Overeducation in Cyprus

Andri Kyrizi

The University of Leicester

Department of Economics

Abstract

In this paper we investigate the effects of excessive and limited schooling on the individuals' earnings in Cyprus. This important issue has not yet been tested analytically for Cyprus due to a dearth of individual level data. Using the conceptual framework of over- under- and adequate education we find that overeducated individuals still receive a positive return for their surplus schooling whereas the undereducated receive a negative return on their earnings for the deficit years of schooling. Additionally, using a logit model we tested whether being overeducated increases the probability of being unemployed under periods of economic crisis. We find statistically significant evidence that individuals with surplus schooling are more likely to lose their jobs while undereducated individuals are less likely to become unemployed. This might be due to the lower reservation wage of the undereducated relative to their overeducated counterparts. Consequently employers do not find it profitable to employ overeducated individuals during hard time such as the current global downturn.

Introduction

It has been, so far, well established empirically and theoretically that the more years of education one has the higher the earnings. Following the Human Capital Theory, each extra year of education should be accompanied with a respective increase in earnings. Education has been appreciated by many as a form of investment[1] and more and more individuals have been observed to enter higher education institutions because of expectations for higher returns. Almost every advanced country in the world has been experiencing an increase in the supply of higher education graduates, raising a lot of concerns as to what the results would be of such an effect.

This paper investigates the prevalence of overeduction in Cyprus labour market, something that has not yet been tested. What is interesting about Cyprus is that, despite its small size, over the past decade there has been a very high amount of high school graduates entering tertiary education. Menon (1998) has argued that 60% of young people have been planning to enter higher education and this has caused major concerns whether the limited

[1] We acknowledge that the Human Capital's effects are debatable by the Signalling Theory which views education as a form of screening devise for employers to distinguish among high and low ability individuals.

capacity of the Cypriot economy can support this increase in supply. After the entrance of Cyprus in the European Union, in 2004, the percentage of people entering higher education increased from 66% to 75% in just one school year. Additionally, the increase in the supply of students in the tertiary education was further enhanced by the reform of the educational system in Cyprus after several colleges gained recognitions and became private universities that reached the 82% in 2007. Additionally, the latest Statistics of Education report (2008/2009)[2] showed that 79% of the total secondary education graduates continued their studies beyond the secondary level. Although this may raise some concerns about the quality of the graduates in Cyprus, it does not change the fact that more and more individuals hold a graduate certificate.

Furthermore, this paper tries to move the research and literature one step further by looking whether overeducated individuals are more likely to being unemployed. The idea behind this hypothesis is that overeducated individuals receive a higher wage than their adequate educated co-workers. As a result, employers under certain circumstances may not find it profitable to employ overeducated individuals and this will result in an increase in unemployment. Cyprus is one of the most appropriate countries to test this since the rate of individuals entering the tertiary education is extremely high in the last years. As Decreuse (2000) in one of the two main arguments in his paper states that individuals may not protect themselves from unemployment by acquiring more years of education if all individuals are highly educated.

This paper continues as follows. Section 2 describes Previous research followed by the theory behind the methodology adopted in Section 3. Section 4 describes the data used and Section 5 is divided into two sub-sections discussing the results for the effect overeducation has on earnings and whether overeducated individuals are more likely to lose their jobs and become unemployed in a period of crisis. Finally, Section 6 concludes.

Previous research on the effect of overeducation on wages

Much of the literature has dealt with the real cost of overeducation on individuals, that is the wage penalty. Following the increasing supply of graduates almost in every developed economy in the last 30 years, concerns were raised as to the effect this would have. Duncan and Hoffman (1981) were the first to test for the effect of overeducation and concluded that overeducated individuals received a higher wage than their adequately educated co-workers but lower than individuals holding the same amount of education in well matched jobs. Additionally, undereducated received less returns than their adequately co-workers but more compared to individuals holding the same education in well matched jobs. Although different methodologies were engaged in some of the empirical works, results have been consistently the same (Rumberger 1987; Sicherman, 1991).

These results were also supported for different countries. Hartog and Oosterbeek (1988) have confirmed the above results for Netherlands and Cohn and Ng (2000) for Hong Kong. On Portugal, Kiker et al (1996) argue that research on the impact of schooling on earning should not be done using the Mincerian regression as it is misleading. Additionally, in another paper (Mendes et al, 2000) they show the importance of including interaction terms between over- under- and adequate education with experience and tenure.

[2] Statistical Service of Cyprus, Educational Statistics, Series I, Report No.41

Research on the UK has confirmed that overeducated individuals receive less than individuals with similar levels of schooling but working in matched jobs (Dolton and Vignoles, 2000). Additionally, it was found that individuals with surplus schooling experience a higher wage penalty in their first job than in their last (Dolton and Silles, 2008). Frenette (2004) found that overeducated Canadian college and bachelor's graduates experience an earnings penalty whereas, although master graduates are more likely in being overqualified, they experience little earnings effect.

Theory and Methodology

There is no solid theory behind the overeducation model presented here. However, this model derives from two important theories in labour economics; the human capital model (1) and the job competition model (2).

The supply side of the labour market, Human Capital model, assumes that wages are determined solely from the personal characteristics of individuals like the years of education, experience, training etc. It is assumed that workers' productivity is fully utilized and the wage received reflects the marginal productivity of the individual.

Human Capital Model (Mincer, 1974):

$$\ln Y_i = \alpha_0 + \alpha_1 S_i + \alpha_2 E_i + \alpha_3 E_i^{\,2} + \varepsilon_i \qquad (1)$$

where S_i are the individual's years of schooling

The demand side, Job competition theory, suggests that it is not the personal characteristics, like years of schooling of the individual or experience, that determine wages but the jobs characteristics, like the required level of schooling.

Job Competition Model(Thurow,1975)

$$\ln Y_i = \alpha_0 + \alpha_1 S_i^{\,R} + \varepsilon_i \qquad (2)$$

where S_i^R is the amount of schooling Required by the job.

Finally, Duncan and Hoffman (1981) by including the required, the surplus and deficit level of education triggered the literature on overeducation. The attained level of education is separated into *A=R+S-D*. If an individual has surplus (S) education the deficit (D) variable takes a value of zero and when S is added to R then the acquired level of education is obtained.

Overeducation Model /Assignment Theory (Duncan and Hoffman, 1981)

$$\ln Y_i = \alpha_0 + \alpha_1 S_i^R + \alpha_2 S_i^O + \alpha_3 S_i^U + \alpha_4 E_i + \varepsilon_i \qquad (3)$$

The above equation has become a trademark in the literature of over- under and adequate education. They have intelligently incorporated both the supply and demand sides of the labour market by including job characteristics and personal characteristics. $\ln Y_i$ is the natural logarithm of hourly earnings, S_i^R is the amount of schooling Required by the job, S_i^O is the individual's surplus schooling, S_i^U the deficit schooling and E_i are the years of experience.

The human capital theory assumes that the coefficients of required, over and under-education (α_1, α_2 and α_3) should equal each other. The job competition model assumes that only required schooling determines wages. Both theories are rejected using the assignment model. From the results of previous work it is expected that $\alpha_1 \neq \alpha_2 \neq \alpha_3$ and that although $\alpha_1 \rangle \alpha_2$ the coefficient on surplus schooling is still positive (Dolton and Vignoles, 2000; Hartog and Oosterbeek, 1988).

Data

The data used in this paper is the European Union Statistics on Income and Living Conditions (EU SILC) survey performed by Eurostat. It is a cross-sectional and longitudinal micro data collecting information on income, poverty, living conditions, housing conditions, social exclusion, educational levels, health status, and employment status on a household and on an individual level.

Focusing on Cyprus, the survey was conducted by CYSTAT, the Statistical Service of the Republic of Cyprus, and by the time this chapter was written only three waves, years 2005, 2006 and 2007, were available. We were not able to derive a panel since the personal identification number was not the same through the years, and as a result only a cross-section form and pooled data could be used.

The variables used are the logarithmic of earnings, the years of schooling, the required years of schooling, actual experience, experience squared, gender, marital status, health status and whether the job is permanent or not. Occupation and industry dummies were also used as control variables.

