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Educational Level and Differential Impact of Broad Band on Economic Growth

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Abstract: *Research dealing with the relationship between information and communication technologies (ICT) and economic growth in developing countries has increased during the last two decades. However, the role of telecommunications by itself on economic growth is limited unless is also accompanied by parallel investments in education which favors its absorption and applicability. Contributing to strengthen this issue, this paper examines the long-run relationship between education, access to telecommunication services and economic growth focusing on broadband services. A sample of 57 countries with different educational levels is used to examine the impact of broadband on economic growth. Three panel data analysis are applied, for each group of countries divided by their educational level: low, medium, and high. The econometric analysis includes unit tests root tests, cointegration tests and a Dynamic Ordinary Least Squares (DOLS) panel model. The evidence confirms the presence of a differential impact of broadband on economic growth related to educational levels.*
***Key words*:** *broadband, dynamic panel, economic growth, education, ICT.*
JEL Classifications: I25; L96; L86; J24

I. Introduction

An extensive literature about ICT role on economic growth has been developed during the last two decades, particularly promoted by international organizations (Bilbao, Soumitra and Bruno, 2013 [1]; ITU, 2012 [2]; World Bank, 2012 [3]; OECD, 2012 [4]). These studies have identified ICT as a key factor on economic growth through competitiveness and productivity changes in several countries. However, the research agenda has focused on technological change in developed countries, above all the U. S., and on analyzing how ICT have contributed on productivity changes (Dedrick, Gurbaxani and Kraemer, 2003[5], Van Ark, Hao, Corrado & Hulten, 2009 [6]; Silva & Teixeira, 2011 [7]; Biagi and Loi, 2013 [8]; Taylor, 2015 [9] and; Aboal and Tacsir, 2015 [10]).

The ICT level and mechanisms of impact on competitiveness and productivity differ among each research; similarly, there is not a consensus about the speed and intensity of these changes. Nevertheless, most of the studies present a common vision: ICT have an essential role as a change agent for economic growth in all the economies, particularly high speed internet, regardless of the particular features and conditions of each country.Opposing that view, this paper examines the educational level of the labor force in each country as a key factor and indispensable condition on ICT use and exploitation (especially internet), that can produce changes on competitiveness and productivity, materializing on economic growth. We hypothesize that ICT infrastructure availability is not enough to promote changes on competitiveness and productivity (as international organisms point stress); its contribution rather depends on a set of conditions and features, among which stands out the educational attainment of the labor force (understood as education, in this research), in order to have an effective and productive use of this technology.

Based on the above considerations, Broadband service was selected to examine this issue because it is the telecommunication service most associated with intellectual, productive and technological processes. Furthermore, Ortiz, Sosa and Díaz (2015) [11], have proved that broadband has a positive impact on economic growth and its effect depends of the educational level, which is not the case of other telecommunication services like fixed and mobile phone. Our hypothesis is tested using a sample of 57 countries divided into three groups according to their educational levels: high, middle and low separated in three equivalent intervals of 19 countries each one, for the period 2003-2013.

The econometric tests include three panel data analyses: one for each of the three groups of countries; the econometric analysis includes (a) unit tests root tests to verify the order of integration of the variables; (b) cointegration tests to examine the presence of long-term relationships; and (c) an DOLS (Dynamic Ordinary Least Squares) panel model to estimate the impact of the access to telecommunication service (broadband) on economic growth, depending on the educational level.

The rest of the paper is organized as follows. Section 2 reviews the literature, first that related to the role and relationship between ICT, education and economic growth, and second with a review concerning ICT, telecommunications and economic growth. Section 3 deals with methodological issues; it describes the data, the construction of the panels to be examined according to differentials in educational levels; and it defines the econometric methodology. Section 4 reports the evidence obtained. Finally, section 5 concludes the work.

