

THE EFFECTS OF TELECOMMUNICATIONS INFRASTRUCTURE ON LATIN AMERICA'S ECONOMIC GROWTH

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Abstract. We examine the effects of telecommunications infrastructure on economic growth in 15 countries of Latin America (LA) for the period 1995-2016. We estimate the aggregate relationship of economic growth with electricity access, individuals using the internet, and Information and Communication Technology (ICT) imports, while accounting for other key macroeconomic variables using a static and dynamic model. The results confirm that there is a positive relationship between economic growth and electricity access, internet accessibility, and ICT imports. These results provide evidence to conclude that telecommunications infrastructure contributes to economic growth for LA countries.

Key Words: economic growth; electricity; internet; ICT imports.

LOS EFECTOS DE LA INFRAESTRUCTURA DE LAS TELECOMUNICACIONES EN EL CRECIMIENTO ECONÓMICO DE AMÉRICA LATINA

Resumen. Se examinan los efectos de la infraestructura de las telecomunicaciones en el crecimiento económico de América Latina para el periodo 1995-2006. Usando un panel dinámico y estático, se estima la relación agregada de crecimiento económico con acceso a la electricidad, personas usando internet e importaciones de Tecnologías de la Información y la Comunicación (TIC), mientras se controla con otras variables macroeconómicas. Los resultados confirman que existe una relación positiva entre el crecimiento económico y las variables señaladas. Estos resultados proveen evidencia de que la infraestructura de telecomunicaciones contribuye al crecimiento en América Latina.

Palabras clave: crecimiento económico; electricidad; internet; importaciones de TIC.

Clasificación JEL: C13; C30; O30; O40; R1.

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1. INTRODUCTION

This research examines the effect of telecommunications infrastructure on economic growth for countries in Latin America (LA) for the period 1995-2016. Telecommunications infrastructure has been seen as a key driver that brings opportunity for growth in many sectors of an economy. Its importance on growth has been analyzed and discussed in several researches at an industry level and at a country level with a main focus in developed countries worldwide. There are few studies focused on analyzing this impact in countries of this region on the world. The three key variables included in this study strongly compliment each other in a daily basis. Electricity, internet and Information and Communication Technology (ict) are becoming a major need in infrastructure which eventually in the future will be omnipresent in any economy in the world. The access to electricity is a determinant for human welfare in aspects such as health, education, food and poverty (The World Bank Group, 2018) and in the literature reviews it is found that it is a stimulant for development in an economy. Internet usage is described as a main contributor at the industry level. Its adoption from country to country varies, therefore, its contribution to the overall economy varies as well accordingly to the level of infrastructure that each country is exposed to. Moreover, ict adds value and it is economically justified, countries with similar infrastructure could benefit from investments in ict (Edquist and Henrekson, 2017), however, its impact on emerging and developing economies is different due to a lack of appropriate level of human capital as well as complimentary factors such as R&D expenditures (Keller, 2004).

Watania (2012) concluded that telecommunication infrastructure is indispensable for economic growth. The impact of the development of telecommunication sector is essential to decrease transaction and business costs and lower the cost structure of the value chain of business operations; thus lowering the cost of delivery of goods and services the end consumers will be more efficient with a minimum cost. Alleman *et al.* (2002) stressed that proper telecommunication infrastructure and access influences the economy in three folds: first, it can reduce the cost of production. Second, it can increase revenues. Third, it can increase employment through both direct and indirect effects.

Roller and Waverman (1996) estimated jointly a model for telecommunication investment with a production function; they found evidence of significant positive causal relationship between telecommunication infrastructure and aggregate output; the impact was greater in OECD countries than it was in non-OECD countries.

Eggerton *et al.* (2002) show how basic telecommunication infrastructure can create a “digital provide” by making market efficient through information dissemination to isolated and information-deprived locals and improve the living standards of the world’s poor, which in turn accelerates growth.

Our study aims to fill the gap in the literature by employing a dynamic growth model to study the effect of telecommunications infrastructure on regional economic development. A focus on LA economies, instead of other countries, is not without merit. In the past two decades of market-oriented reforms, LA have been one of the world’s slowest-growing economies (IMF, 2019). It is a common conception that a modern communications system is essential to development (Bradford and Summers, 1993; ITU, 1993). All these studies attest to the need to have a modern efficient telecommunications sector as part of a nation’s basic infrastructure and as a precursor to economic growth. Aschauer (1989) found that the return to infrastructure could be as high as 70% per year. This would imply that US\$1 million invested over 30 years would result in a return of almost US\$5 trillion (Datta and Agarwal, 2004).

