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The Americas

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The economic contribution of broadband, digitization and ICT regulation

Econometric modelling for the Americas

The economic contribution of broadband, digitization and ICT regulation: Econometric modelling for the Americas

Acknowledgements

This report has been prepared by the International Telecommunication Union (ITU) with the collaboration of the ITU Telecommunication Development Bureau (BDT) Regulatory and Market Environment Division (RME). It is based on regional findings from research prepared for the ITU report on the economic contribution of broadband, digitization and ICT regulation published in 2018. The research study is based on desk research and on data from the ITU ICT Regulatory Tracker and the Digital Ecosystem Development Index developed with funding from the CAF (Corporación Andina de Fomento) Development Bank for Latin America.

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Foreword

The transformative power of digital technologies and connectivity is empowering people, creating an environment that nurtures innovation, and is triggering positive change in business processes and in the global economy.

The recent ITU study on the economic contribution of broadband, digitization and ICT regulation provided a global econometric analysis of robust and reliable data resources to measure the impact of fixed and mobile broadband and digital transformation on the economy as a whole. It also analysed the impact of institutional and regulatory variables to the development of the digital ecosystem.

Based on the data and analysis to measure the impact of digitization as a whole, a further need was identified to conduct studies that delved deeper into these effects, focusing on specific regions of the world. By applying the same methodologies and econometric models used for assessing global effects, this study focuses on the impact of broadband, digital transformation and policy and regulatory frameworks on the growth of markets for digital services in the Americas region.

This report provides evidence of the importance of regulatory and institutional variables in driving digital growth. It illustrates that broadband technologies and effective ICT regulation can have positive impacts on the growth of national economies and prosperity.

The report suggests that an increase of 10 per cent in fixed broadband penetration would yield an increase in 1.9 per cent in GDP per capita. In addition, it suggests that pricing remains a key enabler for adoption of broadband and a 10 per cent drop in prices will boost adoption by more than 3.0 per cent.

I am delighted to present this ever-growing body of research for the Americas region will assist membership in designing sustainable policies and strategies to benefit from the dynamic and exciting broadband ecosystem.

Doreen Bogdan-Martin
Director, ITU Telecommunication Development Bureau

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1 Introduction

ITU published the findings of a global study on the economic contribution of broadband, digitization and ICT regulation in September 2018[1]. The *Economic contribution of broadband, digitization and ICT regulation: Econometric modelling for the Americas region* presents a set of econometric analyses that estimate the economic contribution of broadband and digitization, as well as the impact of ICT policy on the development of the digital economy on a global scale. It provides substantial evidence regarding the impact of broadband and digital transformation on the economy as well as the impact of institutional and regulatory variables on the growth of the digital ecosystem. The ITU global econometric report in 2018 was based on a large set of advanced and emerging economies, and showed effects for countries based on their level of development:

- Fixed broadband economic impact is guided by a returns to scale effect[2], according to which the economic impact of fixed broadband is higher in more advanced countries than in emerging economies.
- The economic impact of mobile broadband reflects a saturation effect, according to which the mobile broadband contribution is higher in emerging economies than in more developed ones.
- The impact of the digital ecosystem on countries with more advanced economies is higher than in countries with emerging economies.
- The regulatory and policy framework has a consistent impact on the development of the digital ecosystem, regardless of the country's level of development.

This evidence was considered significant for policy makers and regulators in particular with regards to two key issues:

- Which technologies should become a policy priority in terms of adoption?
- How to ensure that, beyond broadband adoption, policies are deployed to stimulate the development of the digital ecosystem?

The conclusions generated by this research has prompted calls to conduct studies that delve deeper into these effects, focusing on specific regions of the world. By applying the same methodologies and models used for assessing global effects, this report focuses on the Americas region, summarizing the results of the global study, and presents the results of the analyses for the Americas region.

2 The effects identified on a global scale

The global ITU study cited above was focused on testing three effects:

1. the economic contribution of fixed and mobile broadband;
2. the economic contribution of digitization (a variable that subsumes broadband technology within a larger set of digital ecosystem components); and
3. the impact of the policy and regulatory frameworks on the growth of markets for digital services and applications.

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1 Katz, R. and Callorda, F. (2018). *The economic contribution of broadband, digitization and ICT regulation.* Geneva, International Telecommunications Union (https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/FINAL_1d_18-00513_Broadband-and-Digital-Transformation-E.pdf).

2 Generally, *returns to scale effect* describes what happens as the scale of production increases over time, when inputs such as physical capital usage are variable. The *ITU report on the impact of broadband on the economy, 2012 (*https://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_Impact-of-Broadband-on-the-Economy.pdf*)* states that according to the returns to scale theory, the economic impact of broadband increases exponentially with the penetration of the technology.

The findings for each of the analyses are presented in order to provide the context within which the regional models are specified.

Economic impact of fixed broadband

The structural econometric model, composed of four equations[3], developed for the ITU global study generated further evidence of the economic impact of fixed broadband between 2010 and 2017. Based on a model run for 139 countries (general fixed broadband model), an increase of 10 per cent in fixed broadband penetration yielded an increase in 0.8 per cent in Gross Domestic Product (GDP) per capita. The sample was split between high, medium, and low income countries to test whether fixed broadband contribution still existed and whether the impact increased or decreased by level of economic development:

- Countries with GDP per capita higher than USD 22 000 (50 countries);
- Countries with GDP per capita between USD 12 000 and USD 22 000 (26 countries);
- Countries with GDP per capita lower than USD 12 000 (63 countries).

The results supported the hypothesis that the economic contribution of fixed broadband increases with economic development:

- Higher income countries: 10 per cent increase in broadband penetration yields 1.4 per cent increase in GDP growth.
- Middle income countries: 10 per cent increase in broadband penetration yields 0.5 per cent increase in GDP growth.
- Low income countries: while the coefficient of fixed broadband impact was similar to the middle impact countries, it was not statistically significant.

Economic impact of mobile broadband

Mobile broadband has a higher impact of on the world economy than fixed broadband has. Relying on a similar structural model run for a 139 country sample (the general mobile broadband model) from the ITU global study, it was estimated that on average, an increase of 10 per cent in mobile broadband penetration yielded an increase in 1.5 per cent in GDP.

In this case, the level of economic contribution of mobile broadband was the opposite to fixed broadband. The economic impact of mobile broadband is higher in countries with lower levels of development:

- High income countries: no economic impact was detected.
- Middle income countries: An increase of 10 per cent in mobile broadband penetration yields an increase in 1.8 per cent in GDP.
- Low income countries: An increase of 10 per cent in mobile broadband penetration yields an increase in 2.0 per cent in GDP.

The difference in impact of mobile broadband between high income and low income economies depends on the number of consumers who have access to fixed broadband. In many emerging economies, mobile broadband is the only technology that enables Internet access, while mobile broadband contribution to high income economies is only marginal while the impact in low income countries is extremely important.

Economic impact of digitization

The economic impact of digitization was tested by relying on an endogenous growth model that linked GDP to the fixed stock of capital, labour force, and the CAF Digital Ecosystem Development Index. The

[3] Detailed description of models and methodologies can be found in the ITU global study cited in footnote 1.

approach followed in this case was similar in terms of first testing the economic contribution for a sample of 73 countries worldwide (the "general digitization model") and then splitting it for countries from the Organization for Economic Co-operation and Development (OECD) and non-OECD countries. According to the general digitization model, an increase of 10 per cent in the CAF Digital Ecosystem Development Index resulted in a 1.3 per cent growth in GDP per capita. When the sample was split between advanced and emerging economies, economic impact increased with development:

- OECD countries: An increase of 10 per cent in the Digital Ecosystem Development Index resulted in a 1.4 per cent growth in GDP per capita.
- Non-OECD countries: An increase of 10 per cent in the Digital Ecosystem Development Index yielded a 1.0 per cent growth in GDP per capita.

Furthermore, a single variable model with country and period fixed effects indicated that digitization also has an impact on labour and total factor productivity. An increase in the digitization index of 10 per cent yielded an increase in labour productivity of 2.6 per cent and in total factor productivity of 2.3 per cent.