Results

The results are shown in the table below with the Mincerian regression in the first column, the ORU regression in column (2) and column (3) with the inclusion of interactive dummies for experience.

Table 7: Full Sample Results for Schooling and ORU model

Variables	lnEarnings	lnEarnings	lnEarnings
	(1)	(2)	(3)
Schooling	0.051		
ReqSch		0.081	0.089
		(50.13)**	(29.33)**
OverE		0.013	0.034
		(6.11)**	(7.99)**
UnderE		-0.041	-0.064
		(12.50)**	(9.59)**
Experience	0.045	0.048	0.058
	(28.15)**	(30.53)**	(22.77)**

Exp2	-0.001	-0.001	-0.001
	(19.18)**	(21.45)**	(22.46)**
Gender	0.368	0.382	0.384
	(32.71)**	(34.92)**	(35.15)**
Married	0.139	0.124	0.118
	(9.95)**	(9.15)**	(8.71)**
Healthstat	0.104	0.070	0.071
	(5.98)**	(4.13)**	(4.20)**
Permanent	0.646	0.548	0.551
	(37.47)**	(31.82)**	(32.05)**
OverExp			-0.001
			(5.86)**
UnderExp			0.001
			(3.60)**
ReqExp			-0.000
			(2.69)**
_cons	6.943	6.768	6.621
	(238.99)**	(227.34)**	(141.83)**
R^2	0.44	0.48	0.49
N	11,742	11,579	11,579

* $p<0.05$; ** $p<0.01$

For the variable of interest, the results show a return of 5.1% for every extra year of schooling in the Mincerian regression. As expected the rate of return of the actual years of schooling is lower, by 3 percentage points, than the return to the required years of schooling. Individuals holding the exact amount of schooling as required by the job receive 8.1% for every year of schooling they acquired. Individuals holding surplus schooling receive a return of 1.3% for every year of extra schooling they obtain above the required level. On the other hand, undereducated individuals receive a wage penalty of 4.1% for every year they are undereducated.

Looking at the coefficients of the interactive terms, the experience and overeducation explain a substitution effect because of their negative value. Similarly, for the adequately educated individuals the years of experience are a substitute. Overeducated and adequately educated individuals receive a somewhat lower return for every year of experience. Additionally, the relationship between undereducated and experience is complementary suggesting that undereducated individuals receive a higher wage for every year of higher past experience.

Overeducation and Unemployment

Using the Cyprus Labour Force Survey we investigate whether being overeducated increases the likelihood of being unemployed especially in a period of economic crisis. The CY LFS contains information on unemployed individuals regarding their previous occupation and industry. This survey collected information of individuals quarterly for years 2008, 2009 and 2010.

Using the years of schooling and information on last employment of the individual we can distinguish whether the unemployed individual was over- under or adequately educated. For the dependent variable, 1 was used for individuals who were at the time of interview unemployed and 0 for those who were employed. The overeducated measure included both unemployed and employed individuals with the number of surplus years of schooling. Every other variable in the logistic estimation concerned everyone in the sample.

To check if being overeducated increases the probability of being unemployed a logit model was used.

Table 9: Logit model

	Unemployed (All)	Unemployed (Males)	Unemployed (Females)
Over Educated	0.030	0.071	0.009
	(2.10)*	(3.43)**	(0.46)
Under Educated	-0.040	-0.079	-0.011
	(2.55)*	(3.52)**	(0.50)
Required	0.022	0.016	0.042
	(1.99)	(1.04)	(2.64)**
Experience	-0.084	-0.065	-0.086
	(14.68)**	(7.39)**	(10.76)**
Exp2	0.002	0.002	0.002
	(21.30)**	(13.92)**	(14.84)**
Sex	-0.316		
	(6.65)**		
Married	-0.212	-0.916	0.236
	(3.77)**	(9.71)**	(3.15)**
General	0.385	0.549	0.234
	(4.14)**	(4.06)**	(1.79)
Children Education	-0.263	-0.144	-0.261
	(1.72)	(0.44)	(1.43)
Art and Human Studies	0.122	0.128	0.134
	(1.05)	(0.69)	(0.88)
Greek and Foreign Language	-0.262	-0.158	-0.297
	(1.67)	(0.41)	(1.66)

Social Science	-0.391	-0.438	-0.359
	(4.44)**	(3.14)**	(3.14)**
Maths and Computer Science	-0.365	-0.228	-0.659
	(0.89)	(0.46)	(0.88)
Environmental Studies	-1.132	-0.612	-1.551
	(2.40)*	(0.98)	(2.12)*
Science	0.293	0.055	0.548
	(1.85)	(0.25)	(2.36)*
Computer Science	-0.525	-0.856	-0.095
	(2.43)*	(2.61)**	(0.32)
Architecture and Engineering	-0.316	-0.440	0.074
	(3.42)**	(3.78)**	(0.42)
Geologist	0.056	-0.016	0.166
	(0.20)	(0.05)	(0.32)
Health and Social Studies	-0.126	-0.432	-0.014
	(0.88)	(1.45)	(0.08)
Service Studies	-0.372	-0.784	-0.068
	(3.08)**	(3.83)**	(0.44)
Larnaca	0.289	0.235	0.358
	(4.38)**	(2.45)*	(3.89)**
Limassol	0.147	-0.051	0.320
	(2.63)**	(0.61)	(4.16)**
Famagusta	0.634	0.467	0.822
	(6.92)**	(3.40)**	(6.58)**
Paphos	0.458	0.332	0.541
	(6.11)**	(3.04)**	(5.17)**
_cons	-1.422	-1.491	-2.051
	(9.96)**	(7.50)**	(9.57)**
N	16,071	8,238	7,833

* $p<0.05$; ** $p<0.01$

The table above shows that there is a positive and significant relationship between being overeducated and between the probability of being unemployed. Therefore it can be concluded that in a period of economic crisis the first group to lose their jobs are overeducated individuals. Additionally it is shown that undereducated individuals, who are

subsequently paid less than their co-workers, are less likely to be unemployed. As expected, more experienced individuals are less likely to lose their jobs and males are found to be less likely in being unemployed compared to females.

Moving to the second and third columns overeducated males are more likely to be unemployed and undereducated males are less likely as in the full sample. Similarly, married males are again less likely to lose their jobs. On the other hand the results for over and under educated females are insignificant but strangely adequately educated females are more likely to lose their job. Additionally, married women are more likely to become unemployed.

In the full sample and the males sample being adequately educated is statistically insignificant and we cannot draw any results in the model. This could be because only a small amount of individuals who hold the required amount of schooling are unemployed.

This might be due to the lower reservation wage of the undereducated relative to their overeducated counterparts. Subsequently employers do not find it profitable to employ overeducated individuals during hard time such as the current global downturn. A possible policy implication of the above would be to encourage migration for overeducated individuals in other countries of the European Community. After the Bologna Process agreement in 1999, European countries aimed for an easier occupational mobility of individuals resulting from the compatibility of qualifications. This agreement enforced all EU countries that by 2010 a European Higher Education Area would be created.[3]

Conclusion

Overeducation exists greatly in Cyprus. Almost 50% of the tertiary sector graduates are found as being overeducated indicating that this is creating a problem. Late reports have shown that one out of four university graduates is unemployed during the economic crisis in Cyprus. The effect of over- under- and adequate education on earnings was tested using Cypriot data confirming that overeducated individuals receive less although still positive returns for each surplus of schooling they acquire. Additionally, undereducated receive less than their co-workers but more than their counterparts in less-qualified jobs.

A new hypothesis was tested whether overeducated individuals are more likely in losing their jobs especially in a period of crisis. The results show that overeducated individuals have a greater probability of becoming unemployed in a period of recession. This suggests that overeducation does not secure individuals from unemployment but can even cause it. Overeducated although not paid the full amount of money they should receive, they still receive a positive amount over and above individuals that hold the required amount of schooling. As expected at some point, is not profitable for employers to employ overeducated workers as it is more costly. Furthermore, undereducated individuals are less likely in losing their jobs, as expected, since they are paid a lower return for their deficit schooling than their adequately educated co-workers.