As ICT infrastructure develops, it reduces transition costs, and will increase output for firms in various sectors of the economy (Roller and Waverman, 2001). Therefore, investment in advancing ICT including telecommunications infrastructure and their derived services provide significant benefits to the economy. A number of researchers have hypothesized that ICT infrastructure lowers both the fixed costs of acquiring information and the variable costs of participating in markets (Norton, 1992).

There is some recent literature that shows that the internet has changed the markets by allowing more efficient search. Similar to other infrastructure investments, investing in telecommunication will increase the demand for the goods and services used in their production and increase total national output. Such investments can increase employment through both direct and indirect effects (Alleman *et al.*, 2002).

Hardy (1980), using data from 45 countries was the first to explore the impact of telecommunications on growth, with the largest effect of telecommunication investment on Gross Domestic Product (GDP) found in the least developed economies and the smallest effect, in the most-developed economies. Garbade and Silber (1978), find that the telegraph and Trans-Atlantic cable led to efficient markets everywhere by narrowing inter market price differentials. Leff (1984), argues that firms can have more physically dispersed activity with increased telecom services and enjoy economy of scale and scope. Overall, the literature estimates that 1% growth in telecommunication services generates 3% growth in the economy (Gupta, 2000).

Datta and Agarwal (2004) investigated the impact of infrastructure on economic growth in 22 OECD countries; their results showed higher number of access lines per 100 inhabitants is found to significantly increase real per capita GDP for the examined country sample. Bertschek and Niebel (2016) analyze whether employees' access to mobile internet improves firms' labor productivity.

This paper contributes to the literature and opens opportunities for further research in LA. Section 2 reviews the literature on each of the variables included in the research and its respective relationship with economic growth. It shows the different approaches, samples, and data used to conduct such researches. Section 3 describes the data sets and the empirical model used for this research. Section 4 presents the results of the study where it includes a description of the coefficients for our key variables and their respective positive impact on economic growth. Lastly, section 5 presents the conclusion for this research.

2. LITERATURE REVIEW

Effect of telecommunication infrastructure on economic growth

Multiple studies focused on developing countries or specific regions showcase the strong positive relationship between communications infrastructure, specifically the telecommunications infrastructure and economic growth. To the best of our knowledge there has not been a research focused specifically on LA region. However, already performed studies provide us with good foundation to discuss the observed effects between telecommunications infrastructure and economic growth.

Telecommunication is ability for the societies to communicate and participate in the global economy. Gómez-Barroso and Marbán-Flores (2019) solely rely on analysis of multiple papers to understand the relation between telecommunication and economic development for the 21st century. Their work includes research of papers both specifically focused on single or group of countries. In addition to other important findings, they conclude that telecommunications or its components as discussed, a whole sector, broadband connection or mobile telephony, has a positive impact on growth. The statement remains valid even during the multiple financial crisis across the world.

Chakraborty (2009) studied impact of telecommunications infrastructure investment and economic growth in developing countries. The outcome

of the research showcased warring results for the specific country groups. Though, for less developed countries, the investments in the telecommunication growth can be a key driver for the economic development.

In more specific country context, Oladipo Olalekan (2013) finds that advancement of telecommunications infrastructure could be a source to aid the digital divide gap and promote economic growth for Nigeria. Moreover, as the study analysis the impact of the labor employed, capital stock, and electricity supply on economic growth. The results show positive impact of electricity supply on economic development both, in short and long run.

To advance the research and evidence of positive relationship between telecommunications infrastructure and economic growth, Batuo (2015) explored 44 African countries from 1990 to 2010 using a dynamic panel method. The results of the study found that the telecommunications variables were statistically significant and had a positive correlation to economic growth. In addition, the research found the investment in telecommunications can have a positive impact on increasing returns. The author suggested that countries that have higher telephone communications return higher growth.

In different regional context, Ding and Haynes (2006), analyzed panel dataset of 29 regions in China over a 17-year period to examine linkage between telecommunications infrastructure and regional economic growth. Using dynamic fixed effects model, they concluded that telecommunications infrastructure advancement is the key indicator to China's economic growth. The results remained the same even when adjusting for past levels of per capita GDP, lagged growth, and other variables.

