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The relation between education and economic growth for the period 1990 to 2020: A dynamic panel data model

Abdat Baya
Senior Lecturer B. Faculty of Economics and Business, University of Algiers 3, Algiers, Algeria
Email: abdat.baya@univ-alger3.dz

Boubaa Abdelwahab
Senior Lecturer A. Faculty of Economics and Business, University of Tipaza, Tipaza, Algeria
Email: boubaa.abdelwahab@cu-tipaza.dz

Mohammed Touitou
Faculty of Economics and Business, University of Algiers 3, Algiers, Algeria
Email: touitoutouitou@yahoo.fr

***Abstract*---**This study aimed at examining the relationship between economic growth and education in 62 selected countries, in the period 1990–2020. To prove these relationships, we used average years of schooling as a proxy for human capital, as well as Arellano and Bond's (1991) methodology. Our results are in favor of the theory according to which education is of vital importance to explain the growth rate of an economy. We found that the primary education level, out of the three used in the sample, significantly influences a country's economic growth rate.

***Keywords*---**Human Capital, Education, Economic Growth, Arellano-Bond.
JEL numbers: I20; O40; C33

1- Introduction

The idea that education is one of the foundations of a country's development is not new. For several decades until now, a concept that has been repeated by researchers in almost all fields of knowledge, the purpose of improving education

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in terms of coverage and quality through system reforms is a slogan used by policymakers. However, it is interesting to compare the data by how true this hunch is. This is why the aim of this research work is to examine the relationship between education and economic growth for a heterogeneous group of countries over several decades; that is, by using panel data methodology.

Despite the fact that there are many theoretical models that highlight the role of human capital in the growth of income in economies (Lucas, 1988; Romer, 1986), the truth is that there does not seem to be a consensus regarding the contrast of the theory with the data. Classic works such as that of (Barro,1991), or some less famous ones such as that of (Gyimah-Brempong, Mitiku and Paddison, 2006), find that education, which is one of the dimensions of human capital, does matter in explaining the growth of employment and Real GDP per capita. However, other research has found that this variable is not significant in explaining economic growth, at least by itself. Other works of (Levin and Kelley, 1994; Oroval and Escardíbul, 1998) highlight the importance of certain complementary inputs that must also be strengthened if education is to affect the per capita GDP growth rate.

Through the consolidation of a panel of data from 62 countries, with an analysis period that covers from 1990 to 2020, the present work intends to make an estimation by using the (Arellano, Bond, 1991) methodology to contrast the hypothesis according to which Education positively affects economic growth, a debate of great importance in terms of economic policy that has existed since the first studies that highlighted the role of human capital. Even taking into account that there are other aspects that are part of human capital, this paper will use education as a proxy variable. A review of the relevant literature shows that in works with international coverage, given the difficulty in finding more variables, education becomes the main way of measuring the accumulation of human capital.

Article content as follows: In Section 2, there is a review of the aforementioned literature. Section 3 explains the Arllano and Bond method for painting data. Section 4 contains results estimation by using the aforementioned methodology; and concludes in Section 5.

2- Literature review

Barro (1991) finds a series of empirical regularities with respect to the average economic growth rate 1960-1985 for a cross section of 98 countries. With respect to human capital, measured by school enrollment rates, the author finds that its initial level in 1960 is positively related to the growth rate of Real GDP per capita. However, it should be noted that Barro's analysis is static, since he uses averages of the dependent variable, which is the growth rate of Real GDP per capita, between 1960 and 1985 to measure the explanatory power of the human capital variables. It is evident that methodologies should be used to take into account changes over time in economic variables, and thus better capture their effects on the growth of an economy.

An important referent is the classic work by (Mankiw, Romer Weil, 1992), in which the authors used a version of the neoclassical Solow model augmented with human capital. In this modified model, it is argued that the accumulation of human capital helps to counteract diminishing returns in the accumulation of physical capital. Given that, the stock of human capital of a society is a variable that in turn has many components, such as the level of education, general health conditions, specific training for productive tasks, etc., the authors take as proxy the percentage of the working-age population enrolled in secondary school. The results obtained show that human capital, captured through the aforementioned education variable, is significant in explaining international differences in per-capita income.