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[3] For more information on the Bologna Process http://ec.europa.eu/education/higher-education/doc1290_en.htm

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Estimating a generalized Leontief knowledge production Function using a non – linear mixed model: the case of OECD

Nikolaos E. Petridis

Department of Economics, Aristotle University of Thessaloniki,
petridin@econ.auth.gr

Emmanouilidis J. Christos

Department of Economics, Aristotle University of Thessaloniki,
cemman@econ.auth.gr

Varsakelis Nikolaos

Department of Economics, Aristotle University of Thessaloniki,
barsak@econ.auth.gr

Abstract

Knowledge Production Function (KPF hereafter) is widely used in the relative bibliography since it was first introduced by Griliches (1979). It is the mathematical relation which between inputs and outputs. Gross expenditure on research and development (GERD hereafter), total amount of researchers (TR hereafter) is used as inputs while total amount of patents produced in national level is used as output. In many studies Cobb-Douglas KPF is estimated, silently assuming that inputs are substitutes. Intuitively seems a very strong assumption that inputs are close substitutes. On the contrary, this research is based on the hypothesis that inputs are complements, rather than substitutes. For that reason a generalized non-linear KPF (Diewert 1971) was implemented, which relaxes the assumption of complementarity between inputs. Data refer to 26 member – countries of OECD from 1995 – 2007, and were gathered from free on-line datasets, such as Pen World Tables, WIPO and OECD official website. Gross expenditure on research and development in 2000 constant prices and full-time equivalent personnel have been used as independent variables and private patents in national level as dependent variable. The estimation of the non-linear regression with mixed effect was fulfilled with the use of panel data analysis, introducing a random-effect term on the exponent of the equation, which shows the elasticity of scale. All parameters have been found to be statistically significant ($p < .001$) and developed countries seem to perform constant economies of scale while developing countries decreasing economies of scale. Due to that fact, further co-operation between universities and institutes of OECD member- countries should be encouraged, in order a convergence to be achieved. Furthermore, countries with relative small GDP, which tend to perform decreasing returns to scale, should develop mechanisms of storing the diffused knowledge, which will enhance the competitiveness of nation's universities.

Literature Review

Knowledge Production Function was first introduced by Griliches (1979), in order to examine the contribution of expenditure on research and development to economic growth. The means of study contained analysis of historical case studies and estimation of an econometric production function. The latter have prevailed due to least ambiguous and objectively tested results. In his model, which contains inputs measured at the micro or macro level and are capital and labor and a final output, incorporates the stock of previous technical knowledge as function of the current. Based on the previous statement, it is indirectly implied that there are no diminishing returns or rising costs at the annual R&D level. For simplicity and lack of proper data, Cobb-Douglas functional form of Knowledge Production Function was estimated. Nevertheless a more complex functional form, i.e. CES or translog function can be used if there is a large dataset. Total factor productivity which is the analogy of inputs to output, depends directly on labor (or capital) and on stock of accumulated knowledge. Suggested inputs, according to Griliches, are the gross expenditure on research and development which may preferably be measured in constant prices, total amount of researchers, who are engaged in the field of research and development, and output shall be measured in total patents which are produced at national or regional level. Since then, numerous studies have been implemented in order a knowledge production function to be estimated using micro, regional and national data.

Conte και M. Vivarelli (2005) tried to investigate the determinants of three alternative measures of innovation output, by using firm's R&D activities and foreign technology which each firm has acquired. The paper examines small and large firms as well as firms of low and high tech sectors, for the case of Italy using industrial sector during the period 1998-2000. The subsample counts 2,949 firms, data from which were derived from European Community Innovation Survey (CIS 3). A bivariate probit analysis was implemented in order determinants of product and process innovation to be tested, and Cragg's test yielded strong indication that Tobit model should be estimated against a two-part model, as far as the intensity of innovation is concerned. R&D and Foreign technology have been found to be statistically significant determinants of product innovation and process innovation respectively and both have a positive impact on innovative intensity.

At the same year, Heshmati (2006) estimated a generalized knowledge production function using Swedish firm level data. The model examines the relationship between corporate competitiveness strategy, innovation, efficiency, productivity growth and outsourcing. Different measures of the variables are discussed and transferred into a single multidimensional index of corporate strategy, implementing principal component analysis. A stochastic frontier production function is estimated to test the effect of efficiency and factor productivity on growth at firm level.

In 2007 Catozzella and Marco Vivarelli have been engaged in testing the effect of in-house R&D on the complementarity of innovative inputs. A sample of 3,045 firms which belong in the area of manufacturing was gathered from the third Italian Community Innovation Survey from 1998 to 2000. Two different approaches were

used in order to be tested the effect of several sources of innovation on each other. The latter is represented by internal and external R&D and embodied and disembodied foreign technology. The two approaches show ambiguous results since there is evidence that complementarity or substitutability between inputs depend on type of the innovation output.

Stephan, Black, and Gurmu (2007) have estimated a negative binomial knowledge production function for university patenting. Under the assumption that personnel employed in the university do not contribute the same to patent activity, a distinction among students takes place. The results show that there is a positive and statistically significant effect on counts of patents coming from the number of faculties, number of PhD students and postdocs. The contribution in patenting depends on the visa status.

Buesa et al. (2008) estimated a KPF for the case of Spain, using initially 21 explanatory variables and patents as dependent variable. After applying a factor analysis were reduced to five big groups of determinants, which national environment, regional environment, innovation firms, universities and the R&D done by public administration. All factors are found to have statistical significant effect on patents.

In order to investigate the assumption that distance encourages or discourages the co-operation between institutes, Hoekman et al. (Hoekman, Frenken, και F Oort 2008) estimated gravity equations, and found not only significant evidence that previous hypothesis holds, but also that elite structures exist between excellence and capital region.

At the same framework was the study of Ponds, F van Oort,and Frenken (2010), in which the diffusion (spillover) from academic research to regional innovation was examined. An extended KPF was estimated, for the case of Netherlands, to investigate the hypothesis that a university – industry co-operation would have a significant impact on knowledge spillovers. They found that networks and geographical proximity affect the relationship between academic research and regional innovation.

Generalized Leontief Production Function

A great majority of previous papers, which use either regional or national data, estimate a Cobb-Douglas KPF. Basic assumption of Cobb-Douglas production function is that inputs are considered to be substitutes. In this paper we relax the hypothesis of substitution between inputs, assuming them to be complements. For that reason we implement a generalized Leontief production function (Diewert 1971), which under certain circumstances result in complementarity of inputs.

The generalized Leontief Production function, or else Diewert, is one of the most flexible functional forms, which allow elasticity of substitution to vary (Mishra 2007). The linear case of the generalized Leontief production function is given below:

$$y = f\left(\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij} * x_i * x_j\right)^{1/2} \quad (1)$$

where f is differentiable function, continuous and monotically increasing. It generally holds the assumptions that:

$$\lim_{x\to\infty} f(x_i, x_j) = \infty \quad (2)$$

$$f(0) = 0 \quad (3)$$

$$a_{ij} = a_{ji} \quad (4)$$

$$\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij} = 1 \quad (5)$$

It is concave if all parameters are positive. Furthermore it is linearly homogeneous of degree 1, while it is not possible to restrict and maintain approximation properties (Chambers 1988). A major advantage of this function, is that it can be easily tested the interaction between inputs pair wise and that it permits function to be non linear by introducing an exponent, which denotes the elasticity of scale.

$$y^{nu} = f\left(\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij} * x_i * x_j\right)^{1/2} \quad (6)$$

The hypotheses of symmetry between parameters and sum equal to unity do not hold any more. In order equation (6) to be a production function indeed, several conditions must be satisfied: i) function must be non-decreasing to inputs, ii) function must be continuous and differentiable in all the function's definition field, iii)marginal products of each input must be non negative, and iv)Hessian matrix must be negative definite or semi – definite. Condition iii) denotes that the larger the input, the larger the output, while iv) suggests that production function is convex and x*, y* are global maxima or local maxima, depending on whether Hessian matrix is negative definite or negative semi – definite. The model which is used in this study is a generalized Leontief production function with two inputs and in the general form can be written:

$$z = \left(a_{11} * x + a_{22} * y + a_{12} * \sqrt{x * y}\right)^{nu} \quad (7)$$

The dependent variable (z) stands for the amount of private patents produced in each member – country of OECD, while the independent variables (inputs) contain x which denotes the total, full – time equivalent personnel which is engaged in the R&D sector at national level and y represents each OECD member - country gross expenditure on R&D in 2000 constant prices.

