Pergamon

Economics of Education Review 21 (2002) 513–521

Economics of Education Review

www.elsevier.com/locate/econedurev

Growth and educational levels: a comparative analysis

P.E. Petrakis [a,*], D. Stamatakis [1,b]

[a] *Athens Kapodistrian University, Stadiou 5, Suite 106, Athens 10562, Greece*
[b] *Athens Kapodistrian University, Stadiou 5, Suite 308, Athens 10562, Greece*

Received 6 December 1998; accepted 21 May 2001

Abstract

This article investigates the effect of human capital on growth in three groups of countries that exhibit significantly different levels of development. The empirical work attempts to uncover differences between OECD developed market economies and less developed countries to show that each educational level contributes to growth among countries of different development levels. The empirical findings of the cross-country data sets suggest that the link between growth and education varies as a result of different levels of economic development. They also suggest that the role of primary and secondary education seems to be more important in LDC nations, while growth in OECD economies depends mainly on higher education. © 2002 Elsevier Science Ltd. All rights reserved.

JEL classification: 011; 047; 053; 120

Keywords: Human capital; Educational levels; Growth; Level of development

1. Introduction

The present study constitutes an empirical attempt to link economic growth with investment in human capital, by detecting differences in the way that level-specific educational investment contributes to growth. It investigates and compares three cross-country groups of significantly different development: less developed, developed and advanced. The newly developed and advanced groups pertain to OECD countries, while the less developed group corresponds to poor nations outside the OECD. The empirical section of this study utilizes the new endogenous growth theory by projecting a corresponding stochastic model for three alternative country groups, one for each development category, and comparing the coefficients of each educational level among the different development categories.

2. Prior research

In recent times, education has been recognized as a very important growth factor. Alderman, Behrman, Ross, and Sabot (1996) claimed that developing countries invest over $100 billion per year on education and other human capital investments such as health. Consequently, understanding how these investments contribute to growth becomes a very important factor in understanding growth trends and growth differences in a worldwide context.

A wealth of theoretical contributions by, among others, Lucas (1988), Becker, Murphy, and Tomura (1990), Mulligan and Sala-i-Martin (1992) and Mankiew, Romer, and Weil (1992), have provided a conceptual framework that links education and growth.

Psacharopoulos (1989, 1994), Mincer (1988), Cohn and Geske (1990), Cohn and Addison (1998) and others have concentrated their efforts in the alternative direction

* Corresponding author. Tel.: +30-11-301-3689353; fax: +30-11-301-3689352.

E-mail addresses: ppetrak@cc.uoa.gr (P.E. Petrakis), stamatd@hotmail.com (D. Stamatakis).

[1] Tel.: +30-11-301-3689359; fax: +30-11-301-3689352

PII: S0272-7757(01)00050-4

of calculating and comparing educational rates of return for different countries.

In contrast to classic contributors (Schultz, 1961; Denison, 1985 etc.) that tried to explain the impact of education on growth by technological change, modern theorists such as Romer (1986, 1990) and Lucas (1988) attempted to provide satisfactory answers to the so-called "convergence controversy".[2] They re-emphasized the role of human capital by stressing the impact of education in the context of formal schooling and on-the-job training. Lucas (1990) explained that technology fails to flow to poor countries because of their poor endowment in complementary human capital, a claim which is consistent with aggregate cross-sectional studies conducted by Benhabib and Spiegel (1994).

Overall, most of the growth literature and the empirical work about human capital could lead to two stylized facts of great interest: (a) economies with a larger stock of human capital experience faster growth; and (b) investing in schooling is a prerequisite for the creation of human capital which, in turn, generates ideas and promotes the development of new products (Romer, 1990).

In an attempt to understand the growth miracle of East Asia, Kim and Lau (1996) and McMahon (1998) produced empirical evidence to the effect that, if political stability was assumed, investment in education was a key factor in the rapid growth rates. Barro's (1991) cross-sectional study involving 98 countries found a positive relationship between enrolment rates and growth, while the role of initial GDP per capita was negligible for flexible enrolment rates. On the other hand, when enrolment rates were held constant, the correlation between per capital growth and initial GDP became negative. Romer (1990) stressed the importance of human capital as a key input in research, while Nelson and Phelps (1966) claimed that a high level of initial human capital improved an economy's ability to utilize new ideas discovered elsewhere.