Impact of policy and regulatory framework on digitization development

In this case, the contribution to digitization development was tested through a multivariate regression model with fixed effects based on two independent variables: the ICT Regulatory Tracker[4] and a year lag of the same variable for control purposes. The model provided further evidence of the importance of the regulatory and institutional variable in driving digital ecosystem growth. An increase of 10 per cent in the ICT Regulatory Tracker yielded a positive increase in the CAF Ecosystem Development Index of 0.348 per cent in the subsequent time period.

The same types of analyses, methodologies, and results relied upon for the ITU global study used in this econometric modelling study of the Americas region, focusing on validating the results with the regional studies. The presentation of the econometric model results is preceded by a review of the research literature on the economic contribution of broadband in the Americas region.

3 The economic contribution of broadband and digitization and the impact of policy on digitization in the Americas region

The Americas region, considering the very different economic conditions and market dynamics for the purpose of this study, was analysed in two separate geographical areas: north America, which includes Canada and the United States of America, and Latin America and the Caribbean (Table 1), considering the countries were data is available, which includes Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Jamaica, Mexico, Panama, Paraguay, Peru, Dominican Republic, Trinidad and Tobago, Uruguay, and Venezuela.

Table 1: Comparative economic and market dynamics 2018 (North America and Latin America and the Caribbean)

	North America	Latin America and the Caribbean
GDP per capita	USD 60,818.78	USD 8,787.19
Mobile telephony penetration (individuals)	117.89 %	107.48 %

[4] ITU ICT Regulatory Tracker: https://www.itu.int/net4/itu-d/irt/#/tracker-by-country/regulatory-tracker/2017

	North America	Latin America and the Caribbean
Fixed broadband penetration (households)	88.99 %	46.00 %
Mobile broadband penetration (connections/ individuals)	126.28 %	68.36 %
Mobile broadband penetration (unique users/ individuals)	74.61 %	52.95 %
Smartphone penetration (devices/individuals)	84.73 %	69.41 %
Computer penetration (devices/households)	93.44 %	46.98 %

Note: Regional numbers are prorated by population

Sources: World Bank; IMF; ITU; GSMA

As depicted in Table 1, with the exception of mobile telephony penetration, where the results are fairly close, north America and Latin American and the Caribbean represent two distinct economic and social contexts. Consequently, this study will explore the economic and policy contribution of broadband and digitization both in aggregate and sub-regional terms.

3.1. Review of the research literature

The research literature on the impact of broadband on economic growth in the Americas Region covers numerous aspects, ranging from its aggregate impact on GDP growth to the differential impact of broadband by industrial sector, the increase of exports, and changes in intermediate demand and import substitution[5]. While the research on the contribution of broadband to GDP growth has confirmed its positive impact, it has also yielded results that vary widely.

Given the distinct evidence generated with regards to the effects identified for North America and Latin America and the Caribbean, no study exists that deals with them in an integrated manner, although there is a wealth of literature conducted separately.

3.1.1. Economic impact of broadband: United States of America

The past studies of the economic impact of broadband in the United States of America has been primarily focused in estimating the contribution of technology to GDP growth. Crandall et al. (2007) was one of the first studies that applied a cross-sectional dataset using broadband penetration data to determine the impact of the technology on output. This study provided some empirical support for the conclusion that expanded broadband capacity led to an increase in GDP, particularly in the service sector, namely finance, real estate, and educational services. The authors also found that while the correlation between broadband penetration and GDP was positive, the result lacked statistical significance.

Gillett et al. (2006) conducted an econometric study measuring the impact of fixed broadband availability on local economic development using sub-state geographic data in the United States of America. The study classified each ZIP (postal) code area based on its broadband availability in 1999, and then followed the growth in economic indicators over time. The statistical methodology included matching ZIP code areas with broadband to those without to create 'treatment' and 'control' groups, regression analysis, and other econometric techniques designed to distinguish causality from mere

[5] See Katz, R. (2012). *The impact of broadband on the economy: research to date in Economy.* Geneva: International Telecommunications Union. https://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_Impact-of-Broadband-on-the-Economy.pdf)

correlation. The major findings of the study were that broadband added 1.0 to 1.4 per cent to the growth rate of local employment, and 0.5 to 1.2 per cent to the growth rate of the number of business establishments from 1998 to 2002.

In another study, Kolko (2010) found that broadband expansion is correlated with economic growth over the period 1999-2006 in the United States of America. This relationship was strongest in industries that relied heavily on ICT: information; professional, scientific, and technical services; management; and administrative services. The author estimated an instrumental variables regression that explicitly accounted for the potential simultaneity of broadband and employment growth.

Greenstein and McDevitt (2009) tackled the task of finding broadband net contribution to GDP. Using the same methodology as for official calculation of the national income and product accounts, they concluded that the direct, net impact of broadband deployment was approximately USD 8.3 to 10.6 billion of new GDP in 2006. They also found an additional USD 4.8 to 6.7 billion in new consumer surplus created by broadband (net of what would have accrued with dial-up service), which by definition does not show up in GDP.

3.1.2. Economic impact of broadband and digitization in Latin America and the Caribbean

The first analysis of the economic impact of broadband in Latin America (Katz, 2010) was based on a cross-sample of countries. In the absence of time series, the analysis employed the ordinary least square (OLS) method[6], using a sample of pooled data for the years 2004 and 2009. Despite the lack of panel data, this study could establish a positive impact of broadband in the economic growth of Latin America and the Caribbean. When controlling for education and GDP per capita, a 10 per cent increase in broadband penetration raised GDP by 0.15 per cent.

The model yielded positive signs in the key variables, with statistically significant coefficients. In 2014, increased availability of disaggregated data made it possible to conduct studies at the national level. The first was carried out in Colombia with data for the years 2006 to 2010, and analysed the impact of fixed broadband on GDP growth, controlling for initial level of economic development, population growth and human capital (proxied as average years of education). In this case, the study showed that an increase in broadband connections in Colombia had a positive effect on GDP growth. An increase in connections of 10 per cent yielded a growth in GDP of 0.037 per cent. This effect was less than what was found in the prior regional model, mainly because the average rate of fixed broadband penetration at the time of the study was below the Latin America average. These results suggested a returns to scale effect.

In 2012, two studies tested the impact of fixed broadband in Brazil and Chile. The model built to estimate the impact of broadband on the Brazilian GDP growth relied on a database for the 27 states of Brazil comprising data on regional GDP per capita, literacy rate, interstate trade costs, costs to create a new business, average of GINI coefficient[7], and broadband penetration. Recognizing the model limitations in terms of the number of observations, the evidence pointed directionally to an increase of 10 per cent in fixed broadband penetration could contribute 0.08 percentage points to GDP growth. In the case of Chile, the model relied on quarterly data for each administrative region comprising regional GDP growth, percent population with some level of tertiary education, population (size and growth), rate of urbanization, contribution of agricultural and trade sectors, and broadband penetration. Broadband penetration was found to be statistically significant and with the expected sign in terms of contributing to GDP growth According to the coefficient of this variable, a 10 per cent increase in penetration resulted in an increase of 0.09 percentage points in Chile's regional GDP.

[6] Ordinary least squares (OLS) is a type of linear least squares method for estimating the unknown parameters in a linear regression model.

[7] In economics, the Gini coefficient is a measure of statistical dispersion intended to represent the income or wealth distribution of a nation's residents, and is the most commonly used measurement of inequality.