Data

The non-linear mixed model effect generalized Leontief production function, was estimated from data which were derived from a free on – line databases, some of which are Penn World Tables 6.3, World Intellectual Property Organization (WIPO) and OECD official website. Our data consist of 26 out of 34 countries, due to lack of observations for whole period. The time period starts from 1995 and ends at 2007. The sample counts 259 observations per variable. Specifically, z denotes counts of patents per thousands by application office, which are produced by residents of a country within the country, without concerning about patents which are produced by citizens of the country who live abroad. This distinction is made in order to have a clear picture of the productive possibilities of each OECD member – country. The first independent variable, x, shows the total amount of researchers, men and women total intramural full time equivalent on R&D activities, while y represents the gross expenditure on R&D from private and public sector in million dollars constant prices of 2000. In order to ease computations, all variables were reduced by dividing them with 1000. It is very obvious, even with visual inspection that there are great differences between countries inside the organizations and three major groups are formed, based on mean of real GDP (Laspeyres) at 2005 constant prices for time period 1995 - 2007: the small GDP countries, Slovakia, New Zealand, Ireland, Hungary, Finland, Denmark, Czechoslovakia, Portugal, Norway and Greece, the medium GDP countries Switzerland, Austria, Sweden, Canada, Belgium, Poland, Netherlands, Turkey, Korea, Mexico, Spain. Italy and the high GDP countries France, Great Britain, Germany, Japan and United States of America.

Table 1: Descriptive statistics for dependent and independent variables for countries with low and large GDP.

Greece				
	Min	**Median**	**Mean**	**Max**
TP	0.31200	0.42000	0.41186	0.56200
TR	8.78715	14.14140	14.32528	19.14790
GERD	0.72940	1.21050	1.15456	1.46630
Hungary				
	Min	**Median**	**Mean**	**Max**
TP	0.68900	0.74250	0.76217	0.91900
TR	10.57920	14.15360	13.47373	16.50474
GERD	0.66490	1.09445	1.08428	1.61970
Czech Republic				
	Min	**Median**	**Mean**	**Max**
TP	0.52600	0.61850	0.60442	0.65800
TR	11.41375	13.74939	15.10447	25.10560
GERD	1.34960	1.86215	1.92600	3.00830
Japan				
	Min	**Median**	**Mean**	**Max**
TP	333.7700	358.1840	360.3378	384.2010
TR	596.7120	646.2000	647.9185	699.1600

GERD	89.18130	98.78300	99.50374	115.14330
United States				
	Min	**Median**	**Mean**	**Max**
TP	119.2140	171.1540	162.1821	189.5360
TR	1024.812	1300.493	1271.481	1420.107
GERD	199.8841	266.8261	253.2841	275.0488
South Korea				
	Min	**Median**	**Mean**	**Max**
TP	50.59600	73.27250	80.65833	125.47600
TR	91.7148	121.8996	130.3850	199.0969
GERD	14.67940	19.52270	20.85392	32.51090

With a first look at the descriptive statistics, one can see the large chasms between members – countries of OECD. The mean of variables total patents, total researchers and gross expenditure on R&D are approximately the same for countries which belong to the same group. On the contrary the means of the same variables among USA, Japan and South Korea differ significantly, but they are 200 to 600 times greater than the means of the variables which were computed for cases of Greece, Hungary and Czech Republic.

Methodology

The KPF was estimated using non – linear mixed effect model (Laird και Ware 1982 ; Lindstrom και Bates 1990). The structure of the data imposes the use of panel data analysis with random effect term. The general model in matrix form can be written as:

$$y_{i,t} = f(\varphi_i, x_{i,t}) + e_{i,t} \quad (8)$$

The dependent variable, $y_{i,t}$, is the response of the time t on the i th country, $x_{i,t}$ is the matrix of values of independent variables, f is a non – linear function, φ_i is a vector of parameters to be estimated and $e_{i,t}$ is the error term, which is assumed to be identically and independently normally distributed. In term φ_i fixed effect and random effect terms are incorporated. Due to the fact that in generalized Leontief production function exists no constant term, there will not be a fixed effect term. Thus φ_i will take the form:

$$\varphi_i = A_i + B_i * b_i \quad (9)$$

where $b_i \sim N(0, \sigma^2 * D)$ is a q vector of random effects with individual i and matrices A and B are design matrices. Random effects are normally distributed with mean zero and variance – covariance matrix equal to $\sigma^2 * D$. Estimation is carried out, by using a Newton Raphson (Marquardt 1963) algorithm, which tracks down the estimates of parameters, which maximize likelihood function.

Empirical Results

The KPF which was estimated does not contain a constant term that is why a non – linear regression with random term was applied. In the general form the model can be written as:

$$TP_{i,t} = (A * TR_{i,t} + B * GERD_{i,t} + C * \sqrt{TR_{i,t} * GERD_{i,t}})^{D+d_i} \quad (10)$$

Random effect term was added on the exponent, which depicts the returns to scale. A value of D less than unity means that country performs decreasing returns on scale, or that country's KPF is homogeneous of degree smaller than 1. In other words, if all inputs are i.e. doubled, output will increase but not at the same percent. The KPF could be characterized as inefficient. A value of D equal to unity means that country performs constant returns on scale while a value of D greater than unity increasing returns on scale. Coefficients of regression A, B and C do not have any economic meaning. As shown in the section of data presentation, there are great differences among OECD members – countries, so any guess about the type of returns on scale of the pooled OECD sample should be unreliable. The estimation of non – linear regression model was carried out with the help of statistical package S-Plus, using Maximum Likelihood method.

Table 2: Non linear Mixed Effect Knowledge Production Function for OECD countries

Parameters	Value	Std Error	DF	t-value	p-value
A	-2.2788	0.634346	230	-3.592364	0.0004
B	-17.00521	4.613660	230	-3.685840	0.0003
C	14.23264	3.819177	230	3.726626	0.0002
D	0.40110	0.082608	230	4.855506	<.0001

All parameters are found to be statistical significant at less than 1% level of significance and the value of the coefficient of returns on scale is 0.40110. This means that if OECD was a nation, it would perform decreasing returns on scale. Any effort of increasing the knowledge output, which in our case is represented by total amount of patents produced within country, would prove to be useless. Total amount of researchers and gross expenditure on R&D seem to have an effect on innovative product and the interaction is also found to be statistically significant and positive, which leads us to the result that inputs are complements.

Table 3: Analysis of Variance (AN.O.VA) for the Knowledge Production Function

Sources of Variation	**Value**	**Degrees of Freedom**	**Mean Sum of Squares**	**F**	**p-value**	**R^2 (%)**
Regression Sum of Squares	1539001	1	1539001	31213.53	<.0001	99.192
Residuals Sum of Square	12523.61	254	49.30557	-	-	-
Total Sum of Squares	1551525	255	-	-	-	-

The KPF is also found to be statistical significant at less than 1% level of significance and the coefficient of determination is extremely close to unity, which gives a strong evidence that models fits almost perfect the available data. In order to achieve such estimates, numerous starting values were tested. The appropriate vector of staring values came from the estimated parameters of the pooled model, on which numbers drawn from uniform distribution were added. Estimates fitting better our data also found, but were rejected due to the fact that they did not satisfying the assumptions of a production function.