ICT and growth variable's review

Access to electricity

Defined by The World Bank Group (2019) as the percentage of the total population with access to electricity, this World Development Indicator has been closely associated with economic growth as it is a main factor for the production of goods and services for all the economies of the world.

Electricity represents a barrier to progress for the world's population and has a significant impact on a wide range of development indicators such as health, education, food, and poverty reduction (The World Bank Group, 2018). As an important component in modern life, access to electricity is still a challenge and a goal to achieve for the governments of all the LA countries.

As part of telecommunications infrastructure, and as previously mentioned; electricity possesses vital value, and is considered the source of energy that supports every aspect of the economy (Rehman and Deyuan, 2018). Rehman and Deyuan (2018) examined the relationship between economic growth, electricity access, energy use, and population growth in Pakistan for the 1990-2016 period. The study revealed that electricity access to total population has a significant impact on economic growth. Also, it reports that despite the development level of a particular country, demand for electricity is determined by the population growth as well as other factors, including electricity prices, people's migration to cities, and weather.

On the other hand, according to Jimenez (2016), supply of electricity could be derived by the following factors; first, household income due to the amount of cost that a household can afford; second, the geographical location of any individual as it could represent a technical challenge in terms providing a quality electric service. This conclusion is also supported by Rehman and Deyuan (2018), they illustrate that the reason behind this is that certain rural areas have complex geography, moderately low electricity demand, and a huge cost of long delivery systems.

Best and Burke (2018) showed that electricity availability does appear to be important for economic growth for most countries, however, the significance of this effect mostly disappears when controlling for other key growth determinants other than electricity. Moreover, Rahimi and Rad (2017) studied the relationship of electricity consumption with economic growth and internet usage of "developing-8" countries for the period of 1990-2013. The findings suggest that internet usage has a long-run effect on electricity consumption, whereas economic growth has short and long-run effect with electricity consumption. Similarly, Freidin and Burakov (2018) analyzed the same relationship as Rahimi and Rad (2017) for countries members of the Commonwealth Independent States for the 1991-2017 period. Results revealed an identical positive relationship where internet usage affects electricity consumption in the long run, while economic growth causes a short-run and long-run impact on electricity consumption.

Internet usage

There has been extensive research on the effects that internet usage can have on the economy. Paunov and Rollo (2015) examined the impact of internet on firm productivity from different countries across different stages of development. They found that despite the different obstacles that firms can face such

as financial constraint, power outages, skill outages, corruption, and cumbersome labor regulation, internet has a positive impact in which more productive firms benefited more than less productive firms. Andres *et al.* (2010) analyses the diffusion of the internet on a sample of 214 countries, the study showed the determinants of internet adoption and found that per capita GDP has a significant positive impact on internet adoption, concluded that a 10% increase in per capita GDP is associated with a 21.5% increase in the number of internet users per capita. Also, Lapatinas (2018) research examines the effect of the internet usage on economic sophistication and shows that there is a positive effect and the relationship is statistically significant. Choi and Yi (2005) research studies the internet usage and inflation rate. Their findings suggest a negative relationship between internet usage and inflation. Further evidence is seen in Choi and Yi (2009), where it analyzes the increased use of internet and its impact on economic growth. It was found that internet usage is statistically significant and had a positive impact on economic growth.

Contrarily to the literature reviewed previously where it was found that internet has a positive relationship with economic growth (Choi and Yi, 2009), the research conducted by Maurseth (2018) concludes the opposite. Maurseth (2018) examined the effect of internet on economic growth by using the same models and data used by Choi and Yi (2009) for the period 1990-2015. Maurseth (2018) added the time periods 2001-2015 to the panel data of the periods 1990-2000 used by Choi and Yi (2009). He concluded that there is a negative relationship between internet usage and economic growth for the periods 1990-2015 and 2001-2015.

ICT imports

There is not much specific research on the effect of ICT goods imports on economic growth, although there is sufficient literature evidence of the overall impact that ICT can have on economies. Several researches have analyzed the impact of ICT mainly at a firm level. For instance, Commander *et al.* (2011) examines 1 000 firms from Brazil and India to determine whether ICT has had positive consequences on productivity. Results show that ICT adoption at a firm level have given high returns. Furthermore, the analysis suggests that poorer infrastructure quality and labor market policy are associated with low ICT adoption, while poorer infrastructure is also associated with low returns to investment. Gust and Marquez (2004) support that ICT adoption is affected by regulatory environments, particularly, in the labor market, in which has caused significant impact in productivity growth.