Psacharopoulos (1994) demonstrated empirically that in less developed nations, the educational effect of primary education (in a rates of return context) was higher than in the developed economies. A similar argument is presented by Esim (1994), in which she distinguishes the importance of secondary education in the growth of some Asian countries (S. Korea, Malaysia and Thailand) that are in the developing stage.

Apart from the theory-consistent empirical findings, with regard to the positive contribution of human capital to growth, Kim and Lau (1996), in an empirical study of East Asia, found no relationship between human capital and technological progress. This result must be treated with some scepticism, however, since technical progress should, at least partly, be the outcome of education. A speculative explanation for this could that technical progress is due to higher education,[3] which provides the foundation for R&D. Regarding East Asia, McMahon (1998) found that a higher contribution to growth is made by primary and secondary education. Consequently, a closer look at the growth role of each educational level may provide an explanation for the findings by Kim and Lau.

These prior findings delineate a field in which the role of education on growth is relevant to the issue of economic maturity and level of development. The efficient utilization of human capital investment could be studied in the context of specific educational levels and not as a totality when an economy's level of development is identifiable.

The present attempt is expected to complement prior empirical studies (Barro, 1991; Kyriacou, 1991; Lau, Jamison, & Louat, 1991) that used large cross-section samples. Furthermore, it emulates the methodology and perspective of a recent study done by Barro (2000), in which growth determinants were compared between three groups of countries; OECD, rich and poor.

3. Methodology and data

Since the focus here is on identifying differences among three distinct groups of countries, it is vital to group the data into subgroups of adequate similarity in terms of development level. The level of industrialization meets this requirement as a criterion for capital stock and economic advancement, which in most ways are synonymous with economic development. The categorization is based on GDP, physical capital stock and a composite index of development found in UNDP (1997).

The country data is divided into three groups: advanced economies, newly developed economies and less developed economies. The newly developed group is taken from the OECD's developed market economies, but its average level of capital stock is significantly lower than that of the advanced group, while the less developed

[2] By which growth rates of poor countries tend to be larger than those of wealthy ones. As a result, in a global sense, there is a convergence dynamic towards a comparable per capital income level. This is called β-convergence, and as shown by Barro and Sala-i-Martin (1992), the existance of β-convergence does not eliminate the possibility of σ-convergence which refers to income dispersion.

[3] Technical progress is mainly the result of R&D but it would be logical to assume that the R&D function is carried out by employees who have, at least, completed university; most research and product development teams are mainly staffed by personnel who have acquired post-graduate degrees.

group consists of non-developed market economies[4] with low levels of capital stock (see Table 1). It should be noted that the term "developed" is somewhat vague; the purpose though is to define a group that has either recently entered the developed stage or is approximately within that group. The data set is in a pooled format for two different time periods. Of course the values of the variables do not correspond to the same year because of the existence of time lags.

The pooled data set for the empirical part was obtained from three different sources. The educational data was obtained from the work of Psacharopoulos and Ariagada (1986, 1991), while Barro and Lee (1993) also provided some help in compiling the data set. Growth and capital stock data was retrieved from the Summers and Heston (1991) data set and from the OECD reports *Trends in developing countries* (1996) and *Historical statistics* (1997b). In general, the educational data refers to the educational attainment of the labour force, while capital investment is quoted as a GDP percentage.

4. Model specification

The model is adapted from endogenous growth theory and function is based on Lucas's (1988) production function with Romer's (1986) contribution, as developed out of Solow's (1956) neo-classical production function. This production function differs from previous ones in that, in addition to the endogenous determination of human capital (household time allocation decisions), it also contains an externality effect. The average level of education in society as created by households and educational institutions raises productivity within the firm.

Lucas's (1988) production function is then followed by some simplifications, originally attempted by Kim and Lau (1996) and also found in McMahon's (1998) empirical work.

Table 1
The three groups of countries for which data was compared

Advanced (OECD)	Developed (OECD)	Less developed (world)
USA	Mexico	Mauritius
Canada	Belgium	Pakistan
Japan	Greece	Sri Lanka
Germany	Spain	Paraguay
UK	Korea	Zambia
France	Netherlands	Indonesia
Denmark	Portugal	Nigeria
Sweden	Turkey	India

[4] This classification refers to non-communist economies; communist economies are totally excluded from this study.

The implicit production function is:

$$Q_t = f(K_t, N, \mu_t H_t) A H_t^a \tag{1}$$

where: Q=output, K=physical capital, H=average level of human capital employed in the economy, μ=proportion of time that each worker devotes to production within the firm; thus μH=human capital engaged within the firm, N=number of persons, while A represents the technological state and H^a denotes the productivity effect within the firm of the average education level in society created by households and educational institutions.