Table 4: Values for the elasticity of scale per country

Country	**Deviation from the exponent**
Portugal	-0.1647419436
Slovakia	-0.0420322638
GREECE	**-0.0989698044**
Mexico	-0.1989982355
Czech Republic	-0.1797555828
Belgium	-0.2371257827
Hungary	-0.1053550604
Turkey	-0.2186669597
Ireland	-0.1126127421
Norway	-0.1291064364
Denmark	-0.1205284277
New Zealand	-0.0005687742

Austria	-0.0626234173
Netherlands	-0.1100772492
Australia	-0.1302511517
Finland	-0.1049255165
Poland	**0.0319313023**
Spain	-0.1193680875
Sweden	-0.0413936716
Canada	-0.0696228493
France	**0.1425081903**
United Kingdom	**0.2254804163**
Germany	**0.3548931393**
Korea South	**0.5759220644**
United States	**0.3516297399**
Japan	**0.5643591036**

In Table 4, values of the random effect which is added in the exponent are presented. We expected members – countries with large GDP to be more efficient than the others. Excluding South Korea and Japan, which perform constant returns to scale as the sum of pooled estimated parameter and value of random effect for these two countries is approximately unity, all other countries move below unity. France's Germany's, United Kingdom's and USA's value of returns on scale moves above the average, but it does not exceed the critical value of unity. Surprisingly Poland also moves above average, nevertheless performs decreasing economies of scale as well. Of the lowest values of returns on scale score Belgium, Turkey, Mexico and Czech Republic whose value of returns on scale is 23%, 21%, nearly 20% and nearly 18% below average respectively. Greece moves approximately 10% below average as well, as far as the value of economies of scale is concerned. However the estimates are satisfying well, the non – linear regression needs to be simultaneously a production function. The latter means, as referred to the section in which generalized Leontief production function was presented, that marginal products of inputs should be positive and Hessian matrix should be negative definite or semi definite.

Table5: First and Second Order Condition for Knowledge Production Function

Inputs	**dTP/dTR**	**dTP/dGERD**	**d^2TP/dTR^2**	**$d^2TP/dGERD^2$**	**$d^2TP/dGERDTR$**
TR (x)	0.0184985	-	-0.000415825	-	0.00190465
GERD (y)	-	0.00524136	-	-0.011267	0.00190465

First derivatives of the total patents with respect to total researchers and gross expenditure on R&D have correct sign. The interpretation of the marginal products is that if one more person is added on the research personnel then the amount of patents which will be produced is going to increase by 1.8 %, while if OECD as a nation spends one more million on R&D then the innovative product would increase by 0.524%. The signs of second derivatives are correct as well, which suggest that KPF is convex in TR and GERD and that there is a global maximum.

Conclusions

As shown above, the decreasing returns on scale seems to be a general problem of the member – countries which belong to OECD . Japan and South Korea are the leaders in the production of patents, namely they will produce double the amount they did, if the amount of total researchers and the expenditure towards institutions for R&D and creating of new knowledge is also doubled. Thus there is an imperative need, institutions from other countries to converge towards prime universities. Collaborations of institutions within OECD should be encouraged, so that the least productive to become more competitive and the latter should develop larger mechanisms of storing diffused knowledge which comes from universities, whose countries exhibit constant economies of scale.

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

M. Solaki[1*]

[1] PhD Candidate, Harokopio University, Athens Greece

*Corresponding author. Tel +30 2109549361, E-mail: msolaki@hua.gr

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.

Keywords: *VECM, Granger Causality, Macro-Level Data, Education, Economic Growth.*

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 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

[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).
[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.

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). 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 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

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[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.

[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.

[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.

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.

Table A.1. and Table A.2[17]. summarize the empirical results using the two-step Engle Granger co-integration method The results suggest that the hypothesis of no co-integration between the education variables and GDP growth can be rejected. To verify the results, the Phillips –Hansen method was applied. Table. A.3. and Table A.4. summarize the results of 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.

Table A.5. and Table A.6. present the results of 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]

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

[17] All tables at the Appendix are referring to estimation of the GDPC and TTERT bi-variate model and the GDPC and EXPEND bi-variate model, the results for the other estimated bi-vaiate models 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.

The combined results of the co-integration analysis from the three estimation techniques imply that there is a positive long-run 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. Table A.7. and Table A.8. report 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.

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, Table A.9. and Table A.10. present 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. 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 (Tables A.11.and A.12.). 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

[19] Cusum and Cusumq tests are presented at the Appendix.

[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.

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

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

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. 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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APPENDIX

Table A.1. Bi-variate co-integration test

Methodology	*Dependent Variable*		*Dependent Variable*	
	LGDPC		***TTERT***	
Engle-Granger	*k*	*t*-test	*k*	*t*-test
	3	*-3.27****	*3*	*-3.31****

Z*= LGDPC-0.294021TTERT-8.479824*
(-10.35359) (-123.2884)

***Notes*: The lag length k is chosen so the estimated residuals will be without out autocorrelation according to AIC (Akaike Information Criteria). t statistics are presented in the parenthesis . *** Indicate significance at 1% level of significance.**

Table A.2. Bi-variate co-integration test

Methodology	*Dependent Variable*		*Dependent Variable*	
	LGDPC		***EXPEND***	
Engle-Granger	*k*	*t*-test	*k*	*t*-test
	1	*-3.00****	*0*	*-1.16*

Z *= LGDPC-0.028856EXPEND-8.922661*
(-6.038511) (-172.7645)

***Notes*: The lag length k is chosen so the estimated residuals will be without out autocorrelation according to AIC (Akaike Information Criteria). t statistics are presented in the parenthesis . *** Indicate significance at 1% level of significance.**

Table A.3. Bi-variate co-integration test

Methodology	*Dependent Variable*		*Dependent Variable*	
	LGDPC		***TTERT***	
Phillips-Hansen	*k*	*t*-test	*k*	*t*-test
	3	*-3.13****	*3*	*-3.28****

Z *= LGDPC-0.28800TTERT-8.5190*
(-7.4777) (-90.3778)

Notes: **The Phillips and Hansen estimates are based on the Parzen lag window. The lag length k is chosen so the estimated residuals will be without out autocorrelation according to AIC (Akaike Information Criteria). t statistics are presented in the parenthesis. *** Indicate significance at 1% level of significance.**

Table A.4. Bi-variate co-integration test

Methodology	*Dependent Variable*		*Dependent Variable*	
	LGDPC		***EXPEND***	
Phillips-Hansen	*k*	*t*-test	*k*	*t*-test
	0	*-3.16****	*3*	*-0.67*

Z *= LGDPC-0.030765EXPEND-8.9420*
(-4.9668) (-132.1156)

Notes: **The Phillips and Hansen estimates are based on the Parzen lag window. The lag length k is chosen so the estimated residuals will be without out autocorrelation according to AIC (Akaike Information Criteria). t statistics are presented in the parenthesis. *** Indicate significance at 1% level of significance.**

Table A.5. Johansen and Juselius co-integration test (*LGDPC -TTTERT*): Sample 1961-2006.

Variables: LGDPC, TTERT
Var=2

Maximum Eigenvalues

Null H0	*Alternative H1*	*Eigenvalue*	*Critical values 95%*
		TTERT	
r=0	*r=1*	18.53**	14.26
r<=1	*r=2*	3.15	3.84

Trace Statistic

Null H0	*Alternative H1*	*Trace*	*Critical values 95%*
		TTERT	
r=0	*r>=1*	21.68**	*15.49*
r<=1	*r>=2*	3.14	*3.84*

***Z**=LGDPC -0.198411TTERT-8.699612*
(-4.58912)

Note: **r indicates the number of co-integrating relationships. Maximum Eigenvalue and Trace test statistic are compared with the critical values of the MacKinnon-Haug-Michelis (1999). t statistics are presented in the parenthesis. ** Indicates significance at 5% level of significance.**

Table A.6. Johansen and Juselius co-integration test (*LGDPC -EXPEND*): Sample 1961-2006.

Variables: LGDPC, EXPEND
Var=1

Maximum Eigenvalues

Null H0	*Alternative H1*	*Eigenvalue*	*Critical values 95%*
		EXPEND	
r=0	*r=1*	15.51**	*14.26*
r<=1	*r=2*	0.05	*3.84*

Trace Statistic

Null H0	*Alternative H1*	*Trace*	*Critical values 95%*
		EXPEND	
r=0	*r>=1*	15.57**	*15.50*
r<=1	*r>=2*	0.05	*3.84*

***Z**=LGDPC -0.019452EXPEND -8.984416*
(-2.41277)

Note: **r indicates the number of co-integrating relationships. Maximum Eigenvalue and Trace test statistic are compared with the critical values of the MacKinnon-Haug-Michelis (1999). t statistics are presented in the parenthesis. ** Indicates significance at 5% level of significance.**

Table A.7. Tests for weak and strong exogeneity of variables based on Engle-Granger Co-integration test.