Sepehrdoust (2019) showed that financial development and ICT development have had a positive effect on the economic growth for The Organization of the Petroleum Exporting Countries (OPEC) economies for the period 2002-2015. This work showed that ICT development and economic growth had an elasticity of .048%, while financial development had .05% elasticity to economic growth, however, these results showed a relatively weak influence on economic growth. Similarly, Nasab and Aghaei (2009) research provides more evidence that investments in ICT have a meaningful effect on economic growth for OPEC economies during the 1990-2007 period. Their research suggests that countries can enhance their economic growth by adopting policies that facilitate the investments in ICT. Pradhan *et al.* (2018) find a comparable relationship for a study made to G-20 countries for the 2001-2012 period. They showed that there is a policy implication based on the results where governments should prioritize ICT infrastructure upgrade and expansion to enhance economic growth.

Additionally, there is literature that examines the influence of ICT development on labor productivity. Mačiulytė-Šniukienė and Gaile-Sarkane (2014) examines this relationship in a sample of 27 countries of the European Union. Reveals that ICT development increases labor productivity in the sector producing ICT and the sector using ICT. However, the relationship between labor productivity and ICT development was not found in countries with high productivity and medium productivity. Hong (2017) studied the casual relationship between ICT R&D investment and economic growth. Hong classified ICT R&D investment into public and private sector and found that the private sector has stronger influence on economic growth compared to the public sector. Lastly, another study made by Shahiduzzaman and Alam (2014), investigates the cointegration and casual relationships between ICT and economic output in Australia for a five-decade period. The empirical analysis confirms the existence of the positive role that has ICT on economic growth in the short and long run, although the effect is more profound in the long run.

Unemployment rate

Unemployment rate has been a well-studied topic in economics, there is extensive research done where it is mostly studied as how can this impact economic growth. This relationship of unemployment rate and economic growth is also known in economics as the Okun's law (Okun, 1962). The literature reveals that this relationship can be studied in different ways, Zanin (2014) examines the Okun's law in subgroups of population for the 1998-2012 period of a

number of OECD countries. The age range used is from 15 to 64 years of age where this group contains five different subgroups. The results evidenced that the youngest group is more vulnerable to economic fluctuations compared to older subgroups that means, the unemployment rate of this subgroup has the most significant negative impact on economic growth.

Further research has been done to test the Okun's law, such as the case studied by Elshamy (2013). The analysis attempts to test the law in the country of Egypt for the 1970-2010 period. The test for the Okun's coefficient reveals an expected negative relationship with a high statistical significance for these two variables in the short and in the long run. Supplementary research of the Okun's law is conducted by Doğru (2013) over the Eurozone for the periods 2000-2012. The research confirms that the Okun's law is valid, but the coefficients are less than Okun's coefficient in the USA and other studies in developed countries, as well as it was found that the relationship varies from country to country within this sample.

Population growth

Population growth has been a debatable topic in economics as it relates to economic growth. Literature reveals that its influence on economic activity can vary from country to country. Thuku *et al.* (2013) studied the relationship of population change and economic growth in Kenya for the years 1963-2009. In Kenya, population growth and economic growth are positively correlated, it means that increase in population promotes economic growth hence economic development. Contrarily to this relationship, Afzal (2009) examined Pakistan's case for population growth and economic development. His research found that a rapid population growth is a cause for concern as it contributes to low investment growth and reduces the savings rate.

Gross capital formation

Numerous studies have empirically analyzed the relationship between gross capital formation and economic growth for a great variety of countries. Uneze (2013) analyses the causal relationship between capital formation and economic growth for 13 Sub-Saharan African countries for the years 1985-2007. The research found that there is a bi-directional causality between capital formation in the long run as well as in the short run. Further evidence is seen in Akinola and Omolade (2013), the research examines the relationship between

savings, gross capital formation, and economic growth in the Nigerian economy for the years 1975-2008. It revealed a positive long-term relationship among the three variables in which the coefficients are statistically significant. As evidenced by the literature, the study of gross capital formation and economic growth seems to have a positive relationship across several samples, however, research target different regions of the world, few significant researches were found on LA countries, therefore, this paper wants to demonstrate whether this hypothesis holds across our countries selected or not.