Note that human capital would be engaged either in the production of goods (μ) or in the production of more human capital ($1-\mu$); these fractional uses of human capital, in aggregate, would more or less disappear and as a result a simpler form would be obtained. In succession, if both sides are differentiated with respect to time and divided by output (Q), the percentage change format of the simplified production function is:

$$\partial Q/\partial t\ 1/Q = \partial Q/\partial K\ \partial K/\partial t\ 1/Q + \partial Q/\partial N\ \partial N/\partial t\ 1/Q + \partial Q/\partial H\ \partial H/\partial t\ 1/Q. \tag{1a}$$

It will be observed that the resulting partial derivatives $\partial Q/\partial K$, $\partial Q/\partial N$, $\partial Q/\partial H$ are the marginal products (mp^K, mp^N, mp^H) of physical capital, number of workers and human capital respectively and that $\partial K/\partial t$ and $\partial H/\partial t$ represent the investment flows for the given year(s), in physical and human capital. In Eq. (1a) lags have not been specified; it has been observed that the lagged effect of investment on physical capital is approximately 4 years ($t-4$), while on human capital it is between 10 and 12 years ($t-12$). If a different notation is used for the percentage change terms,

$$\partial Q/\partial t\ 1/Q = q,\ \partial Q/\partial N\ 1/Q = n,\ \partial Q/\partial H\ 1/Q = I^h,\ \partial K/\partial t\ 1/Q = I^K,$$

and if lags are taken into consideration, then [Eq. (1a)] becomes:

$$q_t = mp^K I^{K_{t-4}} + mp^N n_t + mp^H I^{H_{t-12}}. \tag{1b}$$

At this point, ($N_t/Q_t = n_t$) could be subtracted from both sides and by assuming that $mp_t^N = 1$, this would result in the following equation:

$$q_t - n_t = mp^K I_{t-4}^K + mp^H I_{t-12}^H. \tag{1c}$$

Note that the left-hand side of Eq. (1c) represents GDP growth per capita($\ln(q/n) = \ln q - \ln n$), while the right-hand side depends only on physical and human capital investment as percentages of the GDP, since the additions to capital stock ($\partial I/\partial t$) per time period (t) are divided by total output (Q) for the same time period.

Furthermore, the countries within each sample should be assumed not to have asymmetric output cycles; the timing of their recession or growth periods should be approximately the same. A situation in which some of the countries, within the same sample, were at their peak while others were at the bottom of their business cycle would ultimately lead to faulty conclusions; the recent worldwide trends towards economic globalization favours this assumption.

Consequently, GDP growth per capita becomes dependent on investments in human capital (I^H is broken into three; investment in lower (I^l) secondary (I^s) and higher education (I^k), and physical capital, as GDP percentages and if the marginal products are replaced by c_i:

$$q_t - n_t = C + c_1 I^l_{t-12} + c_2 I^s_{t-12} + c_3 I^h_{t-12} + c_4 I^k_{t-4}. \quad (1d)$$

By tracing the level-specific effect of human capital, educational investment is broken down into investment on lower, secondary and higher education and represented as a percentage of GDP.

In order to measure investment in education, an indicator is required that could be adapted as an index of educational output such as the completion rates of the referred levels. McMahon (1999, pp. 164, 166) finds a highly significant positive relation between investment in education leading to higher enrolment rates that are consistent with the logic of the process (Eqs. 11.8–11.5). Similarly, this positive relation is also found between investment in education and completion rates when the latter are expressed as a percent of those who complete the 5th grade (Eqs. 11.8–11.9). This kind of completion rates give a measure of the success of the school system in producing graduates, and therefore reflect the quality of education as distinguished from enrolment rates that mainly reflect quantity. There are differences in the impacts of investment (interpreted to include the quality of education) and enrolment rates (measuring primarily the quantity of education) that are explored further in McMahon (1998).

Consequently, completion rates could be a reasonable proxy for investment. Of course, it should be noted that the variables I^l, I^s, I^h lose in some sense their flow characteristics based on the derivation of Eq. (1d); this is a result of using data on completion rates. Consequently, this practice alters somewhat the interpretation of the coefficients c_1–c_3. They capture the growth effect (or marginal product) of the completion rates rather than the effect of investment in education. The logic that would support the preceding replacement could be on the grounds that investment in education determines the completion rates via qualitative factors such as teaching quality and via quantitative factors such as facilities and teaching personnel. Alternatively, since enrolment rates represent additions to human capital stock and since enrolments are highly correlated with completion rates, they could be interchanged perhaps with some lag difference; based on this rationale, it is through their effect on completion rates that additions to human capital contribute to growth.