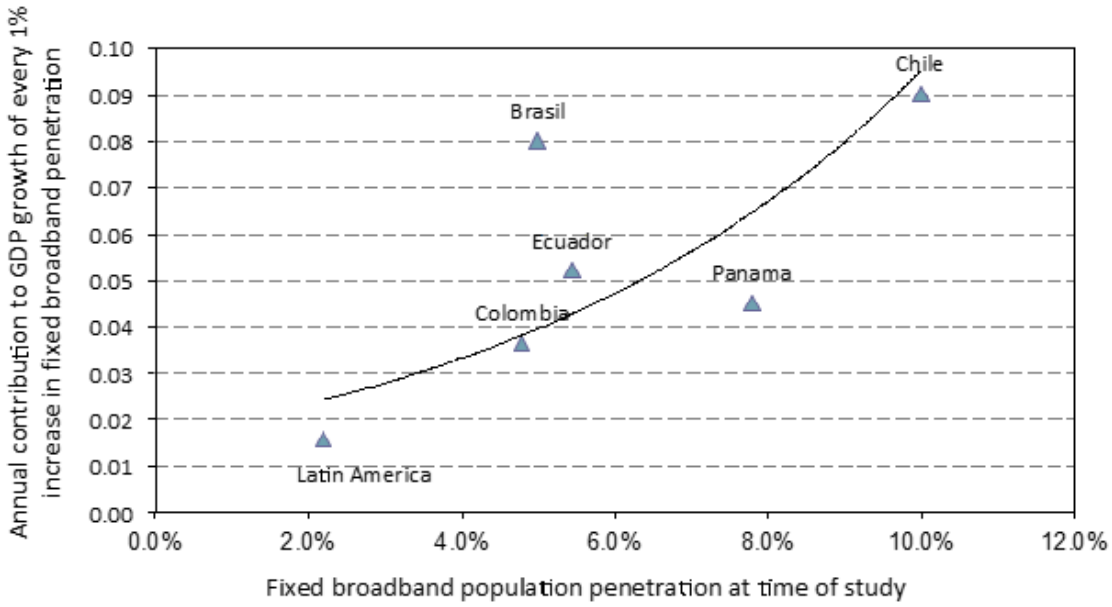
The availability of more extended time series enabled research to implement structural models similar to the one conducted by Koutroumpis (2009) for OECD countries. Along these lines, Katz and Koutroumpis (2012) conducted a study using a structural model to measure the economic contribution of fixed broadband in Panama. Based on this model, fixed broadband was found to have a significant impact on economic growth between 2000 and 2010. Its average annual contribution to GDP growth was estimated at 0.45 per cent for every 10 per cent increase in penetration. Comparison of the results for Colombia confirmed the existence of a return to scale effect. The economic contribution of broadband was greater in the Panama study, where in 2010 fixed broadband penetration was 7.8 per cent, compared with 4.8 per cent in Colombia.

Following on the use of structural models, Katz and Callorda (2013) analysed the economic contribution of fixed broadband to economic growth in Ecuador. According to this study, fixed broadband significantly contributed to the Ecuadorian GDP growth between 2008 and 2012. For every 10 per cent increase in penetration, the average annual contribution to GDP growth was estimated at 0.52 per cent.

A similar study was conducted by Gilchrist (2015) for the ECTEL Member States of the Caribbean[8]. By implementing an OLS (Ordinary least squares) with robust errors model, the author concluded that for the ECTEL states, an increase in the broadband penetration rate of 10 per cent would lead to an increase in real economic growth of 0.76 per cent.

The compilation of the coefficients of most studies reviewed above confirms a returns to scale in fixed broadband in Latin America (Figure 1).

Figure 1: Comparative fixed broadband contribution to GDP growth (Latin America)



Source: ITU

Although the coefficients were derived from different models, they provided evidence that the greater the fixed broadband penetration in Latin America, the higher the impact its expansion will have on GDP growth. The public policy implications are clear: maximizing the economic contribution of fixed broadband is contingent on significantly increasing its penetration.

[8] ECTEL member states comprise the Commonwealth of Dominica, Grenada, The Federation of St. Christopher (St. Kitts) and Nevis Saint Lucia, St. Vincent and the Grenadines.

Interestingly enough, Jung (2015) found in analysis of the impact of broadband of productivity across Brazilian states that the highest gains occurred in the country's less developed regions. However, the author carefully notes that this evidence does not invalidate the returns to scale hypothesis since the poorest regions in Brazil are not those with the lowest connectivity levels.

3.2. Hypotheses

Considering the evidence generated in the research literature and the ITU global study that preceded this analysis, one could stipulate the following effects in the Americas region:

- Impact of fixed broadband: High in north America, lower in Latin America and the Caribbean.
- Impact of mobile broadband: Low in north America, higher in Latin America and the Caribbean.
- Impact of digitization: High in north America, lower in Latin America and the Caribbean.

In light of this, models were first run for a sample where the United States of America and Canada would increase the prorated value of each variable, and then for Latin America and the Caribbean. In addition to testing the economic impact of broadband (fixed and mobile) and digitization, the impact of policy and regulatory frameworks on the development of digitization was tested.

3.3. Economic impact of fixed broadband in the Americas region

In the ITU global study, the structural model used to test the economic contribution of fixed broadband consists of four equations: an aggregate production function modelling the economy and, subsequently, three functions: demand, supply and output[9].

3.3.1. Data

To test the two hypotheses of fixed broadband economic impact presented above, a database was built for the following countries: Argentina, Brazil, Canada, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Jamaica, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, United States of America, Uruguay, and Venezuela[10]. The database contains time series for all the required variables between 2005 and 2017. The data sources are the International Telecommunication Union (ITU), the World Bank, and Ovum (see Annexes A and B for sources of data).

3.3.2. Model results and discussion

The model, run with all 18 countries in the Americas region database, yields statistically significant results, thereby confirming the effects identified in the global model. The results are set out in Table 2.

Table 2: Economic impact of fixed broadband (Americas region)

GDP per capita (PPP)[11]	
Fixed Broadband Subscribers Penetration	0.18797 ***
Capital	0.30414 ***

[9] Each equation has been described in detail in chapter 2 of the authors' ITU global study cited before.

[10] For a number of countries (Antigua and Barbuda, Bahamas, Barbados, Belize, Bolivia, Cuba, Dominica, Grenada, Guatemala, Guyana, Haiti, Honduras, Nicaragua, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname), consistent time series for fixed capital formation and labour education is not available; therefore, it was not possible to include them in the model.

[11] GDP per capita (PPP) refers to the gross domestic product at purchasing power parity per capita: PPP value goods and services produced within a country, divided by the average population for the same year.

Education	0.00063
Fixed Broadband Subscribers Penetration	
Fixed Telephone Subscribers	0.16412 ***
Rural Population	-0.05796 **
GDP per capita	0.81847 ***
Fixed Broadband price	-0.30709 ***
HHI Fixed Broadband	-0.04456
Revenue Fixed Broadband	
GDP per capita	1.41969 ***
Fixed Broadband price	1.52376 ***
HHI Fixed Broadband	-1.21225 ***
Fixed Broadband Adoption Growth	
Revenue Fixed Broadband	-0.40717 ***
Observations	784
Number of countries	18
Country Fixed Effects	Yes
Year and quarter Fixed Effects	Yes
Years	2005-2017
R-Squared first model	0.9905

***, **, * significant at 1%, 5% and 10% critical value respectively.

According to the fixed broadband model, this technology has had a significant impact on the Americas during the last twelve years (2005-2017). An increase of 10 per cent in fixed broadband penetration yields an increase in 1.9 per cent in GDP. Moreover, the structural model provides estimates for other important parameters of the economy, although further analysis would be required in these variables since they are part of the structural model second equation. For example, fixed capital formation is a strong catalyst of GDP growth, suggesting, as expected, an important contribution on the economy (0.30 coefficient). In terms of demand of broadband services, pricing remains a key enabler for adoption of the technology. Strikingly, a 10 per cent drop in prices will boost adoption by more than 3 per cent[12].

Income variation across the sample period seems to have a similar impact on this process. Hence increasing the average disposable income (proxied by GDP per capita) by 10 per cent yields 8.1 per cent more fixed broadband adoption. Supply dynamics suggest that, as expected, income levels affect the revenues and investments of operators. The consumption propensity for broadband services seems to have a significant impact on increasing the supply of digital offerings. Increasing the disposable income (proxied by GDP per capita) attracts 1.42 per cent more supply (based on the coefficient of

[12] A word of caution: considering that this is a structural model based on a system of equations, the results of intermediate equations are inputs for the final result. In that sense, the coefficients of intermediate steps should not be considered general conclusions.