Government expenditure on education

A large amount of literature has researched different aspects of education. One of the aspects is the public expenditure from the government and its contribution to overall economic development for a particular country. It is being discussed that expenditure on education contributes to have higher levels, quantity, and quality of human capital as it contributes for better economic performance (Kabuga and Hussaini, 2015). A study of Nigeria conducted by Kabuga and Hussaini (2015) investigates the relationship of government expenditure on education and economic growth for the 1981-2013 period. The research found evidence of a positive long-run relationship between these two variables where the coefficient was statistically significant. There is more evidence of literature examining this relationship such as the case of Muktdair-Al-Mukit (2012) where it focuses mainly in Bangladesh to conduct the research. It argues that education is an important determinant for economic growth, and inappropriate government policies such as reducing the budget for education, jeopardizes long-run economic growth significantly. Arguments are supported by an empirical analysis of time series data from 1995-2009 where it showed the positive and highly significant impact that spending on education has on economic growth. Mekdad *et al.* (2014) studied the relationship between education and economic growth in Algeria over the period 1974-2012. The empirical results showed that public spending on education affects positively economic growth in Algeria. Moreover, the relationship of education expenditure and economic growth was studied by Yahya *et al.* (2012) in the Malaysian economy for the period 1970-2010. The research found that the economic growth is a short-term Granger cause for education variable and *vice versa*, as well as that education plays an important role in influencing economic growth in Malaysia.

3. DATA AND EMPIRICAL MODELS

Data

The research focuses on the effects of per capita GDP, electricity access, individuals using the internet, ICT imports, unemployment rate, gross capital formation, population growth, and government expenditure on education in LA countries. The data set covers annual data from the year 1995 to the year 2016. With a country-level panel data on 15 countries of LA, there is a total of 119 observations used for this research. Country selection for the study was based on data availability as many of the countries from this region of the world don't have data available for the variables used for the analysis. As the accuracy of the measurements is subject to the reliability and availability of the data, it was considered that all data must be obtained from the World Bank's World Development Indicators (The World Bank Group, 2019b) as this source collects the most reliable and dependable data for the variables relevant to this research.¹

Empirical models

Static effects

The choice of variables used in growth regression follows growth theory and analysis of growth determinants in that literature. Levine and Renelt (1992) find more than 50 variables that, in at least one regression, are significantly related to economic growth. Sala-i-Martin (1997) finds 62 explanatory variables in the cross-country empirical growth literature. The variables considered in growth studies range from traditional economic variables such as physical capital and labor, to a broader range of economic variables including human capital, public capital, R&D investment.

The sources of economic growth have been heavily discussed and investigated (see Barro and Sala-I Martin, 2004). The approach that has been most commonly used when studying the sources of economic growth is using Barro-type framework, which allows testing for conditional convergence by adding to a Solow-type equation a set of variables reflecting differences in

¹ The data that support the findings of this study are available on request from the corresponding author.

the steady-state equilibrium (Barro, 1991). This methodology involves regressing per capita GDP growth during a given time interval on initial per capita income, and a set of conditional variables.

This paper selects the following explanatory variables in the preliminary analysis: fixed investment, unemployment, human capital, population growth, transportation, as well as different measurements for telecommunications per capita access: have been outlined in Equation (3.1). The inclusion of the lagged per capita GDP is outlined in Equation (3.1), (3.4) and (3.5).

It was estimated the following fixed-effects, one-way error component regression model on a panel data for 15 LA countries over an 11-year span.

Table 1. List of countries

<i>Latin America</i>
1. Argentina
2. Bolivia
3. Brazil
4. Chile
5. Colombia
6. Costa Rica
7. Cuba
8. Dominican Republic
9. Ecuador
10. Guatemala
11. Mexico
12. Panama
13. Paraguay
14. Peru
15. Uruguay

Source: own elaboration.

For a proper estimation scenario, a fixed effects model was implemented so that the idiosyncratic error term is not related with the explanatory variables, resulting in a fixed effects estimation unbiased and precise.

$$\begin{aligned}
 \ln gdp_{it} = & \beta_i + \beta_1 \ln gdp_{i,t-1} + \beta_2 \ln elec_{i,t-1} + \beta_3 \ln net_{i,t-1} \\
 & + \beta_4 \ln com_{i,t-1} + \beta_5 \ln unemp_{i,t-1} + \beta_6 \ln inv_{i,t-1} \\
 & + \beta_7 \ln popg_{i,t-1} + \beta_8 \ln govt_{i,t-1} + \varepsilon_{it}
 \end{aligned} \tag{3.1}$$