EQUATIONS		TESTS OF RESTRICTIONS			
	Short-run dynamics		*Weak Exogeneity*	*Joint short dynamics and (ECT)*	
			Error Correction Term		
	ΔLGDPC	*ΔTTERT*	*Z=0*	*ΔLGDPC & ECT*	*ΔTTERT & ECT*
ΔLGDPC	-	*0.02*	*-0.10****	-	*7.12****
ΔTTERT	*0.37*	-	*0.21*	*1.07*	-

Note: The lagged (ECT) is derived by normalizing the cointegrating vector on LGDPC. * Indicate significance at 1% level of significance.**

Table A.8. Tests for weak and strong exogeneity of variables based on Engle-Granger Co-integration test.

EQUATIONS		TESTS OF RESTRICTIONS			
	Short-run dynamics		*Weak Exogeneity*	*Joint short dynamics and (ECT)*	
			Error Correction Term		
	ΔLGDPC	*ΔEXPEND*	*Z=0*	*ΔLGDPC & ECT*	*ΔEXPEND & ECT*
ΔLGDPC	-	*1.62*	*-0.09****	-	*9.60****
ΔEXPEND	*0.25*	-	*1.05*	*0.76*	-

Note: The lagged (ECT) is derived by normalizing the cointegrating vector on LGDPC. * Indicate significance at 1% level of significance.**

Table A.9. Tests for weak and strong exogeneity of variables based on Phillips-Hansen Co-integration test.

EQUATIONS		TESTS OF RESTRICTIONS			
	Short-run dynamics		*Weak Exogeneity*	*Joint short dynamics and (ECT)*	
			Error Correction Term		
	ΔLGDPC	*ΔTTERT*	*Z=0*	*ΔLGDPC & ECT*	*ΔTTERT & ECT*
ΔLGDPC	-	*0.02*	*-0.10****	-	*7.41****
ΔTTERT	*0.37*	-	*0.21*	*1.02*	-

Note: The lagged (ECT) is derived by normalizing the cointegrating vector on LGDPC. * Indicate significance at 1% level of significance.**

Table A.10. Tests for weak and strong exogeneity of variables based on Phillips-Hansen Co-integration test.

EQUATIONS			TESTS OF RESTRICTIONS		
	Short-run dynamics		*Weak Exogeneity*		*Joint short dynamics and (ECT)*
			Error Correction Term		
	ΔLGDPC	*ΔEXPEND*	*Z=0*	*ΔLGDPC & ECT*	*ΔEXPEND & ECT*
ΔLGDPC	-	*1.41*	*-0.08****	-	*8.45****
ΔEXPEND	*1.57*	-	*-1.41*	*1.06*	-

Note: The lagged (ECT) is derived by normalizing the cointegrating vector on LGDPC. * Indicate significance at 1% level of significance.**

Table A.11. Tests for weak and strong exogeneity of variables based on Johansen-Juselius Co-integration test.

EQUATIONS			TESTS OF RESTRICTIONS		
	Short-run dynamics		*Weak Exogeneity*		*Joint short dynamics and (ECT)*
			Error Correction Term		
	ΔLGDPC	*ΔTERT*	*Z=0*	*ΔLGDPC & ECT*	*ΔTTERT & ECT*
ΔLGDPC	-	*0.15*	*-0.10****	-	*14.04****
ΔTTERT	*0.18*	-	*- 0.06*	*1.05*	-

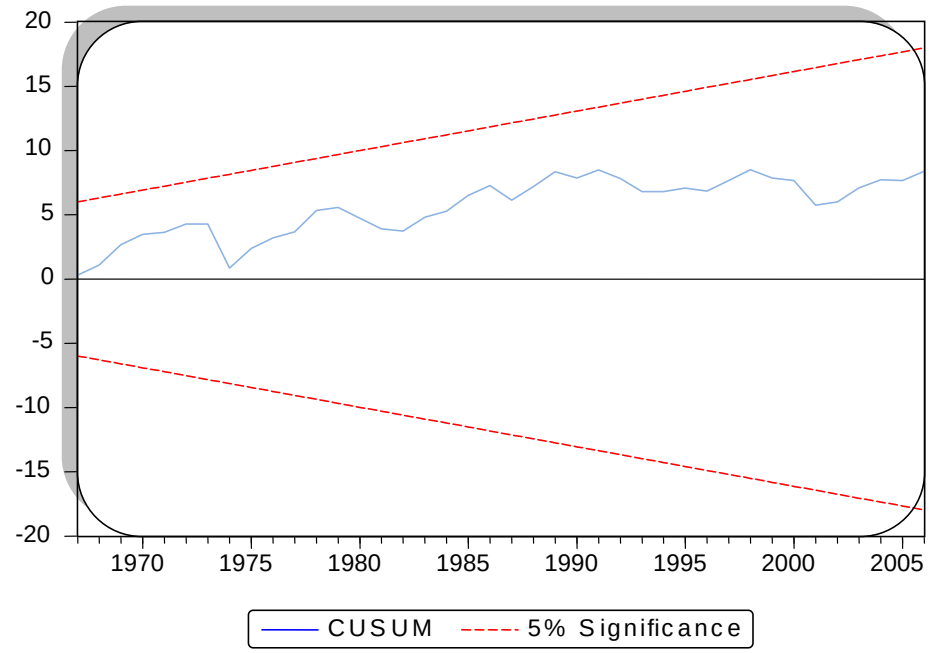
Note: The lagged (ECT) is derived by normalizing the cointegrating vector on LGDPC. * Indicate significance at 1% level of significance**

Table A.12. Tests for weak and strong exogeneity of variables based on Johansen-Juselius Co-integration test.

EQUATIONS			TESTS OF RESTRICTIONS		
	Short-run dynamics		*Weak Exogeneity*		*Joint short dynamics and (ECT)*
			Error Correction Term		
	ΔLGDPC	*ΔEXPEND*	*Z=0*	*ΔLGDPC & ECT*	*ΔEXPEND & ECT*
ΔLGDPC	-	-	*-0.08****	-	-
ΔEXPEND	-	-	*1.11*	-	-

Note: The lagged (ECT) is derived by normalizing the cointegrating vector on LGDPC. * Indicate significance at 1% level of significance.**

Figure A.1. cusum and cusumq test for Public educational expenditures based on Engle-Granger Co-integration test.