II. Related studies

An extensive literature has been advanced dealing with the link between ICT and economic growth. Solow's model and ideas (Solow, 1956) [12] have become the point of departure to motivate relevant research appraising this relationship during the last five decades. The main reason to employ this model lies in its structure that makes it possible to explain growth through key production factors: capital, labor force or the most efficient combination of both, taking into consideration different kind of capital, i.e., ICT and non-ICT.

Several studies agree with this view, finding complementary factors that encourage ICT investment, according to the level (aggregate, sectoral, industry or firm-level) and to the kind of investment made. Wimble, Singh and Auckland, 2015 [13], found that industry factors have significant interaction effects with the link between firm-level ICT and performance. Ren and Dewan (2015) [14], pointed out industry competition, regulation, and technological change, as key factors to reap benefits from the use of information technology across industries. Balboni, Rovira and Vergara (2011)[15], contribute evidence about the importance of human capital quality, innovation capacities and organizational changes as key determinant factors in the performance of firms and their ICT investment. Concerning economic-level some factors that could facilitate ICT investment are the following: public policy, physical and human capital investment and sectoral economic changes (Rovira & Stumpo, 2013)[16].

The main difference between ICT investment and other types of capital is the double purpose of ICT on firms. Firstly, as any other category of capital, ICT are used directly as a technology to produce, increasing workforce productivity. Secondly, ICT play a key role in the transformation of the productive process. According to this second purpose, several works have been forward stressing the impact of ICT on changes in business process, and enhancing multifactorial productivity (Colombo, Croce and Grilli, 2013[17];, Gatautis, 2015 [18]; Tarutė and Gatautis, 2014[19]).

The literature acknowledges three transmission paths concerning the effects of ICT on economic growth:

i) ICT plays a significant role in the creation, safekeeping, cataloguing and transmission of corporate and macro and sectoral information which helps diminishing market failures and information asymmetries. In turn, this impacts grow positively, by promoting sound strategic decisions, as well as organizational innovations and product innovations (Breshnahan and Trajtenberg, 1995 [20]; D'Cruz, and Kini, 2007 [21]; Jorgenson, Ho, and Stiroh, 2002 [22] and 2008 [23]; Van Ark, O'Mahony and Timmer, 2008 [24]; Biagi and Loi, 2013 [25]; Hoelck and Ballon, 2015 [26].
ii) Greater productivity within the ICT-producing sector; these changes are spread into the economy through production chains among sectors, enabling to reduce prices of ICT goods and services, and strengthened the massification of their use in other non-ICT productive sectors (Jorgenson, Ho and Stiroh, 2008[22]; Spiezia, 2011 [27]; Silva and Teixeira, 2011 [7]; World Bank, 2012 [3]; ONTSI, 2013 [28]).
iii) Greater productivity within ICT user sector. The ICT usage increases labor productivity because it increments the associate capital to each worker and, above all, transforming production processes closely related to innovations (Khan and Santos, 2002 [29]; Gutierrez, 2011 [30]; Cecobelli, Mancuso and Gitto, 2012 [31]; Mehmood, Azim, Raza, and Sahib, 2014 [32]).

However, these transmission paths are based on a partial view, disregarding initial differentiated conditions (institutional framework, educational level and attainment of the target population, market structure, size and maturity of the firms, etc.); such setting impacts on the ICT use and exploitation, reducing and, even, inhibiting positive changes on productivity (IDB, 2011)[33].

In this respect, important research has identified education as a key factor on the absorption rate and impact of ICT on productivity: relevant papers on the subject have been advanced by Mankiw, Romer and Weil (1992)[34], Hua (2005) [35], Berger and Fisher (2013)[36], and Neffati and Bisbes (2013)[37]. Indeed, investment in education improves the skills of the workforce which is a prerequisite condition for the absorption of ICT. Thus, the higher the levels of the skills are, the more that the complex and continuously changing technology is absorbed so that growth and development goals are achieved (Neffati and Besbes, 2013[37]);