$$\varepsilon_{it} = v_i + \mu_{it} \tag{3.2}$$

$$\beta_i = \beta_0 + \beta_9 Z_i \tag{3.3}$$

In the regression above, $\ln gdp_{it}$ is the dependable variable and it is the natural logarithm of per capita GDP (current US\$) for country i . $\ln elec_{i,t-1}$ is the natural logarithm of the access to electricity (% of population) for country i lagged one year. $\ln net_{i,t-1}$ is the natural logarithm of the individuals using the internet (% of population) for country i lagged one year. $\ln com_{i,t-1}$ is the natural logarithm of information and communication technology goods imports (% of total goods imports) for country i lagged one year. $\ln unemp_{i,t-1}$ is the natural logarithm of total unemployment as a percentage of total labor force (national estimate) for country i lagged one year. $\ln inv_{i,t-1}$ is the natural logarithm of gross capital formation (% of GDP) for country i lagged one year. $\ln popg_{i,t-1}$ is the natural logarithm of population growth (annual %) for country i lagged one year. $\ln govt_{i,t-1}$ is the natural logarithm of total government expenditure on education (% of GDP) for country i lagged one year.

The independent variables are lagged to reflect the notion of the time that it takes the impacts to be realized.² The effects of the independent variables are not expected to directly impact the dependent variable in the same period. Therefore, the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) options were utilized in STATA in which it was recommended a one period lag for all the independent variables. Z_i represents unobserved characteristics and β_0 , β_7 are coefficients. Being this a one-way error model, v_i denotes the time-invariant and country-specific effects, and μ_{it} denotes the remainder disturbance with mean zero and variance-covariance $\sigma^2 v I_{nt}$.

² Both AIC and BIC appropriate mentioned number of lags.

Table 2. Static Panel (3.1) Results**Dependent Variable: *Ingdp***

<i>Independent Variables</i>	<i>Coefficients</i>
<i>Ingdp</i> _{i,t-1}	-0.804*
<i>Inelec</i> _{i,t-1}	1.537***
<i>Innet</i> _{i,t-1}	0.217*
<i>Incom</i> _{i,t-1}	0.133***
<i>Lnunemp</i> _{i,t-1}	-0.139***
<i>Lninv</i> _{i,t-1}	0.723*
<i>Inpopg</i> _{i,t-1}	0.096
<i>Ingov</i> _{i,t-1}	0.315*
constant	-1.733

 $R^2 = 0.447$

Std Error = 4.65

DW-stat = 2.01

P (F-stat) = 0.02

Notes: T-values are in parentheses; * indicates significance at 1%;

** indicates significance at 5%; *** indicates significance at 10%.

Source: own elaboration.

Dynamic effects

Ignoring the importance of lagged dependent variables, when they are persistent, could lead to the omitted variable bias issue. Thus, we include lagged per capita GDP as another independent variable thereby specifying a model characterized as a first-order autoregressive process with added exogenous variables –more commonly known as a dynamic panel.

Islam (1995) reworked the model developed by Barro into a dynamic panel data model with fixed effects and used panel data procedures to estimate it. The main advantage of this dynamic panel data approach lies in its ability to allow for differences in the aggregate production function across economies. This method can also capture short-run autoregressive behavior by adding a lagged growth rate as an independent variable.

Since our focus is to investigate the role of telecommunications infrastructure and per capita access in explaining the different growth performance

across regions in LA, we can estimate a growth model by following the Barro's conditional convergence framework (Barro, 1991; Islam, 1995). In this study, the growth equation is extended to include the effects of telecommunications infrastructure on growth, except for accounting for differences in initial economic conditions, in lagged growth rates, and a set of other variables.

We model a variant of (3.1) where we regress our per capita GDP $\ln Gdpp_{it}$ in a dynamic setting as follows:

$$\ln Gdpp_{it} = \lambda_0 + \lambda_1 Gdpp_{it} + X_{it} \Gamma \quad (3.4)$$

The matrix of regressors X contains, electricity, internet, ICT goods imports, unemployment, the level of capital formation, population growth, and government spending on education. The usual fixed-effects method of estimating the parameters of (3.4) involves taking first-differences such that:

$$\begin{aligned} GDPP_{it} - GDPP_{it-1} = & \beta(GDPP_{it-1} - GDPP_{it-2}) + \lambda(X_{it} - X_{it-1}) \\ & + (\varepsilon_{it} - \varepsilon_{it-1}) \end{aligned} \quad (3.5)$$

However, the ensuing correlation that arises between the lagged dependent variable would seriously bias the Ordinary Least Squares (OLS) estimator (Hsiao, 2003). Asymptotically, this bias is more pronounced the greater the variance of the individual effects. Nerlove (1971) shows that this result also holds in finite samples. Anderson and Hsiao (1981) describe an instrumental variable implementation that –for our own application– involves choosing either $GDPP_{it-2}$ or $(GDPP_{it-2} - GDPP_{it-3})$ as an instrument for $(GDPP_{it-1} - GDPP_{it-2})$.