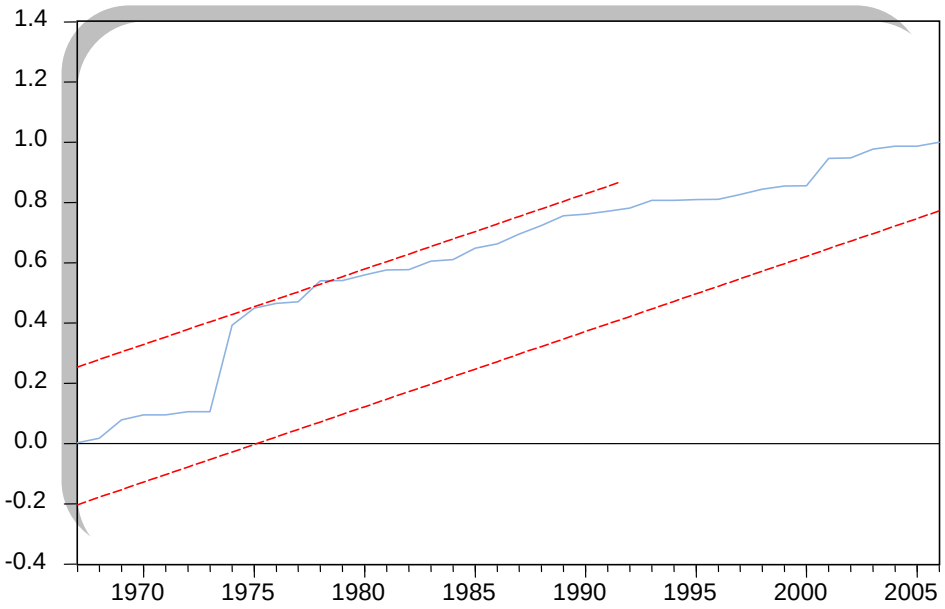
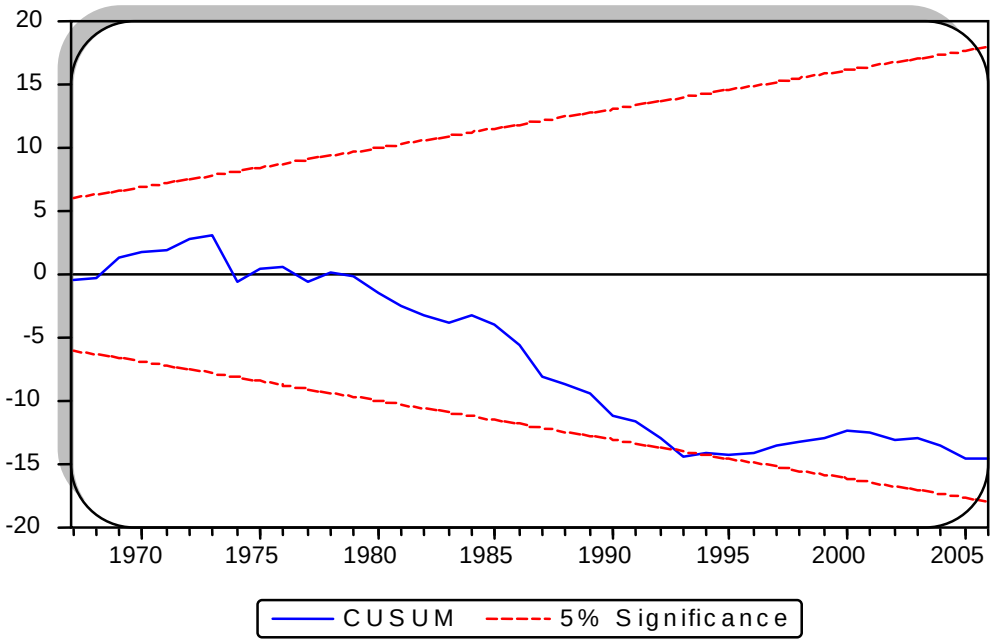


Figure A.2. cusum and cusumq test for Tertiary Education based on Engle-Granger Co-integration test.



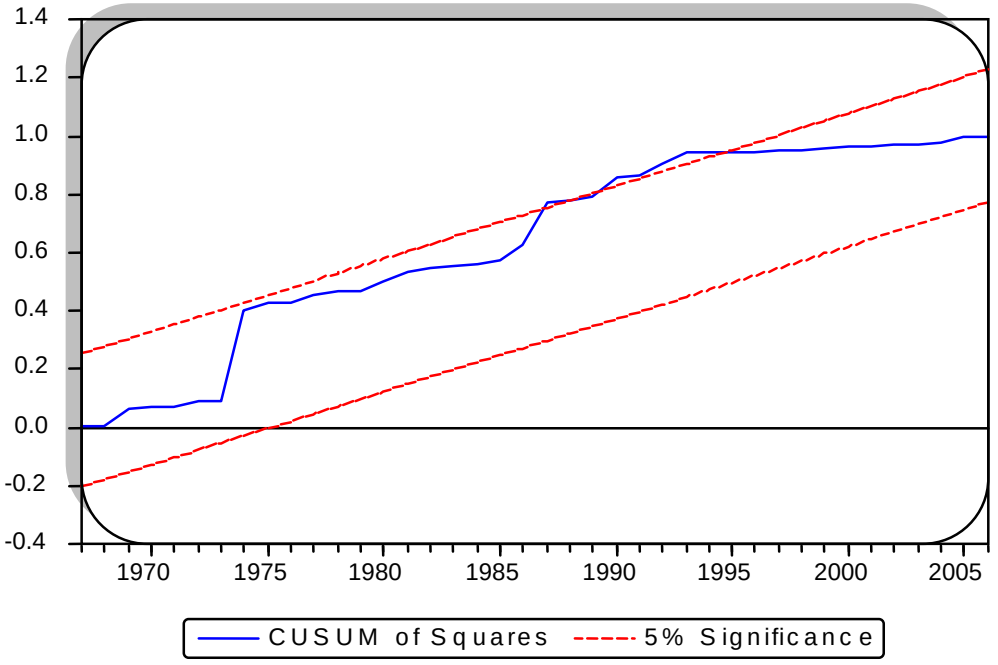


Figure A.3. cusum and cusumq test for Public educational expenditures based on Phillips-Hansen Co-integration test.

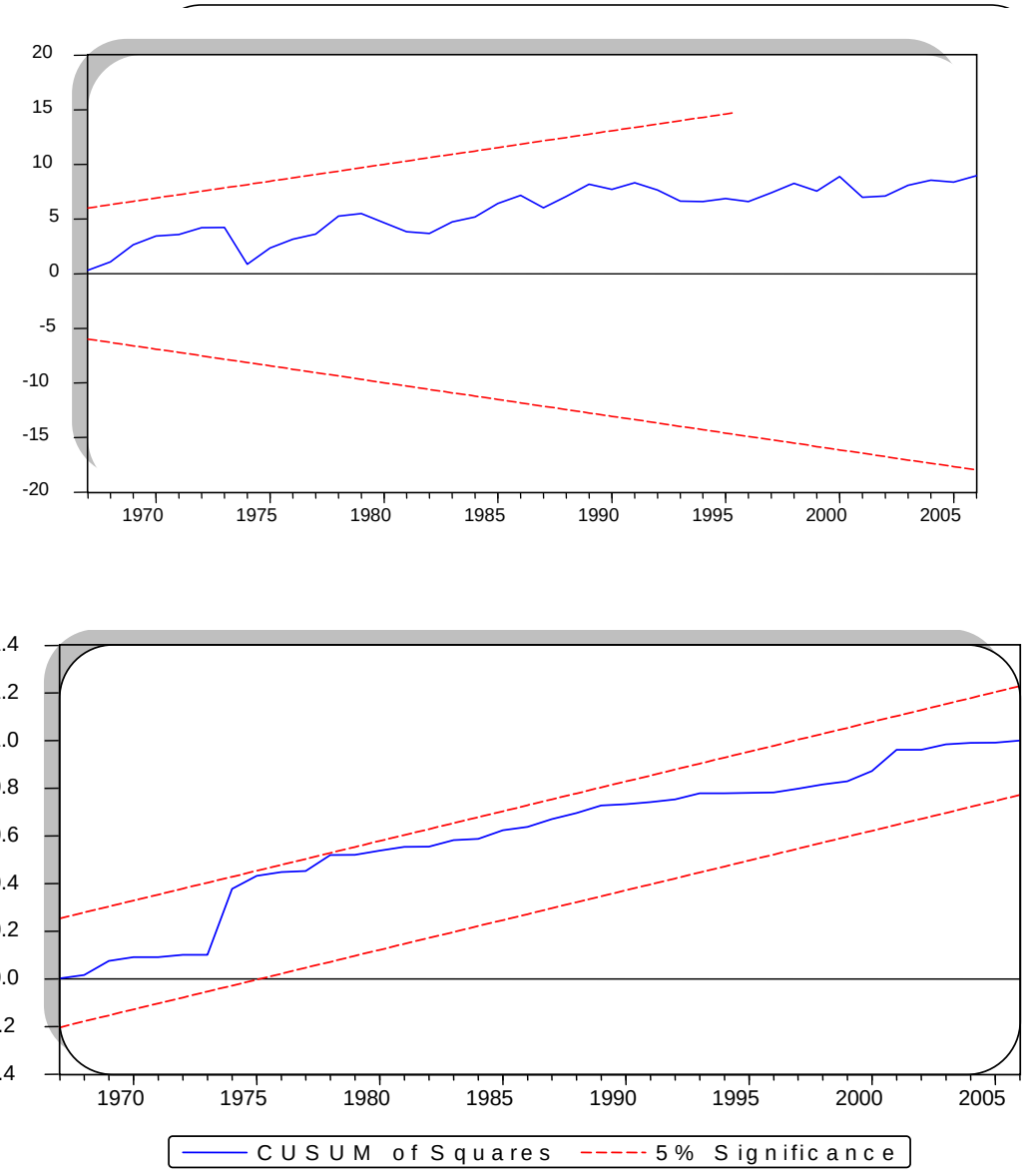
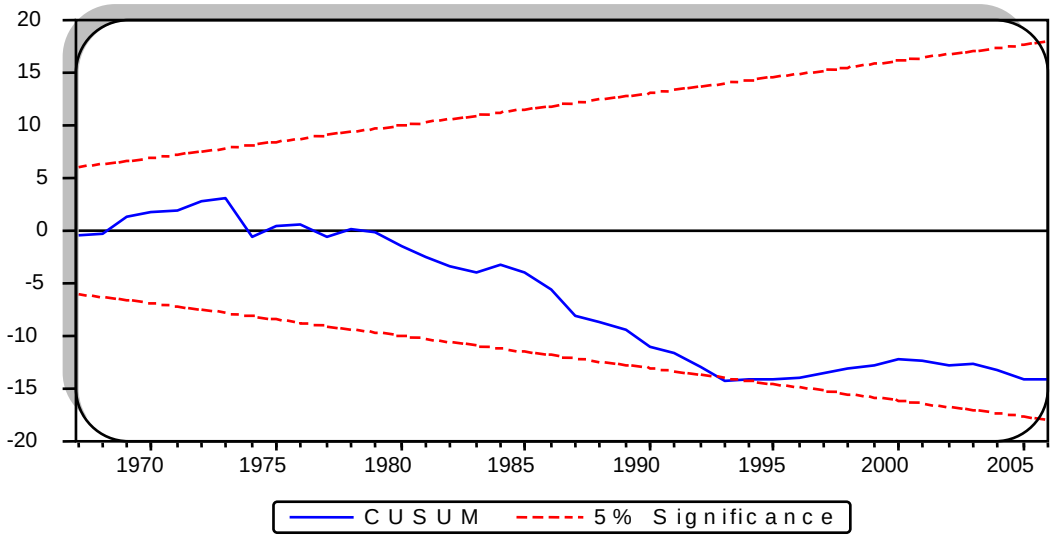