GDP in the supply equation in Table 2). Finally, broadband revenues are found to have a significant impact on the performance of the industry, implying a reinvestment of the output to the productive basis of the economy[13]. This is an additional point supporting the increasing returns to scale of ICT infrastructure.

It is instructive to compare the results of the global model (general fixed broadband model) and the Americas region model to determine whether any particular region-specific effects can be identified (Table 3).

Table 3: Economic impact of fixed broadband (Global model compared to the Americas region)

	Global	Americas region
GDP per Capita (PPP)		
Fixed Broadband Subscriber Penetration	0.07715 ***	0.18797 ***
Capital	0.18922 ***	0.30414 ***
Education	0.05205 ***	-0.00063
Fixed Broadband Subscriber Penetration		
Fixed Telephone Subscribers	0.46780 ***	0.16412 ***
Rural Population	-0.12191 ***	-0.05796 **
GDP per capita	0.83844 ***	0.81847 ***
Fixed Broadband Price	-0.30080 ***	-0.30709 ***
HHI Fixed Broadband	-0.34757 ***	-0.04456
Fixed Broadband Revenue		
GDP per capita	1.23160 ***	1.41969 ***
Fixed Broadband Price	0.18800 ***	1.52376 ***
HHI Fixed Broadband	-0.77502 ***	-1.21225 ***
Fixed Broadband Adoption Growth		
Fixed Broadband Revenue	-0.74541 ***	-0.40717 ***
Observations	3,887	784
Number of countries	139	18
Country Fixed Effects	Yes	Yes
Year and quarter Fixed Effects	Yes	Yes
Years	2010-2017	2005-2017
R-Squared first model	0.9952	0.9905

***, **, * significant at 1%, 5% and 10% critical value respectively

Note: The global model was started in 2010 given that by then most countries had exceeded the 5 per cent adoption threshold.

[13] This is particularly relevant for markets undergoing high growth, while it not be the case with saturated markets.

As expected, the economic impact coefficient for the global sample is lower than that of the Americas region because the global sample includes a large number of emerging economies. Based on the returns to scale effect, fixed broadband economic contribution increases with the level of economic development. The returns to scale effect was detected when running the same model for the sixteen studied countries in Latin America and the Caribbean[14] (Table 4).

Table 4: Economic impact of fixed broadband (Latin America and the Caribbean)

GDP per Capita (PPP)	
Fixed Broadband Subscribers Penetration	0.15745 ***
Capital	0.31854 ***
Education	0.03039
Fixed Broadband Subscribers Penetration	
Fixed Telephone Subscribers	0.09390
Rural Population	-0.04654 *
GDP per capita	0.89943 ***
Fixed Broadband price	-0.43283 ***
HHI Fixed Broadband	-0.06636 *
Revenue Fixed Broadband	
GDP per capita	1.07432 ***
Fixed Broadband price	1.67497 ***
HHI Fixed Broadband	-1.02064 ***
Fixed Broadband Adoption Growth	
Revenue Fixed Broadband	-0.01968
Observations	688
Number of countries	16
Country Fixed Effects	Yes
Year and quarter Fixed Effects	Yes
Years	2005-2017
R-Squared first model	0.9819

***, **, * significant at 1%, 5% and 10% critical value respectively

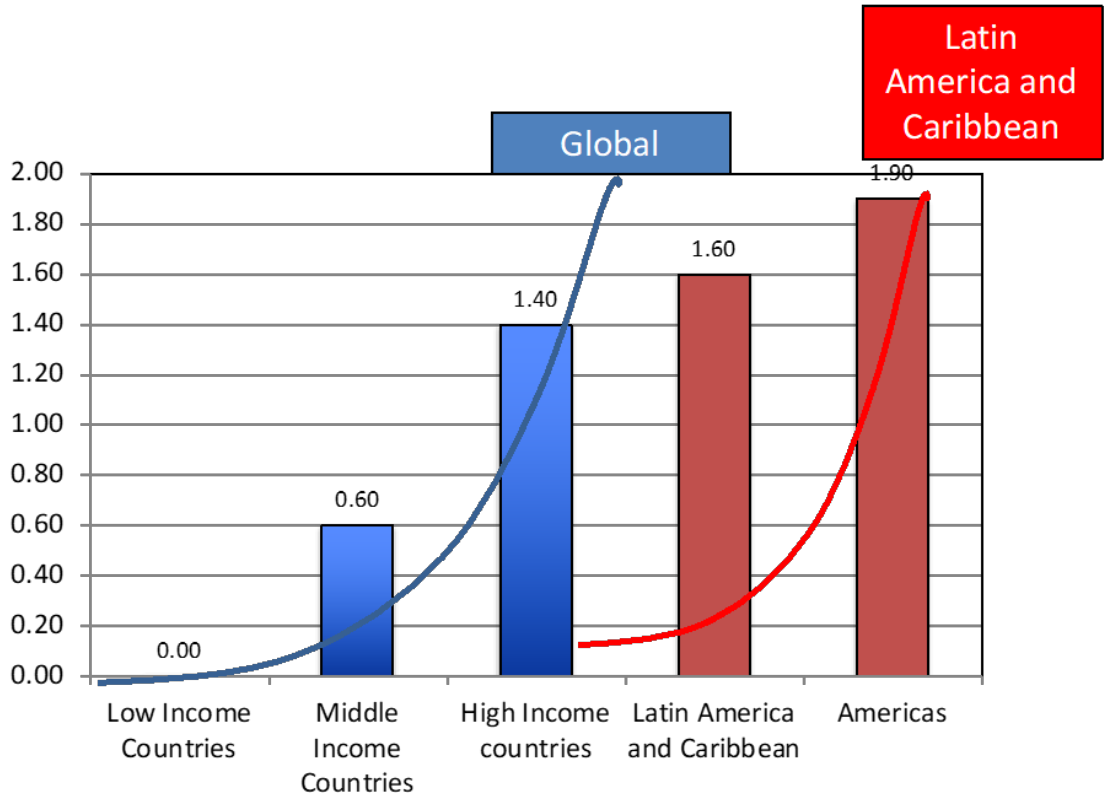
Note: HHI: Herfindahl Hirschman Index is a common measure of market concentration used to determine market competitiveness.

According to the fixed broadband model run only for the Latin American and Caribbean countries, the economic contribution is lower than for the Americas region model. An increase of 10 per cent

[14] Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Jamaica, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela.

in fixed broadband penetration yields an increase of 1.6 per cent in GDP. This result confirms the evidence generated in the ITU global study. Once North American countries are included in the sample, the fixed broadband contribution coefficient increases from 1.6 to 1.9. A comparison of the returns to scale effect for the global sample and for the Americas region can be visualized in Figure 2.

Figure 2: Economic impact of fixed broadband, 2017 (Global model compared to the Americas region model)



Source: ITU

As depicted in Figure 2, the structural model run against both data samples (worldwide: 139; Americas: 18) yields a similar returns to scale effect, confirming the fixed broadband hypothesis.

3.4. Economic impact of mobile broadband in the Americas region

Reflecting the fixed broadband model, the structural model tested the economic contribution of mobile broadband using four equations: an aggregate production function modelling the economy and, subsequently, three functions: demand, supply and output.

3.4.1. Data

To test the two hypotheses of mobile broadband economic impact presented above, a database was built for the following countries: Argentina, Brazil, Canada, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Jamaica, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, United States of America, Uruguay, and Venezuela[15]. The database contains time series for all the required

[15] For a number of countries (Antigua and Barbuda, Bahamas, Barbados, Belize, Bolivia, Cuba, Dominica, Grenada, Guatemala, Guyana, Haiti, Honduras, Nicaragua, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname), consistent time series for fixed capital formation and labour education is not available; therefore, it was not possible to include them in the model.

variables between 2010 and 2017. The data sources are the International Telecommunications Union (ITU), the World Bank, and GSMA (see Annexes A and B for sources of data).