The following mechanisms summarize the importance of education on growth:

i) At the individual level, the more qualified a person is, the more likely that he/she can take advantage of existing work alternatives and enjoy a good standard of living (UNESCO, 2010 [38]; OECD, 2010 [39]); people with higher education levels have higher income which helps them to achieve high levels of well-being (Psacharopoulos & Patrinos, 2004 [40]; Heckman, Lochner & Todd, 2008[41]; Hanushek and Zhang, 2006[42]).
ii) Additionally, higher educational levels have a positive impact on well-being, by promoting cultural experiences, better hygiene habits and nutrition patterns (Larrañaga, 1997[43]; Brunello et al, 2011[44]; Lockheed & Verspoor, 1991[45]).

iii) From a social perspective the strength of the educational system and the number of years of education has positive effects in income per capita. A most capable workforce increases productivity (Lucas, 1990 [46]; Benhabib & Spiegel, 1992 [47]; Lebedenski and Vandenberghe, 2013 [48]).

iv) Moreover, education has direct impacts on individual creativity, generating technical and institutional innovation in different productive sectors (Romer, 1990 [49]; Becker, Murphy and Tamura 1990 [50]; Benhabib & Spiegel, 1992 [47]; Fasko, 2001 [48]; Desh and Srisvastava, 2014[49])

v) Similarly, knowledge, skills, concepts, rules, attitudes and behaviors of individuals may affect and promote other factors (like physical capital investment) and increase productivity of all factors of production (Lucas, 1990 [46]; Benhabib & Spiegel, 1992 [47]; Lebedenski and Vandenberghe, 2013[48]).

In this respect, Lal (2001)[51] does not find a relationship between ICT investments and productivity changes. Miyazaki, Idota, & Miyoshi (2012)[55] find that the impact of ICT on productivity is as high as the sophistication of their use in each firm. Grazzi and Jung (2015)[56], point out the differential ICT impact on productivity, according to the firm size; they argue that innovation does not have the same impact on larger firms than on small one's productivity.

Moreover, there is evidence suggesting that ICT investment increases firm's productivity in developed countries, but not in developing economies. Dewan and Kraemer (2000)[57], Pohjola (2001)[58] and Yousefi, (2011)[59] find an insignificant impact of ICT on output growth for the case of these economies. Aravena, Cavada, and Mulder (2012)[60] analyze the impact of ICT on the economies of Argentina, Brazil, Chile and Mexico for the period 1995-2008; their evidence concludes that non-ICT capital accounted for 38 percent of output growth, and ICT-capital for 12 percent.

Summing up, the literature on ICT and economic growth dealing with developed and developing nations acknowledges a positive effect, albeit the impact is greater for developed economies. Many studies, however, overemphasize the role of investment in ICT as the predominant factor contributing to economic development. This is particularly the case of international organizations; their view is limited because other factors that can enhance o restrict the role of ICT on growth are frequently disregarded. Education and socioeconomic differentials among countries constitute important factors that must be considered. Along these lines, including education levels to gauge the impact of Broadband on economic growth is the contribution of this work.

III. Methodological issues

3.1 Variables description

To test the impact of broadband telecommunications on economic growth due to education, a sample of 57 countries was chosen from the educational level index published by the Office for Human Development from the World Bank (2013)[61] which is reported for 187 countries and comprises average education levels for the 1980-2013 period. These economies were divided into three panels of study according to their educational level: countries with high educational levels, index above 0.84; countries with medium educational level whose educational index ranges between 0.74 and 0.83; and countries with low educational level which their educational index is below 0.73. Table 1 presents the detailed description of the listed grouping countries:

Table 1 Sampled Countries based on educational level

Educational Level	Education Index (average 1980-2013)	Country
High educational level	**0.84-0.99**	Australia, New Zealand, Iceland, Norway, Ireland, Finland, Netherlands, Lithuania, Denmark, Estonia, Canada, Korea (Rep.), United States, Spain, Germany, United Kingdom, , Sweden, France & Italy
Middle educational level	**0.74-0.84**	Japan, Barbados, Montenegro, Poland, Belarus, Slovak Republic, Hungary, Singapore, Kazakhstan, Antigua & Barbuda, Brazil, Hong Kong, Ukraine, Chile, Kuwait, Bahrain, Croatia, Malta & Russia
Low educational level	**0.59-0.73**	Venezuela, Peru, Cyprus, Sri Lanka, Belize, Bahamas, Dominica, Saudi Arabia, Seychelles, United Arab Emirates, Panama, Colombia, Algeria, Mexico, Costa Rica, Turkey, Thailand, China & Albania