Figure A.4. cusum and cusumq test for Tertiary Education based on Phillips- Hansen Co-integration test.



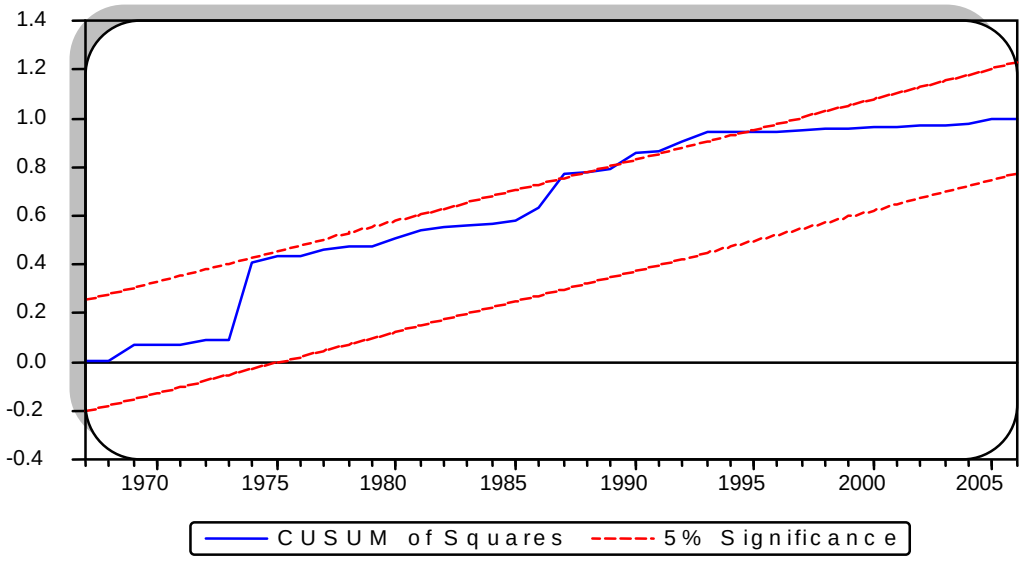
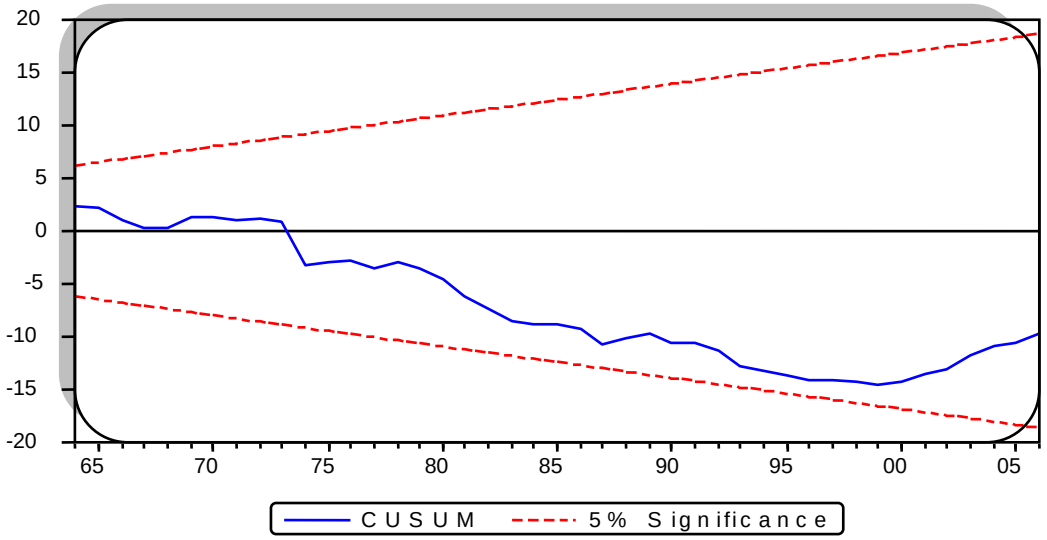


Figure A.5. cusum and cusumq test for Public educational expenditures based on Johansen-Juselius Co-integration test.



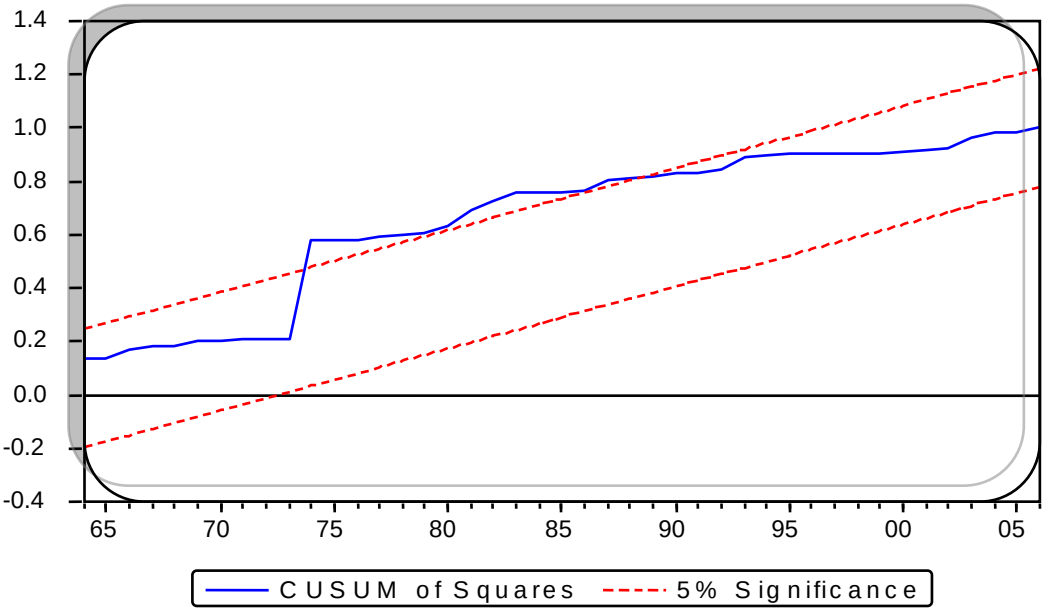


Figure A.6. cusum and cusumq test for Tertiary Education based on Johansen-Juselius Co-integration test.