Furthermore, using completion rates as a proxy for investment in human capital could pose a problem in the poor country group as a result of inefficient resource use within the educational system, especially for higher education. On the other hand, it captures the general importance of the growth impact of education, regardless of the peculiarities found within each educational level. After all, the object of this study is not to examine each country's optimality conditions within each level; these are intrinsically captured by the development grouping.

Hence, having performed the substitutions the corresponding regression model would become:

$$y_t = + a_1 ED^l_{t-12} + a_2 ED^s_{t-12} + a_3 ED^h_{t-12} + a_4 I^k_{t-4} + u_i \quad (1e)$$

where, except u_i which is the stochastic term, the variables in the above model are defined as follows:

y_t	=five-year average (1977–82 and 1989–94) growth of GDP per capita for the years 1982 and 1994, for advanced and newly developed (i.e. OECD groups), OECD (1997a), calculated from table and for LDCs, OECD (1996);
I^k_{t-4}	=real gross private investment as a percentage of GDP for the years 1978 and 1990; the data for the OECD groups were from the "Economic outlook" section in OECD (1997b) and IMF (1997); and for the LDC group, OECD (1996);
ED^i_{t-12}	=the completion rate of the ith educational level (e.g. i=1 for primary), for the years 1970 and 1982, as a percentage of the labour force, Psacharopoulos and Ariagada (1986), Tables 1 and 2. For a few countries the educational data was missing; these value were approximated from Barro and Lee (1993), Tables 5–8.

Finally, it should be emphasized that due to the nature of the sample, being a pooled sample of only two periods, the intercept term was omitted since it did not alter the significance of the model. It should be noted that R^2 was higher by 0.002 and its t-value was less than 0.2. For a time series sample, the intercept would normally be used to test for the convergence hypothesis, whether or not it shifts through time.

5. Econometric procedures and properties

The empirical results of Table 2 have been obtained by the Weighted Least Squares (WLS) regression method in which the weights are cross-section weights. This constitutes a variation of the least squares method. This procedure first divides the weight series by its mean

Table 2
WLS estimation results of Eq. (1d), after correcting for heteroscedasticity; the terms in parentheses are the corresponding *t*-values from the WLS estimation

Variables	Advanced (OECD)	Developed (OECD)	Less developed	y_t (10 yr average)
$a_{1(t-12)}$ primary education	0.40942	0.2681	0.44883	0.004403
	(12.66192)*	(2.48916)*	(1.327857)	(0.327857)
$a_{2(t-12)}$ secondary education	0.315262	1.430081	1.512706	0.462406
	(1.92145)**	(1.185311)	(3.531951)*	(3.531951)*
$a_{3(t-12)}$ higher education	−0.113143	0.268194	0.445216	0.541113
	(−0.636343)	(0.137655)	(1.834390)*	(1.834390)*
$a_{4(t-4)}$ physical capital inv.	0.707979	1.6359	0.311664	1.53521
	(2.33711)*	(1.889)*	(21.00365)*	(21.00365)*
n	16	16	16	16
R^2-adjusted	0.514707	0.611707	0.981978	0.3470789
F-ratio**	5.886721	6.301506	273.4430	2.067862
BL-statistic	1.391808	0.365952	1.090944	2.376176
W-statistic	2.0113	1.1838	0.258501	0.259890
ARCH-statistic	1.62452	1.24017	0.313697	0.958308

and then multiplies all of the data for each observation by the scaled weight series in such a way as to normalize the data set. This does not affect the parameter estimation but makes the weighted residuals more comparable to the unweighted ones. This procedure is quite common, especially when heteroscedasticity of a known form is a problem. It is also permissible to use it in combination with other correction methods for heteroscedasticity (see below).

Another issue in running the specific model is simultaneity. Incorporating the independent variables into the regression equation without the prior specification of a system does impose a theoretical void, but the lag structures are sufficiently long for the equation to be described as recursive.