Source: Human Development Index Office

The variables used for the cointegrated panel analyses for the period 2003-2013 were gathered from the World Development Indicators of the World Bank, WDI (2013). The corresponding per capita GDP in constant 2005 dollars annual data is used as a proxy for economic growth; telecommunications variable is broadband subscriptions per hundred inhabitants on an annual basis. The variables used are transformed into natural logarithms.

3.2 Econometric Tests

Following closely a previous paper by Ortiz, Sosa and Diaz (2015)[11], panel analysis is applied for each subgroup panel, according to the classification previously made in order to analyze the sensitivity of economic growth to broadband per hundred inhabitants. Previous to this analysis, unit root and cointegration tests are called for.

3.2.1 Unit Root Test

Unit root tests are performed to determine the order of integration of each variable; four techniques are implemented in this paper: (a) Levin test *LLC* (Levin, Lin, and Chu , 2002)[62]; (b) *IPS* proposed by Im, Pesaran and Shin (2003)[63]; (c) *ADF*-Fisher (Dickey Fuller Augmented) based on germinal ideas from Fisher; and (d); *PP*-Fisher (Phillips Perron) also based on observations made by Fisher (1932)[64]; these last tests advanced by Maddala and Wu (1999)[65]. The Levin test is based on the within dimension approach; this test assumes that there is a common unit root process across the cross-sections. The other three tests *IPS*, *ADF* & *PP* are based on estimators that simply average the individually estimated coefficients for each member, assuming that there are individual unit root processes across the cross-sections (Adhikari and Chen, 2012)[66]. In other words, the Levin test assumes the presence of a common unit root process crosswise for a panel data analyzed; the other three tests assume the presence of an individual unit root process tested with the pooled data.

The four tests are performed both in levels and in first differences. In addition, cross sectional unit root tests have advantages over unit root tests for time series, because they combine time series and cross sectional data obtaining more degrees of freedom, which improves properties of the estimators; furthermore, cross sectional unit root tests correct non observer heterogeneities (Robledo and Olivares, 2013)[67].

As a first step LLC test performs separate ADF regressions for each cross section:

$$\Delta y_{it} = \rho_i y_{i,t-1} + \sum_{k=1}^{p_i} \varphi_{i.k} \Delta y_{i,t-k} + \delta_i X_{i.t} + \varepsilon_{i,t}, \qquad (1)$$

Where Δ is the first-difference operator. The lag order ρ_i, is allowed to vary across the *i* cross-sections. In the LLC test the null hypothesis is for $i = 1, \ldots, N$, while the contrasting homogenous alternative is: $H_1^1: -1 < \rho_i = \rho < 1$ for $i = 1, \ldots, N$. For this test, the null hypothesis implies the presence of unit root, whereas the alternative hypothesis signals the absence of a unit root (Adhikari and Chen, 2012)[66]. A limitation of the LLC test is its assumption that all cross-sections have the same first order autoregressive parameter, i. e. $\rho_i = \rho$, for all units. Such restriction is due to the fact that the statistical test is carried out crosswise.

The IPS test relaxes this assumption, by allowing different cross-sections order. Firstly, getting separate ADF regressions with different lag orders across cross section, from estimating (1). Afterwards, averaging of the individual t-statistics from the ADF regressions as follows;

$$\bar{t} = \frac{1}{N} \sum_{i=1}^{N} t_{\rho i}, \qquad (2)$$

The average is adjusted according with the desired test statistic. IPS standardize their test statistic based on simulations of the mean and variance of the t_ρ series, (Belke, Dobnik and Dreger, (2011) [68]:

$$z(\bar{t}) = \frac{\sqrt{N}\left(\bar{t} - E(t_p)\right)}{\sqrt{Var(t_p)}} \qquad (3)$$

Where the *Z*-statistic has an asymptotic normal distribution. The simulated values are tabulated in Im, Pesaran and Shin (2003)[63].