However, Arellano and Bond (1991) point out that these (second lags) are not the only two viable instruments. For our purposes, any $GDPP_{it-2-j}$ term $\forall j = 0, 1, \dots$ may be uncorrelated with the error term while not necessarily uncorrelated with the lagged endogenous term. Arellano and Bond (1991) developed a procedure that treat the model as a system of equations, one for each period, where the matrix of differenced instruments is built recursively and estimated within a GMM approach.³

³ With this differenced-GMM approach the endogenous variable is properly instrumented with suitable lags of its own levels –other exogenous regressors and outside variables may enter the matrix of instrument in a standard way. However, with this differenced-GMM Arellano-Bond estimator, the lag levels may be poor instruments for first differences in models (like ours) in which highly persistent variables are considered. Thus, we opt to make use of an augmented version—a system-GMM

Table 3 reports results from the dynamic panel model (3.5) estimated with the Anderson and Hsiao (1981) *instrumental variable* procedure, and the Arellano and Bond (1991) *system-GMM* procedure.

Here again, the coefficients of the electricity, internet, ICT goods imports, variables are positive. All these results and implications are statistically significant and consistent with our static fixed-effect results. It is worth noting that a less than zero coefficient on lagged output per capita will be consistent with the conditional convergence theory of the neoclassical model.

Table 3. Dynamic Panel (3.5) Results
Dependent Variable: $\Delta GDPP$

<i>Independent Variables</i>	<i>IV estimation</i>	<i>System GMM</i>
$\Delta Inelec_{it}$	1.431**	1.156*
$\Delta Innet_{it}$	0.205*	0.192*
$\Delta Incom_{it}$	0.126**	0.132**
$\Delta Ineump_{it}$	-0.127**	-0.112**
$\Delta Ininv_{it}$	0.692*	0.618*
$\Delta Inpopg_{it}$	0.077	0.059
$\Delta Ingov_{it}$	0.294*	0.227*
$GDPP_{it-2} - GDPP_{it-3}$	-0.135*	-0.412*
R ² : within = 0.298		SG chi2(93) = 117
between = 0.808		P > chi2 = 0.00
Chi2(11) = 52.7		H chi2(93) = 111
P > chi2 = 0.00		P > chi2 = 0.14

Notes: T-values are in parentheses; * indicates significance at 1%; **indicates significance at 5%; ***indicates significance at 10%; SG and H denote the Sargan and Hansen tests of over-identifying restrictions for the matrix of instruments for the System-GMM estimation procedure.

Source: own elaboration.

approach—first described in Arellano and Bover (1995). For details on this estimation procedure, see Blundell and Bond (1998). We applied the XTABOND2 procedure in STATA which conducts a finite-sample correction to the two-step covariance matrix to correct for the downward bias of the standard errors (see Windmeijer, 2005).

A Random Coefficient Model

An alternative method to country-specific fixed effects is a Random Coefficient Model (RCM). Using the latter procedure, we allow for a unit-to-unit variation in the model parameters (Beck and Katz, 2007). The explanatory and predictive power of the model increases with, among other alternatives, a RCM (Hsiao, 2003). It allows the coefficients to vary randomly, so that we can individually test whether access to electricity, internet and ICT imports of each of the country of interest i , has an impact on the per capita GDP of country. The results are presented in table 4. With the RCM, individual coefficients for each country have been obtained.

Table 4. Group-specific coefficients.