5.1. Heteroscedasticity

To test for heteroscedasticity, White (1980) developed a test which regressed the squares of the regression residuals to the explanatory variable and their squares:

$$u_i^2=b_1ED^l_{t-12}+b_2ED^s_{t-12}+b_3ED^h_{t-12}+b_4I^k_{t-4}+b_5(ED^l_{t-12})^2 +b_6(ED^s_{t-12})^2+b_7(ED^h_{t-12})^2+b_8(I^k_{t-4})^2+e_i.$$

It should be noted that White's test with the cross terms (i.e. $b_i(ED^l_{t-12}ED^h_{t-12})$) would be more efficient, but in that case the degrees of freedom would be very low (e.g. for an *F*-test d.f.=2). As a result, the critical region would be too large in order to minimize the possibility of a type-I error. The null hypothesis would be that all coefficients are equal to zero (b_1=b_2=…=b_8=0), that is, the absence of heteroscedasticity, while the calculated statistic could be either an *F* or chi-square. Whites's test detected heteroscedasticity; of course, even though cross terms were omitted the degrees of freedom were still low and this consequently reduced the power of the test (1-type-II error).

Once heteroscedasticity was detected in addition to cross-section weights, another countermeasure was taken; Whites's heteroscedasticity-consistent covariance method of correction was used, being applied also to the calculation of the standard errors and the *t*-statistics. After the correction, heteroscedasticity could not be detected neither by White's test nor by the ARCH-LM test. The critical value for White's test is: $\chi^2_{8,\,0.95}$=15.51 and in the case of the complementary regressions (Tables 5 and 6 in the expanded version, see footnotes 5 and 6), $\chi^2_{6,\,0.95}$=12.59 (in the output this statistic is quoted as *W*-statistic), and the critical value for ARCH's test is $F_{0.05}$=9.07 (quoted as ARCH).

5.2. Autocorrelation

The presence of autocorrelation is not significant in this econometric model, except for the medium group, which demonstrates a moderate problem of autocorrelation. The testing procedure is a modification of the Durbin and Watson procedure as used by Baltagi and Li (1991). The test follows a χ^2 distribution and the critical value at the 95% significance level is: $\chi^2_{1,\,0.05}$=3.4841 (the statistic is quoted on the output tables as BL) and the null hypothesis is the absence of autocorrelation. If BL$<$3.4841 there is no autocorrelation problem of first order (note, that the pooled sample has a time series of only 2 years).

5.3. Multicolinearity

The possibility of multicolinearity imposes a serious threat to the unbiased assumption of Least Squares estimation; a relationship between the error term and the independent variables can seriously bias the estimated coefficients, especially when there are unobserved or omitted variables Levine and Renelt (1992). This would definitely weaken the validity of the findings, since it would make them sensitive to the specification of the model. This possibility was dealt with by forming sample groups including countries from different geographical regions. In this way the factors that could impose simultaneous deviations on each country group were minimized.[5]

6. Interpretation of empirical findings

The results of the WLS procedure, shown in Table 2, demonstrate different coefficient values that could indicate differences in the way the three education levels affect growth in the different country groups. To investigate whether these differences are significant among the three groups, further testing should be done in two directions: first it should be established that the education coefficients within each regression are statistically different, for which a Wald testing procedure is adapted; and secondly, an *F*-test is performed in order to test for differences among the coefficients of the three separate regressions.

Overall, the coefficient signs are positive (except the one for higher education in the advanced group); this highlights the general importance of educational investment in economic growth.

One rather trivial finding, is the negative coefficient of higher education in the advanced group. It should be marked that the education coefficients of this group changed signs when the growth rate was averaged for different time lengths; specifically when the growth rate was averaged over 10 years (Table 3, column 4), the education coefficients became positive. Furthermore, when the growth rate was not an average, but referred solely to the years 1982 and 1994, higher education exhibited a positive coefficient while the coefficients of primary and secondary were negative.[6] This merely demonstrates a violation of the growth role of education but it could be attributed to exogenous shocks, for example the two oil crises in 1972 and 1978 could have a carrying-over effect; 1982 was also a recession year for most of the advanced nations.

In general, though, for long-run growth rates (Table 2, column 4), the educational effect of the advanced countries is consistent with endogenous growth theory (i.e. positive).

In addition to the results presented in Table 2, it would be of interest to run complementary regressions by manipulating the education variables. One rather interesting finding relates to the advanced group, where a drop in R^2 was produced when higher education was left out, and a remarkable increase in R^2 when higher education was included.[7] It is quite possible that this movement in R-square underlines the importance of higher education in advanced countries, an implication which has gained a lot of acceptance in recent years, where investment in human capital has become a priority.