3.4.2. Model results and discussion

The model, run with 18 countries, including the United States of America and Canada, yields statistically significant results, thereby confirming the effects identified in the global model. The results are shown in Table 5.

Table 5: Economic impact of mobile broadband (Americas region)

GDP per Capita (PPP)	
Mobile Broadband Unique Subscribers Penetration	0.11556 ***
Capital	0.02984
Education	0.62879 ***
Mobile Broadband Unique Subscribers Penetration	
Mobile Unique Subscribers Penetration	1.81434 ***
Rural Population	-0.11386 ***
GDP per capita	-0.12194 *
Mobile Broadband price	-0.09555 *
HHI Mobile Broadband	-1.02608 ***
Revenue Mobile Broadband	
GDP per capita	2.32425 ***
Mobile Broadband price	-0.79913 ***
HHI Mobile Broadband	-3.55965 ***
Mobile Broadband Adoption Growth	
Revenue Mobile Broadband	-0.36353 ***
Observations	565
Number of countries	18
Country Fixed Effects	Yes
Year and quarter Fixed Effects	Yes
Years	2010-2017
R-Squared first model	0.9767

***, **, * significant at 1%, 5% and 10% critical value respectively

According to the mobile broadband model for the Americas, an increase of 10 per cent in mobile broadband penetration yields an increase in 1.2 per cent in GDP. The importance of fixed capital formation is lower in this case than in fixed broadband. Interestingly enough, service pricing is less significant in driving demand, but the negative sign indicates that affordability remains an adoption

barrier. In the aggregate, mobile broadband appears to have a lower economic impact than fixed broadband (1.2 per cent versus 1.9 per cent increase in GDP as a result of 10 per cent increase in broadband penetration).

As mentioned above, these coefficients would need to be studied further since they are part of the second equation. This is the result of including in the sample countries in north America, which, as evidenced in the global study, appear to yield a lower economic impact than fixed broadband. This finding is also confirmed when comparing the Americas region model results with those of the global study (general mobile broadband model), which includes a larger number of emerging economies (Table 6).

Table 6: Economic impact of mobile broadband (Global model compared to Americas region)

	Global	Americas
GDP per capita (PPP)		
Mobile Broadband Unique Subscribers Penetration	0.15022 ***	0.11556 ***
Capital	0.21490 ***	0.02984
Education	0.05569 ***	0.62879 ***
Mobile Broadband Unique Subscribers Penetration		
Mobile Unique Subscribers Penetration	1.6797 ***	1.81434 ***
Rural Population	-0.03596 ***	-0.11386 ***
GDP per capita	0.05968 ***	-0.12194 *
Mobile Broadband price	0.00728	-0.09555 *
HHI Mobile Broadband	-0.37128 ***	-1.02608 ***
Revenue Mobile Broadband		
GDP per capita	0.08839 ***	2.32425 ***
Mobile Broadband price	0.11020 **	-0.79913 ***
HHI Mobile Broadband	-2.12035 ***	-3.55965 ***
Mobile Broadband Adoption Growth		
Revenue Mobile Broadband	-1.14176 ***	-0.36353 ***
Observations	3,858	565
Number of countries	139	18
Country Fixed Effects	Yes	Yes
Year and quarter Fixed Effects	Yes	Yes
Years	2010-2017	2010-2017
R-Squared first model	All	0.9767

***, **, * significant at 1%, 5% and 10% critical value respectively

As depicted in Table 6, the global sample model, which includes a larger percentage of emerging countries than the Americas model, indicates a higher coefficient of mobile broadband economic contribution.

This result is also confirmed when excluding the United States of America and Canada from the Americas region sample: i.e. mobile broadband economic contribution increases. This would confirm the saturation effect identified in the global study. In this case, an increase of 10 per cent in mobile broadband penetration yields an increase in 1.7 per cent in GDP (Table 7).

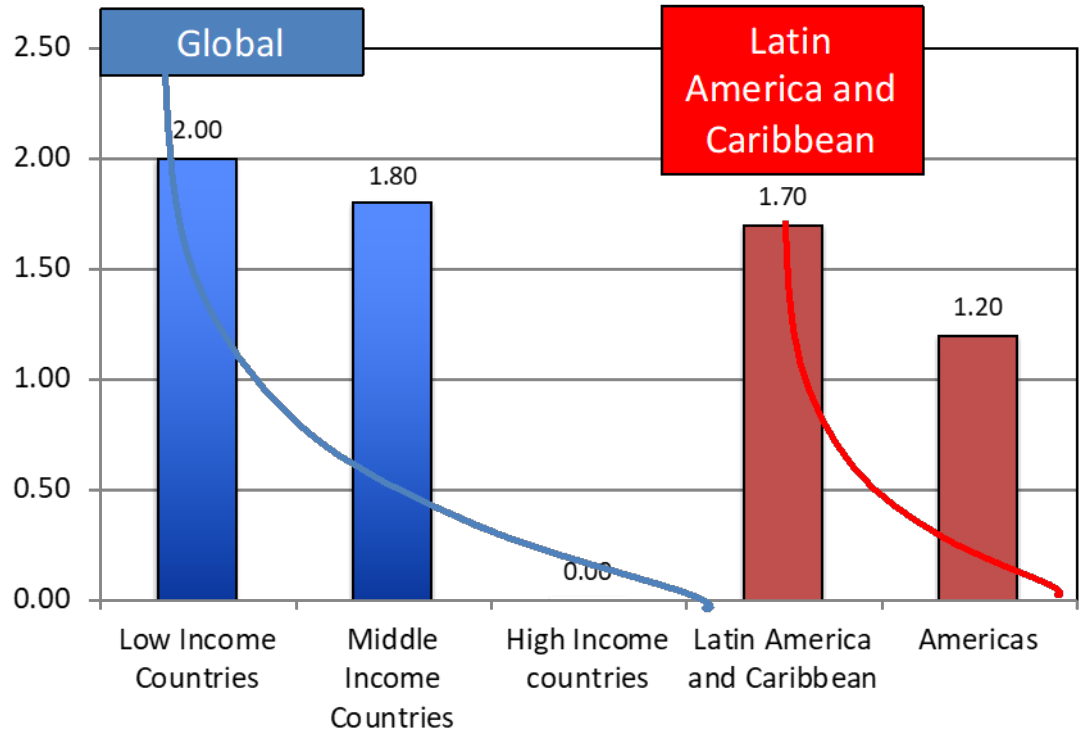
Table 7: Economic impact of mobile broadband (Latin America and the Caribbean)

GDP per Capita (PPP)	
Mobile Broadband Unique Subscribers Penetration	0.17329 ***
Capital	0.03075
Education	0.63360 ***
Mobile Broadband Unique Subscribers Penetration	
Mobile Unique Subscribers Penetration	1.94950 ***
Rural Population	-0.07061 ***
GDP per capita	-0.23404 ***
Mobile Broadband price	-0.58092 ***
HHI Mobile Broadband	-0.85911 ***
Revenue Mobile Broadband	
GDP per capita	1.46456 ***
Mobile Broadband price	-3.89924 ***
HHI Mobile Broadband	-2.47734 ***
Mobile Broadband Adoption Growth	
Revenue Mobile Broadband	-0.17906 **
Observations	501
Number of countries	16
Country Fixed Effects	Yes
Year and quarter Fixed Effects	Yes
Years	2010-2017
R-Squared first model	0.9412

***, **, * significant at 1%, 5% and 10% critical value respectively.

When north American countries are included in the sample, the mobile broadband contribution co-efficient decreases from 1.7 to 1.2. A comparison of the saturation effect for the global sample and for the Americas region can be seen in Figure 3.

Figure 3: Economic impact of mobile broadband 2017 (Global sample compared to the Americas region)



Source: ITU

As depicted in Figure 3, the structural model run against both data samples (worldwide: 139; Americas: 18) yields similar saturation effects, confirming the mobile broadband hypothesis.