For their part, (Levin, Kelley, 1994) test the postulates of many public policy makers, according to which education alone represents a solution to problems of inequality, productivity and economic growth. The researchers argue, based on evidence from previous studies, that improvements in education can only generate increases in productivity and boost economic growth if there are opportunities to employ that more educated workforce. That is, the effectiveness of education depends on the availability of other inputs that act as complements to said variable. This can sustain, as will be seen later, that it is also necessary to take into account factors such as the productive development of an economy in this sense.

In this same order, (Oroval, Escardíbul, 1998) analyze the treatment that various schools of economic thought have given to education as a determinant of economic growth. In their conclusion, the authors highlight the role of education and training as determinants of economic growth, emphasizing that a series of conditions (political, social, economic, cultural, etc.) must exist for this causal relationship to occur.

The article by (Krueger, Lindahl, 2001) sheds light on the apparent discrepancy between the results of micro-econometric studies at the country level, which find evidence that education is a determinant of income for individuals, and many of the studies at the macro level of growth, they do not find a significant relationship between the increase in education and the rate of economic growth. The authors conclude that this discrepancy is due to the high degree of measurement error in the data in the first differences in schooling between countries; once this measurement error is taken into account, it is found that the increases in the educational level are significant to explain the economic growth of the countries. Not only has the effect of education on growth been investigated, but also the implications of the existence of inequality in the distribution of said indicator of human capital within and between countries. Castelló and Doménech (2002) construct, based on educational attainment data, indices of inequality in human capital for a group of nations. With these data, the authors find that high levels of inequality in the education of the countries lead to low rates of investment and, consequently, low rates of economic growth.

Ramcharan (2004) uses a theoretical model to show how the composition of a country's human capital is highly relevant in determining the course of economic

development. The author argues that investing in the wrong level of schooling can lead to such accumulation of human capital having no effect on economic growth.

Wang Ying, and Chao Ni (2015) examined the relation between China's human capital and economic growth with the spatial effect among provinces during 1987 – 2007. The results indicated that there were significant spatial effects of human capital and economic growth in China.

Hanif Nadia, and Noman Arshad (2016) analyzed the impact and contribution of primary, secondary and tertiary education in economic growth of SAARC region over the period 1960-2013. The results showed that education has robust positive effect on economic growth.

Some scholars have demonstrated that educational development serves the needs of economic growth (Becker, Lewis, 1993) and that education improvement raises human capital, which improves labor quality and productivity. This directly or indirectly contributes to economic growth (McMillian, 2010; Min, 2017; Benos, Zotou, 2014; Zhao, Cai, 2022; Zhao, 2022). Different levels of education contribute differently to the economy, and higher education is considered as an important factor in enhancing economic competitiveness (Apostu et.al, 2022). Other studies have concluded that secondary education contributes far more to the economy than primary and university education (Irughe et.al, 2018).

Agasisti and Bertoletti (2022) focused their research on a largely developed region by investigating how education impacts growth in 284 regions within Europe. Their study reveals that the number of universities, their size, and quality of research output positively influences average income growth. Coman et al. (2022) in a study of former Communist States in Europe find mixed outcomes in how public education expenditure affects economic growth. Maneejuk and Yamaka (2021) specified a non-linear kink model in their study of ASEAN-5 (Association of South-East Asian Nations) countries. Enrollment levels at both secondary school and university levels enhanced output growth for individual countries while regionally, growth doubles when enrollment rates exceed a certain threshold.

3- Methodology

The fact that it would be very difficult – if not impossible – to obtain all the exogenous variables that probably explain Real GDP per capita growth for all the countries in the sample, leads us to consider the model of (Arellano and Bond, 1991) dynamic panel, since it uses the lagged dependent variable as one of the explanatory variables. Thus, having a variable that largely explains the dependent variable (itself lagged), other exogenous variables can be included that are available to contrast their importance in determining the dependent variable. Additionally, the Arellano and Bond methodology is appropriate for panel data in which the number of individuals is greater than the observation periods, as occurs in the present work (N=62, T=7).