Table 3
Wald testing results for the null hypothesis *Ho*: $a_1^i=a_2^i=a_3^i$ at a significance level of 95%

Country group	χ^2-statistic	Critical value $\chi^2_{n,\,0.05}$	Decision
Advanced	6.281072	5.14	Reject Ho
Developed	23.86006	5.14	Reject Ho
LDC	9.311841	5.14	Reject Ho

7. Hypothesis testing

Before analysing and interpreting the results, as mentioned above, two types of tests are performed. In an attempt to test whether the educational contribution of each level differs significantly within each country group, a Wald coefficient test is conducted. The null hypothesis is whether the estimated education coefficients of each regression are equal; *Ho*: $a_1^i=a_2^i=a_3^i$, where *i* indicates the country group. The Wald-statistic follows a χ^2 distribution. Table 3 contains the critical values, the calculated χ^2 statistics and the testing results.

Observing the results in Table 3, the educational coefficients within each country group are statistically different and one could argue that each educational level has a unique growth role and, as a result, its growth contribution differs significantly with the other educational levels.

The second testing procedure will test whether the vectors of the estimated coefficients are significantly different between the three country groups. If the estimated equations have the form:

[5] The zero-order correlation matrix did not reveal any problems—included in the expanded version; see footnotes 5 and 6.

[6] The relevant tables can be found in the expanded version of the present article at the following URL address: http://elearn.elke.uoa.gr/petrakis.

[7] The relevant tables can be found in the expanded version of the present article at the following URLaddress: http://elearn.elke.uoa.gr/petrakis.

$\mathbf{y}^i = \mathbf{X}^i \mathbf{a}^i + \mathbf{e}^i$,

where i indicates the country group (advance; i=adv, developed; i=dev and LDC; i=ldc), and **X**, **a** and **e** represent vectors of independent variables, coefficients and residuals, respectively, then the testing procedure will test the null hypothesis:

Ho: $\mathbf{a}^{adv} = \mathbf{a}^{dev}$, $\mathbf{a}^{adv} = \mathbf{a}^{ldc}$, $\mathbf{a}^{ldc} = \mathbf{a}^{dev}$ (hypothesis 1).

The above hypothesis test will indicate coefficient differences—if any—between any two groups of countries; furthermore, the hypothesis:

Ho: $\mathbf{a}^{adv} = \mathbf{a}^{dev} = \mathbf{a}^{adv}$ (hypothesis 2)

will test if there are statistical differences in the estimated coefficients between the three country groups in a simultaneous testing procedure. The test follows an F-distribution and the results are presented in Table 4.

On the basis of the regression coefficients and hypothesis testing (Table 4, row 4) it could be argued that the growth effect of each educational level differs among countries of different economic maturity. Primary and secondary education seems to be very important in the case of LDC and developed groups, while growth in the advanced economies seems to rely mainly on higher education in the long run (Table 4, column 4).

Taking the results of the F-test (Table 4, rows 2 and 3), one could safely say that the OECD groups significantly differ from the LDC group, in the way investment relates to growth. On the other hand, OECD countries (i.e., advanced and developed groups), don't differ significantly from one another. This could be explained by the development distance that separates OECD with LDC countries.

One note of caution in regards to the "Developed" group is its low R^2, which diminishes the applicability of the statistical inference. On the other hand, the fact that the sign of the coefficient for physical capital investment is positive and significant throughout increases the validity of the findings, given its conformance with growth theory.

In general, it appears to be the case that the effect of human capital investment on growth is merely relevant to the level of development. The results suggest that advanced economies benefit more from higher education, while poor ones rely more on primary and secondary education.

Table 4
F-test results for hypotheses (1) and (2) at a 95% significance level

Null hypothesis	F-statistic	Critical value $F_{n1, n2}$	Decision
$a^{adv}=a^{dev}$	2.39	2.78	Fail to reject Ho
$a^{adv}=a^{ldc}$	8.13	2.78	Reject Ho
$a^{ldc}=a^{dev}$	3.58	2.78	Reject Ho
$a^{adv}=a^{dev}=a^{ldc}$	13.127	2.64	Reject Ho

This statement does not contradict prior claims found in the literature. McMahon (1998) concluded in his East Asian research that investment in human capital played a significant role in the high growth rates of East Asian economies. In addition, he claimed that secondary education played a more important role, since high government investment in secondary-level education, high enrolment rates at this level and political stability have triggered an increase in investment in physical capital. Furthermore, Kiso (1993) and Esim (1994) have identified a special development role for secondary education in East Asia. In a similar context, but ignoring primary education, Barro and Sala-i-Martin (1995) and Mankiew et al. (1992) have shown, in cross-section world data, the special role of secondary education, while Kim and Lau (1996), in relation to human capital, did not identify a separate role for technical progress in East Asia. Furthermore, Barro (1991), in his cross-section study, also noted the importance of initial enrollment rates as a convergence factor; primary and secondary enrolment rates in Africa and Latin America were significantly lower and therefore these countries did not acquire the potential for convergence.