3.5. Economic impact of digitization in the Americas region

Rather than measuring the impact of a single communications technology, the economic contribution of digitization, as measured by the CAF (Corporación Andina de Fomento) Digital Eco-system Development Index[16], is being tested.

The hypothesis tests whether the economic contribution of digitization increases at higher development stages. For this purpose, the endogenous growth model, which links GDP to fixed stock of capital, labour force, and the digitization index as a proxy of technology progress, was run for the Americas region and again for Latin America and Caribbean countries to test for a returns to scale effect.

3.5.1. Data

The CAF Digital Ecosystem Development Index was calculated for 15 countries: Argentina, Bahamas, Barbados, Brazil, Canada, Chile, Colombia, Costa Rica, Cuba, Mexico, Panama, Suriname, United States of America, Uruguay, and Venezuela for the period between 2008 and 2017[17]. Countries with current GDP per capita lower than USD 7 500 were excluded because small economies tend to have wide variations in GDP resulting from commodity price fluctuations overriding broadband effects. In addition, the model included independent variables for fixed capital formation (source: World Bank),

[16] The digital ecosystem development index developed with funding from CAF Development Bank for Latin America, Katz and Callorda, 2018e.

[17] For a number of countries (Antigua and Barbuda, Bahamas, Barbados, Belize, Bolivia, Cuba, Dominica, Grenada, Guatemala, Guyana, Haiti, Honduras, Nicaragua, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname) consistent time series for fixed capital formation and labour education is not available; therefore, it was not possible to include them in the model.

GDP per capita (source: International Monetary Fund IMF) and tertiary school enrolment, as a proxy for labour quality (source: World Bank).

3.5.2. Model results and discussion

The model was first run for 15 countries (see section 3.5.1) for the period 2008-2017, which results in 126 observations, and includes fixed effects by country (Table 8).

Table 8: Economic impact of digitization (selected 15 countries from the Americas region)

Variables, 2008-2017	Coefficients
Previous GDP	0.6721 *** (0.0586)
Digitization	0.1882 ** (0.0910)
Capital	-0.0261 (0.0990)
Labour	-1.3788 ** (0.5305)
Constant	2.1224 *** (0.6702)
Observations	126
Year fixed effects	Yes

***, **, * Significant at 1%, 5% and 10% critical value respectively.

According to the model, an increase of 10 per cent in the Digital Ecosystem Development Index results in a 1.9 per cent growth in GDP per capita. This means, for example, that an increase in the CAF Digital Ecosystem Development Index from 50 to 51 will yield an increase of per capita GDP of 0.38 per cent (accounting both for direct and indirect effects on output). The negative sign in the labour variable is due to the fact that this indicator exhibits very low variance in the period that is analysed (in other words, the labour quality indicator is highly inertial, which means that it does not change significantly over short periods of time).

To test the returns to scale effect, the model was also run for a sample of countries that excluded the United States of America and Canada (Table 9).

Table 9: Economic impact of digitization (Latin America and the Caribbean)

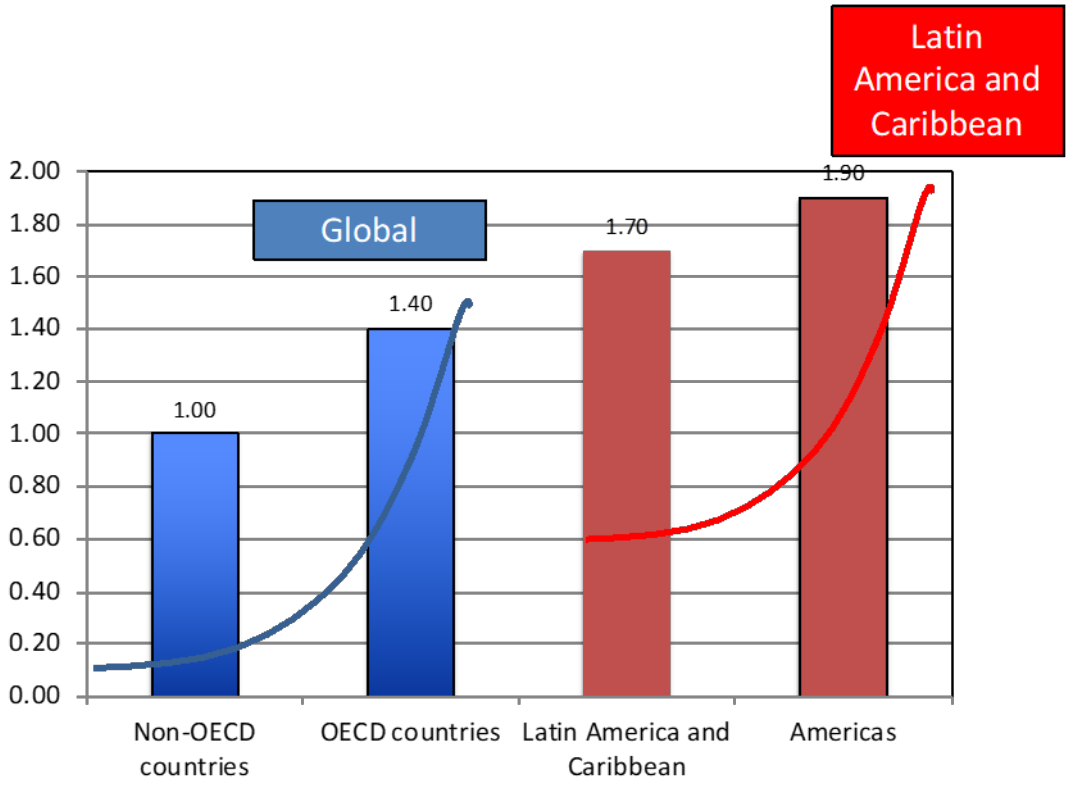
Variable, 2008-2017	Coefficients
Previous GDP	0.6746 *** (0.0633)
Digitization	0.1662 * (0.0995)
Capital	-0.0337 (0.1057)

Variable, 2008-2017	Coefficients
Labour	-1.2501 ** (0.5809)
Constant	2.1421 *** (0.7393)
Observations	106
Year fixed effects	Yes

***, **, * significant at 1%, 5% and 10% critical value respectively

According to this model, an increase of 10 per cent in the CAF Digital Ecosystem Development Index results in a 1.7 per cent growth in GDP per capita. This means that an increase in the CAF Digital Ecosystem Development Index from 50 to 51 will yield an increase of per capita GDP of 0.33 per cent (accounting both for direct and indirect effects on output). While the statistical significance of the digitization variable is at 10 per cent, the model is in line with the global model (general digitization model) run for 73 countries around the world (Figure 4).

Figure 4: Economic impact of digitization: Global compared to the Americas region (2017)



Source: ITU

When including North America in the Americas sample, the coefficient of economic impact of digitization increases confirming the returns to scale identified for the global sample of countries.

3.6. Impact of policy and regulatory framework on digitization in the Americas region

The following analysis relies on the ITU ICT Regulatory Tracker as the independent variable to test its impact on the CAF Digital Ecosystem Development Index. For this purpose, as in the ITU global

study cited above, two models were developed: the first one tests the correlation between the ICT Regulatory Tracker and the CAF Digital Ecosystem Development Index. The underlying premise is that higher regulatory performance is directly related to the development of the digital economy:

$$\text{Dig. Index}_{it} = \beta_1 \text{Reg. Index}_{it} + \text{Year F. E.} + \text{Country F. E.} + e_{it}$$

Beyond measuring the correlation between both variables, the second model was developed with lagged variables:

$$\text{Dig. Index}_{it} = \beta_1 \text{Reg. Index}_{it} + \beta_2 \text{Reg. Index}_{it-1} + \text{Year F. E.} + \text{Country F. E.} + e_{it}$$

Finally, the variables were converted to logarithms to test causality of change in the values of both indices:

$$\ln(\text{Dig. Index}_{it}) = \beta_1 \ln(\text{Dig. Index}_{it-1}) + \beta_2 \ln(\text{Reg. Index}_{it-1}) + \text{Year F. E.} + \text{Country F. E.} + e_{it}$$

3.6.1. Data

The models rely on the ICT Regulatory Tracker and the CAF Digital Ecosystem Development Index for the period between 2008 and 2017 for 34 countries: Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, United States of America, Uruguay, and Venezuela[18]. The CAF Digital Ecosystem Development Index includes an institutional and regulatory pillar, which was excluded from the index calculation in order to avoid co-linearity.