Using the economic growth models of (Lucas, 1988; Rebelo, 1991), it is theoretically supported that the per-capita GDP growth of a country depends on its accumulation of physical capital and human capital, that is, on its propensity

to invest in capital goods and their educational achievements. On the side of the structuralism argument, a variable must also be included that captures the level of structural development of the economy, since it depends on this that an educated labor force can be successfully used. Some studies, such as that of (Ortiz, Castro and Badillo, 2009), tend to use the input-output coefficient of the manufacturing sector in the economy as a proxy for structural development. Said variable captures the level of integration existing in the industry of a country, which is a direct indicator of its structural development. However, for this it would be necessary to collect data on intermediate consumption and gross production of the manufacturing sector for each country in the sample, from the year 1985 onwards, which is considerably difficult. Therefore, the share of the manufacturing sector in GDP was taken as a proxy variable for structural development.

The variables employed in this study as follows: The dependent variable is the real GDP per capita growth rate for each country during the period 1990–2020. Investment variable: participation of investment in GDP per capita for each country. Education variable: average years of education for each country. During the analysis period, the relative size of the manufacturing sector in each country is the structural development. Therefore, the dynamic panel to be estimated by the Arellano and Bond method is the following:

$$gdp_{it} = \alpha + \beta_1 gdp_{it-1} + \beta_2 inv_{it} + \beta_3 educ_{it} + \beta_4 S2_{it} + \varepsilon_{it} \qquad (1)$$

Where: gdp variable, which is explained, as the real GDP per capita growth rate of each country in the period 1990-2020; the variable inv corresponds to the participation of the investment in the GDP per capita of each country; the variable $educ$ shows the average years of education for each country; Finally, $S2$ is the relative size of the manufacturing sector in each country for the years of analysis.

The present study uses three databases, covering the period 1990-2020 with level of variables every 5 years for countries around the world. On the one hand, the education variables are taken from the (Barro and Lee, 2010) database and database of the World Bank. On the other hand, the Heston, Summers and Aten (2009) database is used to extract the variables corresponding to real GDP per capita growth and investment as a proportion of real GDP per capita. The participation of the manufacturing sector in the economy was obtained from the World Development Indicators (2021) database of the World Bank. The number of countries in the sample turned out to be 62 after consolidating the different databases, since some of the nations that appeared in one did not appear in another.

4- Results and Discussion

Regressions were run using the (Arellano and Bond, 1991) estimator and other estimation methods for panel data, in order to compare results. In all the estimation methods, corresponding to Random Effects, Fixed Effects and the Arellano and Bond estimation, investment as a proportion of GDP (to capture the effort to accumulate fixed capital), the participation of the manufacturing sector

in GDP (to capture the level of structural development), and the various measures of human capital mentioned above. It is worth clarifying that the lagged dependent variable is only used in the Arellano and Bond estimation as an explanatory variable, since doing so in the other methods would result in inconsistent estimates. The results of the estimations are shown in Table 1.

Table 1. Estimation results by Fixed Effects, Random Effects and Arellano Bond using primary, secondary and tertiary education

Variable	Fixed Effects	Random Effects	Arellano-Bond
gdp(-1)	-	-	0,0357* (0,0201)
inv	0,1397*** (0,0492)	0,0420 (0,0357)	0,0754* (0,0386)
S2	0,0416 (0,0807)	0,1128*** (0,0384)	0,1771*** (0,0586)
Primary	1,0244* (0,5705)	0,0396 (0,2489)	1,2933*** (0,4617)
Secondary	0,3118 (0,6188)	0,3599 (0,4000)	0,2686 (0,5661)
Tertiary	4,3469* (2,5262)	-0,6589 (1,1735)	0,7626 (2,4364)
const	-7,1621*** (2,3722)	-1,6377 (1,2077)	-8,1961*** (1,4461)
Wald †chi square	-	14,06	86,09
R2	0,0210	0,037	-
Num. Of Instruments	-	-	26
Num. Of Observations	434	434	372
Significance level: ***1%, ** 5%, * 10%. Robust standard errors were used in all cases, which are shown in parentheses. †: for Random Effects, the Wald test is with 5 degrees of freedom; for Arellano-Bond, it is with 6.			

