steady state) of investment in human and physical capital.

The Cobb-Douglas production function of MRW model has been given in the following form:

$$Y = K^{\alpha} H^{\beta} (AL)^{1-\alpha-\beta} \tag{1}$$

where Y represents aggregate output, K is the physical capital, H is human capital and A is a technical efficiency index and L is labour. One assumes that L and A grow at constant and exogenous rates n and g, respectively.

Considering decreasing returns to scale, that is $\alpha + \beta < 1$, transform equation (1) and end up with an equation on income per worker of the following form[2]:

$$\ln \frac{Y}{L} = \ln A + gt - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n+g+\delta) + \frac{\alpha}{1-\alpha-\beta} \ln(s_k) + \frac{\beta}{1-\alpha-\beta} \ln(s_h) \tag{2}$$

where s_k: the ratio of investment to product, s_h: human capital investment, n, g and δ: the growth rates of labour, technology and depreciation rate of capital respectively and t: time.

In their influential contribution, (Mankiw et al., 1992) show that an augmented Solow model that includes human capital formation, provides an excellent description of cross-country differences for 98 non-oil-producing countries, explaining a remarkable 78% of the variance with just three variables: investment rates in physical and human capital, and population growth. However, it explains only 24% of variation in income per working-age person in OECD countries.

Proceeding to the equation (2) and taking the first differences in order to overcome the lack of time-series stationary[3], we end up to the following function:

$$\Delta \ln q_t = c_o + \alpha \Delta \ln k_t + \beta \Delta \ln(n+g+\delta)_t + \gamma \Delta \ln h_t + \varepsilon_t \tag{3}$$

where q: output per worker, k: investment as percentage of GDP, n, g and δ: the growth rates of labour, technology and depreciation rate of capital respectively, h: the gross percentage of the enrolled in secondary education and ε: the error term.

4.1 Proxies of human capital

The proxies of human capital that were used in this study are defined as follows:

1 as flow – secondary enrolment rates (hereafter ln *he*sec$_t$).

The estimation of this variable is achieved by using the following function (World Bank, 2011):

$$GSER^t = \frac{E^t}{P^t} * 100 \tag{4}$$

where $GSER^t$ = Gross secondary enrolment ratio in school year t, E^t = Enrolment in the second level of education in school year t, P_t = Population in age-group which officially corresponds to the second level of education in school year t.

2 as stock – average years of schooling (hereafter ln *have*$_t$).

A proxy measure of human capital is that of the model of Lin (2003). The generic form of our measure of average years of schooling or educational stock (E) is given as:

$$\overline{E} = \frac{\sum_i S_i \cdot A_i}{S} \tag{5}$$

where S_i is the share of employments with the i^{th} level of education; A_i is the average number of years of schooling received in the i^{th} level of education; i designates the classifications of illiterates or no education (A = 0 years), for primary incomplete (A = 3 years), primary complete (A = 6 years), secondary incomplete (A = 9 years), secondary complete (A = 12 years), technological education complete (A = 15 years), higher education incomplete (A = 15 years), higher education complete (A = 16 years) and master or PhD complete (A = 19 years). The rungs of education were categorised according to the educational system in Greece. In this analysis, all levels of schooling are weighted equally. The stock of human capital is, therefore, built-up from past 'investments' in education.

3 as stock – the proportion of the labour force which has received secondary education (hereafter ln *hl* sec$_t$).

The estimation of this variable is achieved by using the following function:

$$LSE^t = \frac{L_p^t}{L^t} * 100 \tag{6}$$

where LSE^t = the proportion of the labour force which has received secondary education in year t, L_p^t = Labour force with secondary education in year t, L^t = Total labour in year t.

5 Empirical analysis

5.1 Data

Gross domestic product (GDP), investment and employment data series were taken from the AMECO (http://ec.europa.eu/economy_finance/ameco/user/serie/SelectSerie.cfm)

database. GDP per worker (hereafter ln q_t) measured at 2000 constant prices. Physical investment (hereafter ln k_t) is the investment as percentage of GDP at 2000 constant prices for the total economy and Employment is civilian domestic employment. For the rate of population growth (lnn), the growth rate of labour force is used. In some specifications of the model, a dummy variable has been included that involves the time period 2001 to 2009, when Greece became a member of Euro zone. Data for constructing human capital proxies were taken from the Hellenic Statistical Authority (HSA) (http://www.statistics.gr/portal/page/portal/ESYE) database. Given the availability of the data, it is not possible to consider wider definition of human capital investment compassing on-the-job training, experience and learning-by doing, the number of repeaters and dropouts in each grade and ignoring its depreciation. The quality of education cannot be taken into account.