The tests advanced by Maddala and Wu (1999) [65], Fisher-ADF and Fisher-PP, owns its development to three important ideas presented by Fisher (1932)[64]. Basically, Fisher proposes that for any continuous statistical test must hold: a) the null hypothesis of the p-values, named as π, are uniformly distributed on the interval $[0,1]$; (2) hence, $-2\log\pi$ is distributed as χ_2^2, where *log* denotes the natural logarithm; and (3) for a group of independent statistical tests $-2\sum_{i=1}^{N}\log\pi$ is consequently distributed as χ_{2N}^2 under the null hypothesis, Hlouskova and Wagner (2006)[69].

The IPS, Fisher-ADF and Fisher-PP tests have null hypothesis of unit root, whereas the alternative hypothesis of some cross sections do not contain a unit root, (Adhikari and Chen, 2012)[66].

Taking this notion into consideration, in addition to the Levin test, this paper applies the tests proposed by Im, Pesaran and Shin (2003)[63] and Fisher (1932)[64], employing the ADF and PP criteria individually. The four tests are carried out both the series levels, as well as for their first differences.

2.3.2 Panel Cointegration Test

In order to test the existence of long-term equilibrium relationships between the variables of access to internet and economic growth, a cointegration test panel is employed; it distinguishes the interdependence of the cross section between individual deterministic effects and trends, as follows:

$$lnY_{it} = \alpha_{it} + \delta_{it} + \beta_1 lnB + \varepsilon_{it} \quad (4)$$

$$\varepsilon_{it} = \rho_{it}\varepsilon_{it-1} + u_{it} \quad (5)$$

Where, ***i* = 1, …*N*** is a member of the panel; t = 1, … T refers to the time period; ***Y*** represents the per capita GDP; ***B*** represents the number of subscriptions to broadband service per hundred inhabitants;. $\beta_1, \beta_2\ y\ \beta_3$ represent the sensitivity parameters to changes in economic growth due to the adoption of internet services. The parameters α_{it} and δ_{it} allow measuring specific aspects of each country and the effects of the deterministic trend, respectively; ε_{it} represents the estimated residual deviations from the long-term relationship. To test the null hypothesis of non cointegration, Pedroni (1999[70], 2004[71]) proposes seven cointegration tests of two types: Four within the model and three between models; all of them are performed in this study.

Following Pedroni (1999)[70], the heterogeneous panel and heterogeneous group mean panel cointegration statistics are calculated as follows Lee (2005)[72].

Panel v-statistic:

$$Z_v = \left(\sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^{-2}\,\hat{e}_{it-1}^{2}\right)^{-1} \quad (6)$$

Panel ρ- statistic:

$$Z_\rho = \left(\sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^{-2}\,\hat{e}_{it-1}^{2}\right)^{-1} \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^{-2}\,(\hat{e}_{it-1}\Delta\hat{e}_{it} - \hat{\lambda}_i) \quad (7)$$

Panel PP-statistic:

$$Z_t = (\hat{\sigma}^2)\sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^{-2}\,\hat{e}_{it-1}^{2}\Big)^{-1/2} \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^{-2}\,(\hat{e}_{it-1}\Delta\hat{e}_{it} - \hat{\lambda}_i) \quad (8)$$

Panel ADF-statistic:

$$\tilde{Z}_t^{\,*} = \left(\hat{s}^{*2}\right)\sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^{-2}\,\hat{e}_{it-1}^{*2}\Big)^{-1/2} \sum_{i=1}^{N}\sum_{t=1}^{T}(\hat{L}_{11i}^{-2}\,\hat{e}_{it-1}^{*}\Delta\hat{e}_{it}^{*}) \quad (9)$$