3.6.2. Models results and discussion

All models in this section were run for countries in the Americas region as a whole, and for those in the Latin America and Caribbean. A correlational analysis between both indices was first run (Table 10).

Table 10: Correlation between ICT Regulatory Tracker and the CAF Digital Ecosystem Development Index (Americas region compared with Latin America and the Caribbean)

Digital Ecosystem Development Index (without the regulatory pillar)	Coefficient (standard deviation) Americas region	Coefficient (standard deviation) Latin America and Caribbean
ITU ICT Regulatory Tracker	0.4279 (0.0236)***	0.4199 (0.0238)***
Constant	7.0161 (1.5569) ***	6.2673 (1.5444) ***
R-square	0.4919	0.4936
Fixed effects for year and country	Yes	Yes
Countries	34	32
Observations	374	352

[18] The CAF Digital Ecosystem Development Index for Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Saint Lucia, St. Vincent and the Grenadines, Suriname was estimated based on a correlation coefficient with TAS Digitization Index. Saint Kitts and Nevis was excluded because of lack of reliable digitization data.

Digital Ecosystem Development Index (without the regulatory pillar)	Coefficient (standard deviation) Americas region	Coefficient (standard deviation) Latin America and Caribbean
Years	2007-2017	2007-2017

***, **, * significant at 1%, 5% and 10% critical value respectively

The correlational model determined that one point in the ICT Regulatory Tracker yields:

- 0.4279 increase in the CAF Digital Ecosystem Development Index (without the regulatory pillar) for the Americas region as a whole, and;
- 0.4199 increase in the same index for the Latin America and Caribbean countries.

In order to test for the causal link, a control of a one-year lag of the ICT Regulatory Tracker was added (Table 11).

Table 11: Impact of the lagged ICT Regulatory Tracker on the CAF Digital Ecosystem Development Index (Americas region compared with countries in Latin America and the Caribbean)

Digital Ecosystem Development Index (without the regulatory sub-index)	Coefficient (Standard deviation) Americas	Coefficient (Standard deviation) Latin America and the Caribbean
Digital Ecosystem Development Index (without regulation pillar)	0.1479 (0.0524)***	0.1481 (0.0527)***
ICT Regulatory Tracker (t-1)	0.2656 (0.0419)***	0.2569 (0.0423)***
Constant	9.0117 (1.9235) ***	8.2755 (1.8969) ***
R-squared	0.4709	0.4715
Fixed effects for year and country	Yes	Yes
Groups	34	32
Observations	340	320
Years	2008-2017	2008-2017

***, **, * significant at 1%, 5% and 10% critical value respectively.

In this model, it was found that an additional point in the ICT Regulatory Tracker yields 0.1479/0.1481 points higher in the CAF Digital Ecosystem Development Index (without the regulatory sub-index) in the same period, and 0.2656/0.2569 higher in the subsequent period. By adding both effects, this yields a total coefficient of 0.4135/0.4050.

Two previous models tested the correlation between both indices. This model was specified through logarithms of all variables to assess change, and the CAF Digital Ecosystem Development Index was recalculated without the regulatory and the competition pillars (since the potential with co-linearity with the ICT Regulatory Tracker is high) (Table 12).

Table 12: Impact of the lagged ICT Regulatory Tracker on the CAF Digital Ecosystem Development Index (Americas region compared with countries in Latin America and the Caribbean)

Log CAF Digital Ecosystem Development Index (without the regulatory and competition pillars)	Coefficient (Standard deviation) Americas	Coefficient (Standard deviation) Latin America and the Caribbean
Digital Ecosystem Development Index (without regulation and competition pillars) (t-1)	0.0250 (0.0009)***	0.0258 (0.0009)***
Log ICT Regulatory Tracker (t-1)	0.0373 (0.0182)**	0.0308 (0.0111)*
Constant	2.4950 (0.0631) ***	2.4987 (0.0636) ***
R-Squared	0.8152	0.8152
Fixed effects for year and country	Yes	Yes
Groups	34	32
Observations	340	320
Years	2008-2017	2008-2017

***, **, * significant at 1%, 5% and 10% critical value respectively.

In this case, it is possible to prove the hypothesis that an increase of 10 per cent in the ICT Regulatory Tracker Index yields a positive increase in the CAF Digital Ecosystem Development Index of 0.373 per cent/0.308 per cent in the subsequent time period. In order to further test the relationship between the regulatory and the digital ecosystem indices, a set of alternative correlations between pillars was run (Table 13).

Table 13: Correlations between ICT Regulatory Tracker and CAF Digital Ecosystem Development Index pillars (Americas region)

Pillars	ICT Regulatory Tracker	ICT Regulatory Tracker (without Competition)	Regulatory authority component	Regulatory mandate component	Regulatory regime component	Competition framework component
CAF Digital Ecosystem Development Index	0.4044 (0.0284) ***	0.3796 (0.0292) ***	0.3819 (0.0471) ***	0.3193 (0.0282) ***	0.3180 (0.0189) ***	0.2502 (0.0220) ***
Infrastructure of Digital Services	0.5851 (0.0547) ***	0.5653 (0.0555) ***	0.5382 (0.0842) ***	0.4336 (0.0527) ***	0.4919 (0.0364) ***	0.3586 (0.0405) ***
Connectivity of Digital Services	**0.7251 (0.0582) *** **	**0.6857 (0.0592) *** **	**0.6754 (0.0938) *** **	0.5671 (0.0570) ***	**0.6246 (0.0376) *** **	0.4532 (0.0442) ***
Household digitization	**0.6539 (0.0489) *** **	**0.6205 (0.0499) *** **	**0.6019 (0.0798) *** **	0.5133 (0.0484) ***	0.5183 (0.0335) ***	0.3946 (0.0379) ***

Pillars	ICT Regulatory Tracker	ICT Regulatory Tracker (without Competition)	Regulatory authority component	Regulatory mandate component	Regulatory regime component	Competition framework component
Digitization of production	0.2444 (0.0417) ***	0.2282 (0.0418) ***	0.1965 (0.0622) ***	0.1867 (0.0391) ***	0.2032 (0.0305) ***	0.1426 (0.0306) ***
Digital Competitive Intensity	0.2621 (0.0335) ***	0.2369 (0.0340) ***	0.2420 (0.0506) ***	0.2000 (0.0318) ***	0.1778 (0.0244) ***	0.1712 (0.0245) ***
Development of Digital Industries	0.2406 (0.0371) ***	0.2036 (0.0376) ***	0.1737 (0.0559) ***	0.1679 (0.0351) ***	0.1942 (0.0272) ***	0.1798 (0.0266) ***
Digital factors of production	0.5503 (0.0435) ***	0.5111 (0.0447) ***	0.4734 (0.0710) ***	0.4395 (0.0425) ***	0.4278 (0.0301) ***	0.3502 (0.0330) ***

***, **, * significant at 1%, 5% and 10% critical value respectively.

Note: The values in bold have correlations higher than 0.60.

A second set of regressions shows that the regulatory regime component of the ICT Regulatory Tracker appears to be the main path of impact of the digital ecosystem development index (Table 14).