5.2 Stationarity tests

The stationarity of the data set is examined using Augmented Dickey-Fuller (ADF) and Kwialkowski-Phillps-Schmidt-Shin (KPSS) tests. We test for the presence of unit roots and identify the order of integration for each variable first in level and next for first difference. The variables are specified including intercept and including intercept and trend. No automatic model selection is performed and the lag order has been taken as fixed equal to one because of small sample data. For ADF test, the null hypothesis is non-stationary, while for the KPSS test the null hypothesis is stationary. Unit root test results are given in Table 2.

Table 2 Results of unit root test

Variables (in levels & first difference)	*ADF test*		*KPSS test*	
	Including intercept	*Including trend and intercept*	*Including intercept*	*Including trend and intercept*
$\ln q_t$	1.0110	–1.8804	1.4153*	0.3522*
$\Delta\ln q_t$	–4.5772*	–5.0710*	0.4942**	0.0789
$\ln k_t$	–0.1938	–2.3949	1.1223*	0.3207*
$\Delta\ln k_t$	–6.2454*	–6.5268*	0.1944	0.0418
$\ln(n + g + \delta)_t$	–3.6348**	–3.5441	0.0579	0.0607
$\Delta\ln(n + g + \delta)_t$	–10.479*	–10.276*	0.0445	0.0425
$\ln have_t$	–1.6472	–0.6930	1.5129*	0.2808*
$\Delta\ln have_t$	–5.3186*	–5.6942*	0.3014	0.0464
$\ln hesec_t$	–2.1974	–2.0133	0.9550*	0.2657*
$\Delta\ln hesec_t$	–5.4637*	–5.5027*	0.3479	0.1224
$\ln hlsec_t$	–1.0780	–1.1356	1.4893*	0.2334*
$\Delta\ln hlsec_t$	–4.9952*	–5.0412*	0.2236	0.0739

Note: *, **indicates the rejection of the null hypothesis of non-stationarity (ADF) or stationarity (KPSS) at 1% and 5% level of significance respectively.

The results in Table 2 show that all variables under study have unit root, or non-stationary or integrated of order one in its level and stationary, or integrated of order zero at its first difference at least at 5% level. Hence, all the series are non-stationary and the standard regression analysis may produce spurious results. If a time series has a unit root, a convenient way to remove non-stationary would be by taking first differences of the relevant variable. Once the series are made stationary, they can be used in regression analysis.

5.3 Cointegration test

Stationary tests show that all the variables which are non-stationary at level, become stationary at first difference. They are in fact integrated of order (1). So there is the possibility that variables of output per worker, investment and human capital are cointegrated. Variable $n + g + \delta$ was taken as exogenous in the test.[4] Output per worker, investment and each of the non-stationary human capital variables have tested for cointegration, following the Johansen (1988) and Johansen and Juselius (1990) procedure. The Johansen multivariate cointegration approach is used to examine the long-run relationship between the variables. The cointegrating model specification that fits the data and the theoretical constraints is one with a linear deterministic trend in the data, and an intercept, but no trend in the cointegrating equation(s). This cointegration method recommends two statistics to check the long run relationship; trace and maximum eigenvalue test. The null hypothesis, in the trace and maximum eigenvalue test is that there is no cointegrating vector. Lag selection is based on minimising the Schwarz (1978) and Akaike (1974) criteria. The null hypotheses of one or more than one co-integrating vectors in the Trace test could not be rejected at 5% in all cases, which implies that there is not cointegrating vector. The finding of one or more than one co-integrating vectors was further supported by the results of the maximum eigenvalue test in which the null hypothesis that there is no cointegrating vector could not be rejected at 5%. So, the results from the cointegration test (Tables 3, 4 and 5), lead to the conclusion that there is no long run relation between output per worker, investment and different proxies of human capital.