Dependent variable: $\ln gdp_{it}$

Variable	Country	$\ln elec_{i,t-1}$	$\ln net_{i,t-1}$	$\ln com_{i,t-1}$
$\ln gdp_{it}$	1	0.329**	0.237**	0.208**
$\ln gdp_{it}$	2	0.234*	0.343**	0.227**
$\ln gdp_{it}$	3	0.208**	0.317**	0.173*
$\ln gdp_{it}$	4	0.383*	0.394**	0.208*
$\ln gdp_{it}$	5	0.263*	0.342*	0.230**
$\ln gdp_{it}$	6	0.294*	0.411**	0.120**
$\ln gdp_{it}$	7	0.410*	0.323**	0.306**
$\ln gdp_{it}$	8	0.150*	0.305**	0.281*
$\ln gdp_{it}$	9	0.148*	0.221**	0.189*
$\ln gdp_{it}$	10	0.345**	0.321**	0.255**
$\ln gdp_{it}$	11	0.264**	0.308**	0.240**
$\ln gdp_{it}$	12	0.335*	0.322**	0.201**
$\ln gdp_{it}$	13	0.248*	0.209**	0.199**
$\ln gdp_{it}$	14	0.357**	0.225**	0.341**
$\ln gdp_{it}$	15	0.228*	0.341**	0.330**

Notes: *indicates significance at 10%; **indicates significance at 5%.

Source: own elaboration.

4. RESULTS

The results of the fixed effects model for the entire data set for the LA countries are displayed in table 2. The coefficients of the regressors for the model used have the expected sign and are statistically significant (except for population growth). Results in tables 2 and 3 suggest that access to electricity has a positive relationship with economic growth. As mentioned by Rehman and Deyuan (2018), electricity possesses vital value as it is considered one of the most important sources that supports every aspect of the economy. Similarly, in his study Oladipo Olalekan (2013) finds that for the short and long run periods, telecommunications and electricity supply have the comparable positive effect on the economic growth. He emphasizes that uninterrupted electricity supply alongside investments in telecommunications is an essential factor for the growth. An increase in the individuals using the internet results in a positive impact to per capita GDP in which its significant at the 1% level. Looking at the contribution of ICT imports to economic growth, the results suggests that there is a positive relationship which is statistically significant at the 20% significance level. Correspondingly, Palvia and Baqir (2018) point out the important role of the ICTs on the socio-economic development. After defining and analyzing the parameters of the socio-economic impact such as doing business or ICT access, the authors found that ICTs contribute to the positive impact on economic growth. In addition, results of the survey of 150 studies from 1990 to 2007 showcased the positive relationship between ICT and economic growth (Cardona and Kretschmer, 2013). The foundation of this study depends on the statement that the development and economic growth of nations heavily rely on productivity. Hence, through analysis of the ICT as General-Purpose Technology, they conclude that productivity is essential in everyday lives and shows the positive and growing impact. Ultimately, the research shows ICT has small impact on economic growth with an elasticity of 0.05.

Unemployment rate, as expected, has a negative impact on per capita GDP, the results reveal that there is a level of significance of 10%. Another variable considered for the estimation is the gross capital formation, in which reveals a positive impact on economic growth. Moreover, the results revealed the positive relationship between population growth and economic growth, although population growth is not statistically significant. Lastly, it was found a positive impact of government expenditure on education on economic growth where it is significant at the 5% level.

Results from our RCM model for all 15 countries, shows that country i 's economic growth is positively and significantly related to electricity access, internet access and ICT imports. The conclusions that can be drawn from these results are evident. Policies promoting using the three variables will have significant positive economic effects.

5. CONCLUSIONS

This study tries to show the role of telecommunication infrastructure effect on economic growth. In evaluating the effects of telecommunications infrastructure in economic growth for 15 countries of LA during the period 1995-2016. We first applied applying a Solow type equation, fixed effect and the system GMM models have been performed to check the importance of macro level variables on economic growth, population, fixed investment, government expenditure, etcetera, all of these variables showed a significant relationship with economic growth (either positive or negative).

Our research shows that there is a positive and significant impact of electricity access, internet usage, and ICT imports with economic growth. With the results it is possible to conclude that LA countries must designate the necessary funds to expand their infrastructure for their population as well as to invest in imports of ICT as it is a way to enhance development and promote economic growth. While an increase in these variables promotes an increase in per capita GDP, we must account that there are economic and significant infrastructure differences in our sample. Further research is necessary to understand the mentioned differences of economic development and infrastructure by conducting a case-by-case scenario for each country to determine any possible discrepancy with the results obtained from this research.

Policy makers have to enhance the use of telecommunications; the result of this study promotes investments and improvements in telecommunications development, especially in sectors that have critical stimulating growth for potential gains from telecommunications by benefiting from the huge access of population to the internet through telecom services. In addition, the telecommunication services can also have an advantage by facilitating the access of population to the government services, as well as other sectors services, like education and health, which rely highly on internet and telecommunication services.

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