In a global scale study on rates of return, Psacharopoulos (1994, Table A-1, p. 1328) indicated that low-income countries relied heavily on primary education and moderately on secondary education while higher education seems to be more profitable in wealthy countries. By way of contrast, and in a manner consistent with the findings of this article, an OECD study by Cohn and Addison (1998) demonstrates that wealthy OECD countries have higher rates of return on university education than the poorer ones. As can be calculated from Table 1 in Cohn and Addison (1998), the mean rate of return on university education in the G7 countries (17.2) is significantly higher than mean rates of return for the rest (13.93).[8]

Thus far, there is evidence to suggest that the growth effect of education on each level is not irrelevant to the development stage of the economy concerned. Kiker, Santos, and de Oliveira (1997) in reference to Portugal, and Magoula and Prodromidis (1999) in reference to Greece, imply that the high completion rates of higher education contributed to unemployment, with a negative overall effect on the economy. Consequently resource allocation, at least on education, was not being carried out optimally.

[8] The mean rates for the G7 countries and the others were calculated from the male column for 1994, in Cohn and Addison (1998, Table 1, p. 257).

8. Conclusions

This paper has attempted to conduct empirical research, in a pooled data context, to investigate the connection between the growth effect of education and the level of development. Most importantly, it has stressed the breaking down of education into its level components, after dividing the country sample into three subgroups by level of development and performing a WLS procedure comparing the coefficients of each educational level within each group and among the three groups.

The empirical findings, consistent with prior findings, merely suggest that as the level of development increases so does the contribution of higher educational levels, especially in reference to OECD versus LDC countries. Alternatively, physical capital seems to have played a more important role in OECD nations. In general, the empirical findings in the context of Lucas' production function indicate structural differences in the way educational investment relates to growth, between OECD and LDC countries, complimentary and consistent with the conclusions in Barro (2000); especially the ones that refer to secondary and higher education.

It should be recognized that the scope of this study has been confined to GDP market-measured effects, and ultimately bypasses non-market externalities, which also constitute part of the economic development impact of education. These non-market effects and externalities, defined and estimated for OECD nations (among others) in McMahon (1999), tend to raise the total returns above the purely market effects.

Acknowledgements

The authors wish to express their great appreciation to Professor G. Psacharopoulos for his constructive input, his wealth of knowledge about the subject and his kindness in providing them with references and data sources. In addition, special thanks are dedicated to the anonymous referee of EER for his/her constructive comments and dedication to share knowledge; a rather exceptional quality. Finally, it should be mentioned that the present work was partly financed by the Hellenic Ministry of Education.

References

Alderman, H., Behrman, J. R., Ross, D. R., & Sabot, R. (1996). The returns to endogenous human capital in Pakistan's rural wage labor market. *Oxford Bulletin of Economics and Statistics*, *58*, 29–55.

Baltagi, B. H., & Li, Q. (1991). A joint test for serial correlation and random individual effects. *Statistics and Probability Letters*, *13*, 277–280.

Barro, R. J. (2000). *Education and growth*. Working paper.

Barro, R. J. (1991). Economic growth in a cross section of countries. *Quarterly Journal of Economics*, *106* (2), 407–444.

Barro, R. J., & Lee, J. W. (1993). International comparisons of educational attainment. *Journal of Monetary Economics*, *32*, 363–394.

Barro, R. J., & Sala-I-Martin, X. (1992). Convergence. *Journal of Political Economy*, *100*, 223–251.

Barro, R. J., & Sala-I-Martin, X. (1995). *Economic growth.* New York: McGraw-Hill.

Becker, G. S., Murphy, K., & Tomura, R. (1990). Human capital, fertility and economic growth. *Journal of Political Economy*, *98*, 279–288.

Benhabib, J., & Spiegel, M. M. (1994). The role of human capital in economic development: Evidence from aggregate cross country data. *Journal of Monetary Economics*, *34*, 143–173.