Source: own elaboration

As can be seen, the results using the Fixed Effects and Random Effects methodology do not show very significant effects of education on economic growth. The level of primary education and tertiary education were hardly significant at only 10%, using the Fixed Effects methodology. However, the coefficient of determination R^2 is extremely low for such an estimate. In the estimation by (Arellano and Bond, 1991) methodology, it is found that the variables of structural development and primary education are significant at 1%. This can be explained by the economic takeoff of some countries in the sample, which in the period of time analyzed went from initially having very few years of education and low economic growth, to accumulating human capital at its most basic levels and thus beginning to experience positive economic growth rates; however, the lagged dependent variable and the investment variable are only significant at 10%, while the other levels of education do not seem to be significant in explaining per capita GDP growth. In short, the results seem to

suggest that the most basic levels of education, together with the variables of physical investment and structural development, are determining factors for economic growth. However, the variable average years of total education can also be used to capture the possible effect that the three types of education together have on economic growth. The results of this are found in Table 2.

Table 2. Estimation results by Fixed Effects, Random Effects and Arellano-Bond using total

Variable	Fixed Effects	Random Effects	Arellano-Bond
gdp(-1)	-	-	0,0393** (0,0193)
inv	0,1446*** (0,0492)	0,0420 (0,0354)	0,0772** (0,0379)
S2	0,0381 (0,0798)	0,1084*** (0,0376)	0,1918*** (0,0573)
total	0,9303*** (0,2165)	0,1081 (0,1001)	0,8891*** (0,1561)
const	-7,0583*** (2,2332)	-1,5977 (1,1557)	-8,0371*** (1,2599)
Wald †chi square	-	14,06	94,73
F-statistic††	10,48	-	-
R2	0,022	0,036	-
Num. Of Instruments	-	-	24
Num. Of Observations	434	434	372

Significance level: *** 1%, ** 5%, * 10%.
Robust standard errors were used in all cases, which are shown in parentheses. In Arellano-Bond, the estimator of two steps by Generalized Least Squares was additionally used. †: for Random Effects, the test is with 3 degrees of freedom; for Arellano-Bond, it is with 4. ††: Fisher's test has degrees of freedom (3.61).

Source: own elaboration

As can be seen in Table 2, when using the Random Effects method, only one significant variable is obtained to explain economic growth, which is the proxy for structural development. Using the Fixed Effects method, both the education variable and the investment variable are decisive in explaining economic growth. However, the variable associated with the structural development of the economy is not significant, which would be in disagreement with the structuralism theory.

However, when analyzing the results of the estimation by the method of (Arellano and Bond, 1991) using total as the education variable, it is found that both the total educational achievements and the level of structural development of an economy, and its effort investment, have a significant impact on the growth of its Real GDP per capita. In addition, all variables have the expected sign. The sign of

the lagged dependent variable shows a positive relationship of the economic growth rate with its past, which would be in favor of the previously referenced sustained economic growth models (Rebelo, 1991; Romer, 1986; Lucas, 1988). Thus, it is notable that the average number of years of education in a country does seem to have a significant effect on its economic growth. In fact, it can be noted that the magnitude of the coefficient associated with the educational variable is similar in the estimation by Fixed Effects and by the Arellano and Bond methodology.

It is also of great importance to carry out a subsequent analysis of the estimate by (Arellano and Bond, 1991) to verify the validity of the results found. The Sargan test makes it possible to statistically verify that the instruments used in the estimation have been adequate. Thus, it is expected that the regression residuals be not correlated with the set of exogenous variables used. When applying the Sargan[1] over-identification test in the estimation corresponding to Table 2, an S value = 15.1562 was obtained. The chi-square value with the corresponding 19 degrees of freedom makes Prob>chi2= 0.7126. Therefore, Ho is not rejected from valid over-identification restrictions, that is, the instruments used in the regression are adequate.

It is understood that, despite the fact that the methodology used avoids an endogeneity problem in the way already mentioned in previous sections, there is always the possibility that one of the "exogenous" variables used in the model is correlated with relevant variables not included in the estimation, which would be in the error term, for which endogeneity problems would persist. In this regard, it would be recommendable to include more exogenous variables that explain the economic growth of the countries in the future, so that the disturbance term of the model looks more and more like a purely random error. Thus, in the present work it is only verified that the magnitude of this possible problem is not very large, through post-estimation tests.