Group ρ- statistic:

$$\hat{Z}_p = \sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{e}_{it-1}^{2}\right)^{-1} \sum_{t=1}^{T}(\hat{e}_{it-1}\Delta\hat{e}_{it} - \hat{\lambda}_i) \quad (10)$$

Group PP-statistic:

$$\hat{Z}_t = \sum_{i=1}^{N}\left(\hat{\sigma}^2\sum_{t=1}^{T}\hat{e}_{it-1}^{2}\right)^{-1/2} \sum_{t=1}^{T}(\hat{e}_{it-1}\Delta\hat{e}_{it} - \hat{\lambda}_i) \quad (11)$$

Group ADF-statistic:

$$\tilde{Z}_t^{\,*} = \sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{s}_i^{2}\hat{e}_{it-1}^{*2}\right)^{-1/2} \sum_{t=1}^{T}(\hat{e}_{it-1}^{*}\Delta\hat{e}_{it}^{*}) \quad (12)$$

Where, e_{it} is the estimated residual from Eq. (5) and $\hat{L}_{11i}^{2}$ is the estimated long run covariance matrix for $\Delta\hat{e}_{it}$. Likewise, $\hat{\sigma}_i^2$ and $\hat{s}_i^2$ $(\hat{s}^{*2})$ are, respectively, the long run and contemporaneous variances for individual *i*. The other terms are appropriately defined in Pedroni (1999)[70] with the property lag length determined by the Newey-West method. All tests have asymptotic normal distribution (Lee, 2005)[72].

2.3.3 Panel Cointegration Estimation

The panel Ordinary Least Squares (OLS), the panel Fully Modified Ordinary Least Squares (FMOLS) and the panel Dynamic Ordinary Least Squares (DOLS) are the most popular methods to test the long-run cointegration vector. However, according to McCoskey and Kao (1998) [73] and Kao y Chiang (2000) [74], DOLS method offers some advantages over FMOLS and panel ordinary least squares (OLS), because is less biased in small samples using Monte Carlo simulations. In addition, the panel DOLS estimator has better sample properties rather than the panel OLS and FMOLS estimators Kao & Chiang (2000)[74].

Based on the above mentioned works, this paper chose DOLS to estimate the long-run cointegrating vector between broadband access and economic growth, that consists of lags and leads of the independent variables. The DOLS estimation is given by the following equation:

$$\boldsymbol{y_{it} = \alpha_i + x_{it}\beta + \sum_{j=-q_1}^{q_2} c_{ij}\Delta x_{it+j} + v_{it}} \quad (13)$$

Where *i=1,… N* for each country in the panel, *t=1,…T* denotes the time period, q_1 represents the maximum length, q_2 represents the maximum lead length and v_{it} denotes the Gaussian vector error terms process.

IV. Empirical Evidence

To analyze the relationship between broadband and economic growth three panels were employed, as previously identified.[1] First, it is necessary to test stationarity of the variables included in each panel. This is accomplished employing four panel unit root tests for each panel. As previously stated, these tests are the Levin,

[1] E-Views 8.0 was used for all econometric analyses.

Lin and Chu test (2002)[62]; *IPS* proposed by Im, Pesaran and Shin (2003)[63]; Fisher test criteria including the Dickey Fuller; and the Phillips-Perron and Maddala-Wu (1999)[65];. Results are shown in Table 2. The null hypothesis sustains the presence of unit root.

Table 2 Unit Root Tests

Countries with high educational level				
	lnB	lnGDP	(D)lnB	(D)lnGDP
LLC	-36.79*	-4.62*	-19.90*	-8.322*
IPS	-41.66*	-1.97**	-12.69*	-2.89*
PP	294.91*	53.44**	163.47*	63.84*
ADF	381.87*	74.67*	173.47*	66.80*
Countries with middle educational level				
LLC	-7.54*	-5.73*	-8.37*	-4.69497*
IPS	-4.35*	-1.11	-2.01**	-0.86767
PP	90.62*	45.34	60.06**	44.1568
ADF	271.57*	122.63*	139.28*	73.3509*
Countries with low educational level				
LLC	-24.30*	-4.32*	-18.66*	-8.19708*
IPS	-17.22*	-0.31	-11.153*	-3.82931*
PP	191.52*	49.29	164.08*	80.7881*
ADF	243.36*	66.46*	133.14*	95.7524*
The null hypothesis is non-stationary. ***Means statistical significance at the level of 10%. **Means statistical significance at the level of 5%. *Means statistical significance at the level of 1%.				