Cohn, E., & Addison, J. T. (1998). The economic returns to lifelong learning in OECD countries. *Education Economics*, *6*, 253–307.

Cohn, E., & Geske, T. G. (1990). *The economics of education* (3rd ed.). Columbia, SC: Academic Advantage. (Reprinted from Pergamon Press, Oxford.)

Denison, E. F. (1985). *Trends in American economic growth, 1929–1982.* Washington, DC: Brookings.

Esim, S. (1994). *Contribution of secondary education to economic development in S. Korea, Malaysia and Thailand*. Second Draft, Education and Social Policy Department, The World Bank.

IMF (1997). *International financial statistics.* Washington, DC: International Monetary Fund.

Kiker, B. F., Santos, M. C., & de Oliveira, M. M. (1997). Overeducation and undereducation: evidence for Portugal. *Economics of Education Review*, *16*, 111–123.

Kim II, J., & Lau, L. J. (1996). *The sources of economic growth of East Asian newly industrialized countries: some further evidence*. Faculty Working Paper Department of Economics, Stanford University, December 1995, Summarized in AEA Papers and Proceedings.

Kiso, I. (1993). *Secondary education and economic development in Japan: A case study of key policy decisions affecting the development of secondary education in Japan.* Japan: Ministry of Education.

Kyriacou, G. E. (1991). *Level and growth effects of human capital: a cross country study of the convergence hypothesis*. Unpublished paper, New York University Press.

Lau, L. J., Jamison, D. T., & Louat, F. F. (1991). *Education and productivity in developing countries: An aggregate production function approach*. Working Paper No. 612, The World Bank.

Levine, R., & Renelt, D. (1992). *A sensitivity analysis of cross-country growth regressions*. World Bank Working Paper Series 609. Washington, DC: World Bank.

Lucas, R. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, *22*, 3–42.

Lucas, R. E. (1990). Why doesn't capital flow from rich to poor countries? *American Economic Review*, *80*, 92–96.

McMahon, W. W. (1998). Education and growth in East Asia. *Economics of Education Review*, *17*, 159–172.

McMahon, W. W. (1999). *Education and development: Meas-*

uring the social benefits. New York: Oxford University Press.

Magoula, T., & Prodromidis, P. (1999). *Education and economic growth*. Discussion paper No 102, Athens University of Business and Economics.

Mankiew, N. G., Romer, D., & Weil, D. R. (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics*, *107*, 407–438.

Mincer, J. (1988). *Job training, wage growth and labor turnover*. NBER Working Paper No. 2690.

Mulligan, C., & Sala-i-Martin, X. (1992). *Two capital goods models of economic growth*. Unpublished paper, Yale University.

Nelson, R., & Phelps, E. (1966). Investment in humans, technological diffusion and economic growth. *American Economic Review*, *56*, 69–75.

OECD (1997a). *Education at a glance: OECD indicators.* Paris: OECD.

OECD (1997b). *Historical statistics.* Paris: OECD.

OECD (1996). *Trends in developing countries.* Paris: OECD.

Psacharopoulos, G. (1989). Time trends in the returns to education: Cross-national evidence. *Economics of Education Review*, *8*, 225–231.

Psacharopoulos, G. (1994). Returns to investment: a global update. *World Development*, *22*, 1325–1343.

Psacharopoulos, G., & Ariagada, A. M. (1986). The educational composition of the labor force: An international comparison. *International Labor Review*, *125*, 561–574.

Psacharopoulos, G., & Ariagada, A. M. (1991). *The international composition of the labor force: an international update*. Unpublished paper, The World Bank.

Romer, P. M. (1986). Increasing returns and long run growth. *Journal of Political Economy*, *94*, 1002–1037.

Romer, P. M. (1990). Endogenous technical change. *Journal of Political Economy*, *98*, 571–593.

Schultz, T. W. (1961). Investment in human capital. *American Economic Review*, *51*, 1–17.

Solow, R. M. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics*, *70*, 65–94.

Summers, R., & Heston, A. (1991). The Penn World Table (Mark 5): A new set of international comparisons, 1950–1988. *Quarterly Journal of Economics*, *106*, 327–368.

UNDP (1997). *Human development report.* New York: Oxford University Press.

White, H. L. (1980). A heteroskedasticity-consistent covariance matrix estimation and a direct test for heteroskedasticity. *Econometrica*, *48*, 817–838.