In addition to the over-identification test carried out, it is important to corroborate the degree of autocorrelation in the residuals of the (Arellano and Bond, 1991) estimate. First of all, remember that since the residuals are in first differences, it must necessarily be true that there is a first-order correlation. Therefore, the null hypothesis of no first-order autocorrelation is expected to be rejected. The m1 statistic calculated from said residuals, for the corresponding estimate in Table 2, was m_1 = -2.0159 ~ N (0.1), so that Prob > Z = 0.0438. Therefore, H0 is rejected.

For correlation of order 2 and above, it is expected that the null hypothesis of zero autocorrelation in the residuals in differences cannot be rejected, since otherwise the model will not be explaining an important part of the dependent variable. The m_2 statistic calculated to test this hypothesis was m_2 = -0.4493 ~ N (0.1), therefore Prob > Z = 0.6532. Thus, H0 is not rejected.

[1] The formulas for calculating the Sargan statistic and the statistic of the autocorrelation tests in the residuals referenced here can be found in Arellano and Bond (1991).

Given the above, it has to be that from order 3 onwards it will not be rejected either, since said relationship weakens as the lags increase. In short, the post-estimation tests support the validity of the estimation results by using the (Arellano and Bond, 1991) method, using total as the education variable.

5- Conclusion

Since the second half of the 20th century, economists have increasingly recognized the crucial role of human capital in generating wealth. Initially, studies focused on the individual level but later expanded to analyze the impact of human capital and knowledge on national economic growth. Theoretical contributions have underscored the vital role of education in explaining the rapid progress of many world economies over the last century and have emphasized that education will remain a key factor in the future, as the level of knowledge in a society determines its capacity for technological advancement and sustained growth.

However, empirically demonstrating the significance of education in explaining GDP per capita growth has proven challenging. Numerous studies' conclusions are often inconsistent, possibly due to differences in the samples used (education may be more impactful in some countries than others), the quality of the data, the inclusion of complementary variables (indicating that education alone may not suffice), and other factors.

This paper utilized the largest available sample of countries and the longest feasible time span to test the importance of educational attainment in driving economic growth. Recognizing that education alone may not be sufficient to generate growth, we included a variable to capture the structural development level of the economy alongside the classical determinant of physical capital accumulation. Given the difficulty of sourcing other variables suggested for explaining economic growth in the sample of 62 countries from 1990 to 2020, we employed the Arellano and Bond dynamic panel methodology. This approach allows the inclusion of the lagged dependent variable as an explanatory factor, thereby addressing potential autoregressive dynamics in GDP per capita growth.

The estimation results support the theory that education is vital for economic growth. We found that primary education significantly influences a country's economic growth rate. Moreover, the aggregate measure of educational attainment (total years of education) was also significant in explaining GDP per capita growth. The results also corroborate the structuralist view that a country's productive capacity is crucial for leveraging its population's knowledge to achieve economic growth. Consequently, state support for education and the enhancement of the industrial sector are highly desirable for fostering a path of sustained growth that benefits the entire population.

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Appendix 1

Countries included in the database

Algeria	Dominican Republic	Malaysia	Singapore
Argentina	Egypt	Mali	South Africa
Bangladesh	El Salvador	Malta	Sri Lanka
Benin	Fiji	Mauritius	Sudan
Bolivia	Ghana	Mexico	Thailand
Botswana	Guyana	Moldova	Togo
Brazil	Hungary	Nepal	Tonga
Burkina Faso	India	Niger	Tunisia
Cameroon	Indonesia	Pakistan	Turkey
Central African Republic	Iran	Papua New Guinea	Uganda
Chile	Italy	Paraguay	Uruguay
China	Jordan	Philippines	Venezuela
Colombia	Kenya	Poland	Zambia
Cape Verde	Republic of Korea	Rwanda	Zimbabwe
Cuba	Lesotho	Saudi Arabia	
Cyprus	Malawi	Serbia	

Source: own elaboration