The evidence is presented both in levels and in first differences. Tests in levels reveal that the series are stationary, at least at 10% in the case of the panel with high educational level. However, IPS and PP tests, suggest that GDP series is not stationary in levels for the panel of countries with middle educational level and low educational level. However, considering first differences, results indicate that the variables are stationary with significance levels of 1%, 5%, and 10%; for the panels of countries with high, medium and low educational level. For the LLC and ADF tests, the results suggest stationarity in middle educational level. These results represent an essential condition for the existence of long-term relationships.

Cointegration test must follow, to identify the presence of linear combinations for each of the panels, which can be described as stationary. The Pedroni (1999)[70] test of cointegration is used. This technique is analogous to the Engle and Granger (1987) test for time series, which is, based on a regression of residuals. Seven cointegration tests are applied to each panel; four are applied within the model and three between models Pedroni (1999)[70].The results are shown in Table 3.

Table 3 Cointegration Tests for each Panel

		Panel with high educational level						
Indvidual intercept	Statistic	0.53*	-0.07*	-1.18*	-2.04	1.96*	0.46*	-0.87*
Individual and trend		-4.18*	5.81*	-4.14	-8.16	6.52*	-10.04	-8
		Panel medium educational level						
Indvidual intercept	Statistic	1.08*	-0.02*	-1*	-1.35	1.28*	-0.97*	-1.32
Individual and trend		-1.05*	3.54*	0.74*	-4.34	4.11*	-0.83*	-3.06
		Panel with low educational level						
Indvidual intercept	Statistic	0.52*	-0.06*	-1.23*	-1.98	1.8*	0.18*	-0.83*
Individual and trend		13.34	2.61*	1.55*	-4.45	3.87*	-4.64	-8.02

Note: The test statistics asymptotically distributed as standard normal. * indicate the rejection of the null hypothesis at 1%. ** indicate the rejection of the null hypothesis at 5% and *** indicate rejection of the null hypothesis of no cointegration at the 10%.

These results, taking into consideration the assumption of individual intercept, show for the panel with high educational level, that for six of the seven tests the hypothesis of no cointegration is rejected. In the case of the panel with medium educational level, five of seven tests, suggest a long run relationship between variables.

Low education panel results suggest cointegration for three individual tests (V, RHO and PP), and for all the group tests the null hypothesis of no cointegration is rejected. Hence, it is confirmed that for all the panel models there is a significant long term equilibrium relationship between broadband access and economic growth. Thus, the next step is estimating the following model using DOLS technique for each of the three models of panel, as follows:

$$lnGDP = \alpha_{0i} + \beta_{3i} lnBB + \varepsilon_{it} \quad (14)$$

Where *ln*BB indicates the natural logarithm for broad band, *ln*GDP is the natural logarithm of the GDP per capita, α_{0i} is the intercept and ε_{it} represents the error term.

According to McCoskey and Kao (1998)[73], Kao and Chiang (2000)[74] the panel DOLS estimator has better sample properties than other estimation panel, like OLS and FMOLS estimators Kao and Chiang (2000)[74].

We use the panel DOLS with 1 lead and 2 lags for high and low educational level; and in the case of medium level a (1,1) DOLS model was used, because of their high R-squared and their significant and positive coefficients. Results are reported in Table 4.