Table 3 Unrestricted cointegration rank test – proxy enrolment rates

Series: lnq lnk lnhesec					
Hypothesised no. of CE(s)	*Eigenvalue*	*Trace statistic*	*5% critical value*	*Max-Eigen statistic*	*5% critical value*
None	0.424032	22.14030	29.79	14.89598	21.13
At most 1	0.225150	7.244319	15.49	6.887331	14.26
At most 2	0.013135	0.356988	3.84	0.356988	3.84

Notes: Trace and max-eigenvalue tests indicate no cointegration at the 0.05 level.
Lags interval: 1 to 1

Table 4 Unrestricted cointegration rank test – proxy average years of schooling

Series: lnq lnk lnhave					
Hypothesised no. of CE(s)	*Eigenvalue*	*Trace statistic*	*5% critical value*	*Max-eigen statistic*	*5% critical value*
None	0.473365	27.17517	29.79	17.31367	21.13
At most 1	0.242345	9.861499	15.49	7.493222	14.26
At most 2	0.083977	2.368277	3.84	2.368277	3.84

Notes: Trace and max-eigenvalue tests indicate no cointegration at the 0.05 level.
Lags interval: 1 to 1

Table 5 Unrestricted cointegration rank test - proxy proportion of labour force

Series: lnq lnk lnhlsec					
Hypothesised no. of CE(s)	*Eigenvalue*	*Trace statistic*	*5% critical value*	*Max-eigen statistic*	*5% critical value*
None	0.518509	27.21490	29.79	19.73344	21.13
At most 1	0.202314	7.481461	15.49	6.103070	14.26
At most 2	0.049770	1.378391	3.84	1.378391	3.84

Notes: Trace and max-eigenvalue tests indicate no cointegration at the 0.05 level.
Lags interval: 1 to 1

5.4 Regression analysis

After the cointegration analysis, in order to assess education's effect on Greece's economic growth in the short run, two specifications of the equation (3) were estimated. It should be noted that, according to Mankiw et al. (1992), assuming that $g + \delta = 0.05$ remains constant for all countries considering that technology (and therefore its rate, g) is a public good available to all countries. These assumptions also apply for Greece. It should be also mentioned that all variables are stationary in their first differences (Table 3). The econometric analysis is based on the time series approach by using OLS method. All specifications examined, were estimated consistently as for the existence of the serial correlation and the heteroskedasticity by using the Newey-West HAC estimator (Newey and West, 1987).

First, specification 1 is focused on. All education proxies yield negative and statistically insignificant coefficients, except enrolment rates coefficient which is significant. If we take a dummy variable into account (specification 2) the coefficients are, negative and significant for the enrolment rates, negative and not significant for the average years of schooling and positive but not significant for the proportion of the labour force.

The coefficient of investment ($\ln k_t$) yields positive and statistically significant at 1% in all the specifications of the model. The price of the coefficient found from the high 0.18 to 0.15. The coefficient on $\ln(n + g + \delta)$ is of negative value, in all specifications, and statistically significant. The dummy variable has no influence on economic growth.

The model explained 26% up to 34%% of the variation of the economic growth rate through the variation of the independent variables in different specifications, which is closer to the Mankiw et al. (1992) results.

Through this framework, it seems that the educational process has had an insignificant negative effect on Greece's economic growth during the period of study (1981 to 2009). The results show that the coefficients of the human capital do not have the expected sign, similarly to Mankiw et al. (1992) study and most studies in literature.

Table 6 Proxies of human capital effect on GDP growth

Variables	*Specification 1*			*Specification 2*		
	Enrolment rates	*Average years of schooling*	*Proportion of the labour*	*Enrolment rates*	*Average years of schooling*	*Proportion of the labour*
c_0	0.014* (0.000)	0.016* (0.006)	0.012* (0.001)	0.010* (0.000)	0.011* (0.048)	0.008* (0.030)
$\Delta\ln k_t$	0.158* (0.000)	0.166* (0.000)	0.179* (0.000)	0.152* (0.000)	0.163* (0.000)	0.160* (0.002)
$\Delta\ln(n + g + \delta)_t$	–0.019* (0.008)	–0.015* (0.057)	–0.015** (0.031)	–0.019** (0.011)	–0.015** (0.063)	–0.014*** (0.052)
$\Delta\ln h_t$	–0.204** (0.012)	–0.227 (0.262)	–0.030 (0.732)	–0.216** (0.040)	–0.116 (0.541)	0.017 (0.846)
Dum				0.010 (0.109)	0.008 (0.125)	0.009*** (0.073)
R^2	0.38	0.36	0.35	0.44	0.39	0.39
Adjusted R^2	0.31	0.28	0.26	0.34	0.29	0.29
Observations	28	28	28	28	28	28

Notes: The dependent variable is $\Delta\ln qt$ (1981 to 2009).
*, ** and *** indicate significant at 1%, 5% and 10% levels respectively.
p-value in parentheses.