Table 4 Dynamic Panel Results

	Panel with High educational level	Panel with Medium educational level	Panel with Low educational level
BB	0.391724 *	0.061973*	0.063242*
t-values	(3.732328)	(7.315939)	(5.648754)
The t-values are in parentheses. * denotes statistical significance at the 1% level, ** denotes statistical significance at the 5% level, and ***denotes statistical significance at the 10% level			

4.1 Evidence for countries with high educational level

The empirical evidence shows that for all countries considered with a high educational level, the model has a high goodness of fit, documented by the R square. The F test shows that the model is statistically representative at the level of 0.05. The impact of broad band on economic growth is statistically representative at a level of 0.01 and with a positive sign that denotes a positive impact of penetration of broad band on economic growth.

Comparing the results for the three panels estimated, the coefficient of countries with high educational level shows that the impact of broad band access on economic growth is bigger than for the other two groups of countries. This result can be explained by the fact that in countries where labor has high levels of education, the dissemination of knowledge provided by the broadband services has a more fertile ground to be harnessed into productive uses by companies.

This argument is in line with the view that an increase in the penetration of broadband services, offers an increased infrastructure for people and businesses; this allows them greater access to information and knowledge generated elsewhere, advertise and market their products through internet, and so on.

4.2 Evidence for countries with medium educational level

For the panel with medium educational level, the results show that broad band variable is positive and statistically significant at the 1% level; the F test shows that the whole model is statistically representative at the same level, and a good explanatory power the R-square registered is also high.

The impact of broadband on economic growth was also positive, although with a lower coefficient with respect to the one corresponding to the panel of highly educated countries. This result highlights the importance of education, considering that broadband, besides being a means of communication (like other telecommunication technologies) is a media that allows greater access to information flows and the creation and dissemination of knowledge.

4.3 Evidence for countries with low educational level

For the group of countries with lower education levels, the corresponding panel shows also a high goodness of fit denoted by R-squared; the overall model is also statistically representative (denoted by a high statistical F). At the level of individual variables, the model shows statistically significant levels of 0.01 for broad band coefficient.

The impact of this variable on economic growth is also positive, with a very similar coefficient to that shown for the panel of countries with medium educational level; this finding supports the hypothesis that the impact of telecommunications, particularly that most related to access and dissemination of knowledge, like internet, tends to be higher the more advanced is the educational level of a nation, due to the following reasons:

1. Countries with higher educational levels, that incorporate ICT in their production processes, can increase efficiency, improve their practices and streamline their processes. This effect can be limited by educational level in countries with lack of qualified labor.
2. Governments can manage public services through Internet and improve communication with the public, and people can connect with each other, increasing the exchange of information. This tends to happen more often in countries where there is greater participation of citizens, typically the more educated.

V. Conclusions

This study analyzed the differential impact of Broad band on economic growth, taken as a point of departure the social educational level. A representative sample of 57 countries was selected and divided in three groups according to their educational levels: high, medium and low. A DOLS cointegrated panel model was employed to test the impact of Broad Band services on economic growth. Previously, unit root tests analysis and cointegration analysis was performed. Unit root tests confirmed the absence of unit root in the series; subsequently, seven cointegration tests were applied to each panel; four are applied within the model and three between models. The test confirms the presence of long term equilibrium between the variables of each panel.

Analyzing the impact of broadband on economic growth, using DOLS technique, we found a positive impact for the three panel studies; its impact is greater the higher level of education is. Thus, the least impact of broadband takes place in the groups of countries with medium and low educational level. This evidence supports the hypothesis that to exploit more efficiently the potential benefits of telecommunications the workforce must have strong educational levels to allow it to take advantage of broadband services; otherwise, the impact of this technology on growth will tend to be limited.

In short, to promote economic development strategic policies must be implemented enhancing the access to telecommunication services, particularly Broad Band, which should be accompanied with strong educational systems. Countries with low economic development and weak educationally systems must pursue more forcefully these policies. At any rate, future research is necessary to shed further light on the importance of Broad Band on economic growth. Further studies, particularly in the case of developing countries research should include longer periods, and more variables to detect the contribution of telecommunications on economic growth.

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