5.5 Granger causality test

In order to improve the validity of the results and verify any causality between education and economic growth, we apply the Granger (1969, 1988) causality test. The best lag is determined by the Akaike (1974) and Schwarz (1978) information criterion. The results from Tables 7, 8 and 9, lead to the conclusion that both enrolment rates and proportion of labour force growth rate is causally related to GDP per worker growth rate and the average years of schooling growth rate is not causally related to GDP per worker growth rate. In the opposite direction, GDP growth rate has no causal relation to education growth rate in any case examined.

Table 7 Granger causality test – proxy enrolment rates

Null hypothesis	*Obs*	*F-statistic*	*Probability*
$\Delta\ln h\text{sec}_t$ does not Granger cause $\Delta\ln q_t$	27	2.973	0.097
$\Delta\ln q_t$ does not Granger cause $\Delta\ln h\text{sec}_t$	27	2.786	0.108

Notes: The F-statistics indicate that $\Delta\ln h\text{sec}_t$, does Granger cause to $\Delta\ln q_t$, on 10% significant level and $\Delta\ln q_t$ does not Granger cause to $\Delta\ln h\text{sec}_t$.
The results are based on a one-period lag time.

Table 8 Granger causality test – proxy average years of schooling

Null hypothesis	*Obs*	*F-statistic*	*Probability*
$\Delta\ln ha_t$ does not Granger cause $\Delta\ln q_t$	27	0.653	0.426
$\Delta\ln q_t$ does not Granger cause $\Delta\ln ha_t$	27	0.809	0.377

Notes: The F-statistics indicate that $\Delta\ln ha_t$, does not Granger cause to $\Delta\ln q_t$, and $\Delta\ln q_t$ does not Granger cause to $\Delta\ln ha_t$, on any significant level.
The results are based on a one-period lag time.

Table 9 Granger causality test – proxy proportion of labour force

Null hypothesis	*Obs*	*F-statistic*	*Probability*
$\Delta\ln h\text{sec}_t$ does not Granger cause $\Delta\ln q_t$	27	4.429	0.045
$\Delta\ln q_t$ does not Granger cause $\Delta\ln h\text{sec}_t$	27	0.048	0.826

Notes: The F-statistics indicate that, $\Delta\ln h\text{sec}_t$, does Granger cause to $\Delta\ln q_t$, on 5% significant level and $\Delta\ln q_t$ does not Granger Cause to $\Delta\ln h\text{sec}_t$, on any significant level.
The results are based on a one-period lag time.

6 Concluding remarks

This paper has analysed the effect of education on economic growth (in terms of GDP per worker) in Greece during the period 1981 to 2009. This period has been most crucial as significant economic, social and political changes of strategic nature have taken place in the country. In order to estimate education's contribution to economic growth, the study used the methodology and model of Mankiw et al. (1992). The approach of human capital has been explored using proxies as flow and as stock. These proxies were the enrolment rates, the proportion of labour force and the average years of schooling. The empirical analysis reveals that there is no long-run relation between education and output per worker. The educational process has had a negative effect on Greece's economic growth during the period of study. The coefficients for the three proxies that were used have resulted in negative sign but the statistical significance was mixed. Specifically, only the coefficient of enrolments rates has resulted in negative sign and statistically significant. The average years of schooling and the proportion of labour force have been found to be negative and statistically insignificant. By testing for Granger causality we may confirm that the education does affect the economic growth rate by using the proxies of enrolment rates and proportion of labour force (and not vice versa). It thus, becomes obvious that during this period of study (1981 to 2009), Greece's economic growth has not been positively affected by education.

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Notes

1 Ministry of Finance and Bank of Greece (http://www.bankofgreece.gr/Pages/en/default.aspx).
2 Please refer to Tsamadias and Prontzas (2011) for equations proof.
3 See empirical analysis section, stationarity tests.
4 The MRW model assumes exogenous rates of n, g, d.