Table 14: Impact of the ICT Regulatory Tracker components on the CAF Digital Ecosystem Development Index pillars (Americas region)

	Digital Ecosystem Development Index	Infrastructure of Digital Services	Connectivity of Digital Services	Household digitization	Digitization of production	Digital Competitive Intensity	Development of Digital Industries	Digital factors of production
Regulatory authority	-0.0205 (0.0727)	0.0511 (0.1368)	0.0245 (0.1443)	0.0107 (0.1296)	-0.1405 (0.1180)	-0.0924 (0.0937)	-0.1283 (0.1051)	-0.2027 (0.1155) *
Regulatory mandate	-0.0507 (0.0599)	-0.3841 (0.1127) ***	-0.2237 (0.1188) *	-0.0231 (0.1067)	-0.0271 (0.0972)	-0.0679 (0.0771)	0.0153 (0.0865)	0.0213 (0.0951)
Regulatory regime	0.3526 (0.0301) ***	0.6512 (0.0567) ***	0.7304 (0.0598) ***	0.5309 (0.0359) ***	0.2491 (0.0489) ***	0.2296 (0.0388) ***	0.2203 (0.0433) ***	0.4635 (0.0478) ***
Constant	2.4624 (0.2552) ***	2.0241 (0.4817) ***	1.5987 (0.5068) ***	1.1304 (0.4551) ***	3.2890 (0.4146) ***	3.9159 (0.3307) ***	2.3762 (0.3691) ***	1.9374 (0.4056) ***
R-squared	0.4677	0.3816	0.4627	0.4122	0.1276	0.1515	0.1430	0.3844

***, **, * significant at 1%, 5% and 10% critical value respectively.

Table 14 indicates that the regulatory regime component always has a positive and significant impact on every single pillar of the CAF digital ecosystem development index[19]. This could indicate that the regulatory regime could be the component that has a higher impact on digital development[20]. The correlations were calculated for the whole Americas region, they were also estimated for Latin America and the Caribbean (tables 15 and 16).

Table 15: Correlations between ICT Regulatory Tracker and CAF Digital Ecosystem Development Index pillars (Latin America and the Caribbean)

Pillars	ICT Regulatory Tracker	ICT Regulatory Tracker (without Competition)	Regulatory authority component	Regulatory mandate component	Regulatory regime component	Competition framework component
Digital Ecosystem Development Index	0.4016 (0.0290) ***	0.3773 (0.0298) ***	0.3807 (0.0481) ***	0.3173 (0.0289) ***	0.3163 (0.0194) ***	0.2477 (0.0225) ***
Infrastructure of Digital Services	0.5779 (0.0559) ***	0.5595 (0.0566) ***	0.5353 (0.0856) ***	0.4278 (0.0538) ***	0.4877 (0.0371) ***	0.3529 (0.0414) ***
Connectivity of Digital Services	**0.7205 (0.0598) *****	**0.6819 (0.0608) *****	**0.6736 (0.0962) *****	0.5642 (0.0586) ***	**0.6221 (0.0388) *****	0.4496 (0.0455) ***
Household digitization	**0.6513 (0.0504) *****	**0.6185 (0.0513) *****	**0.6008 (0.0818) *****	0.5119 (0.0497) ***	0.5173 (0.0345) ***	0.3919 (0.0391) ***
Digitization of production	0.2453 (0.0430) ***	0.2292 (0.0431) ***	0.1967 (0.0641) ***	0.1878 (0.0403) ***	0.2048 (0.0315) ***	0.1425 (0.0315) ***
Digital Competitive Intensity	0.2667 (0.0343) ***	0.2406 (0.0348) ***	0.2434 (0.0519) ***	0.2039 (0.0326) ***	0.1818 (0.0250) ***	0.1738 (0.0251) ***
Development of Digital Industries	0.2311 (0.0370) ***	0.1962 (0.0374) ***	0.1711 (0.0556) ***	0.1609 (0.0350) ***	0.1870 (0.0271) ***	0.1727 (0.0265) ***
Digital factors of production	0.5453 (0.0446) ***	0.5068 (0.0457) ***	0.4716 (0.0725) ***	0.4363 (0.0435) ***	0.4239 (0.0309) ***	0.3469 (0.0337) ***

***, **, * significant at 1%, 5% and 10% critical value respectively

Note: The values in bold have correlations higher than 0.60

[19] The regulatory regime component includes indicators such as type of licenses provided to offer telecommunications services, obligations to publish interconnection offers by operators, monitoring of quality of service, infrastructure sharing for mobile operators permitted and/or mandated, unbundled access in local loop, spectrum secondary trading allowed, and number portability.

[20] While the first two components of the ICT Regulatory Tracker has sometimes a negative sign, the coefficient of regulatory regime and regulatory mandate is always bigger and positive.

A second set of regressions shows that the regulatory regime component of the ICT Regulatory Tracker appears to be the main path of impact of the CAF Digital Ecosystem Development Index (Table 16).

Table 16: Impact of the ICT Regulatory Tracker components on the CAF Digital Ecosystem Development Index pillars (Latin America and the Caribbean)

	Digital Ecosystem Development Index	Infrastructure of Digital Services	Connectivity of Digital Services	Household digitization	Digitization of production	Digital Competitive Intensity	Development of Digital Industries	Digital factors of production
Regulatory authority	-0.0160 (0.0744)	0.0633 (0.1391)	0.0311 (0.1484)	0.0142 (0.1333)	-0.1427 (0.1217)	-0.1006 (0.0958)	-0.1120 (0.1047)	-0.1953 (0.1182) *
Regulatory mandate	-0.0540 (0.0615)	-0.4013 (0.1150) ***	-0.2270 (0.1227) *	-0.0231 (0.1102)	-0.0241 (0.1006)	-0.0572 (0.0792)	-0.0001 (0.0865)	0.0195 (0.0977)
Regulatory regime	0.3514 (0.0308) ***	0.6512 (0.0577) ***	0.7278 (0.0615) ***	0.5292 (0.0552) ***	0.2500 (0.0504) ***	0.2308 (0.0397) ***	0.2164 (0.0434) ***	0.4590 (0.0490) ***
Constant	2.4348 (0.2607) ***	2.0088 (0.4888) ***	1.5794 (0.5201) ***	1.0780 (0.4670) ***	3.2470 (0.4264) ***	3.9053 (0.3375) ***	2.3367 (0.3670) ***	1.8654 (0.4142) ***
R-squared	0.4677	0.3848	0.4612	0.4116	0.1291	0.1588	0.1415	0.3826

***, **, * significant at 1%, 5% and 10% critical value respectively.

As indicated in Table 16 the regulatory regime component always has a positive and significant impact on every single pillar of the digital ecosystem development index[21]. This could indicate that the regulatory regime could be the component that has a higher impact on digital development[22].

4 Conclusion

The analyses of the Americas region have validated the findings generated in the ITU global study, *The economic contribution of broadband, digitization and ICT regulation*.

The main purpose of the present study was to test the findings of the global study as well as the impact of regulation and policy on the digital economy development in the Americas region, based on the following considerations:

- Fixed broadband economic impact is guided by a returns to scale effect, according to which the economic impact of fixed broadband is higher in more advanced than in emerging economies.
- The economic impact of mobile broadband reflects a saturation effect, according to which the mobile broadband contribution is higher in emerging economies than in more developed ones.
- The impact of the digital ecosystem on countries with more developed economies is higher than in countries with emerging economies.

[21] The regulatory regime component includes indicators such as type of licences provided to offer telecommunication services, obligations to publish interconnection offers by operators, monitoring of quality of service, infrastructure sharing for mobile operators permitted and/or mandated, unbundled access in local loop, spectrum secondary trading allowed, and number portability.

[22] While the first two components of the ITU ICT Regulatory Tracker sometimes give a negative sign, the coefficient of regulatory regime and regulatory mandate is always bigger and positive.

- The regulatory and policy framework has a consistent impact on the development of the digital ecosystem, regardless of the country's level of development.

An assessment of the research literature the economic contribution of broadband in the Americas region validated the ITU findings that the greater the fixed broadband penetration in Latin America, the higher its impact on GDP growth. Considering the evidence, different effects have been suggested for North America, and Latin America and the Caribbean:

- Impact of fixed broadband: High in north America, medium in Latin America and the Caribbean.
- Impact of mobile broadband: Medium in north America, high in Latin America and the Caribbean.
- Impact of digitization: High in north America, medium in Latin America and the Caribbean.

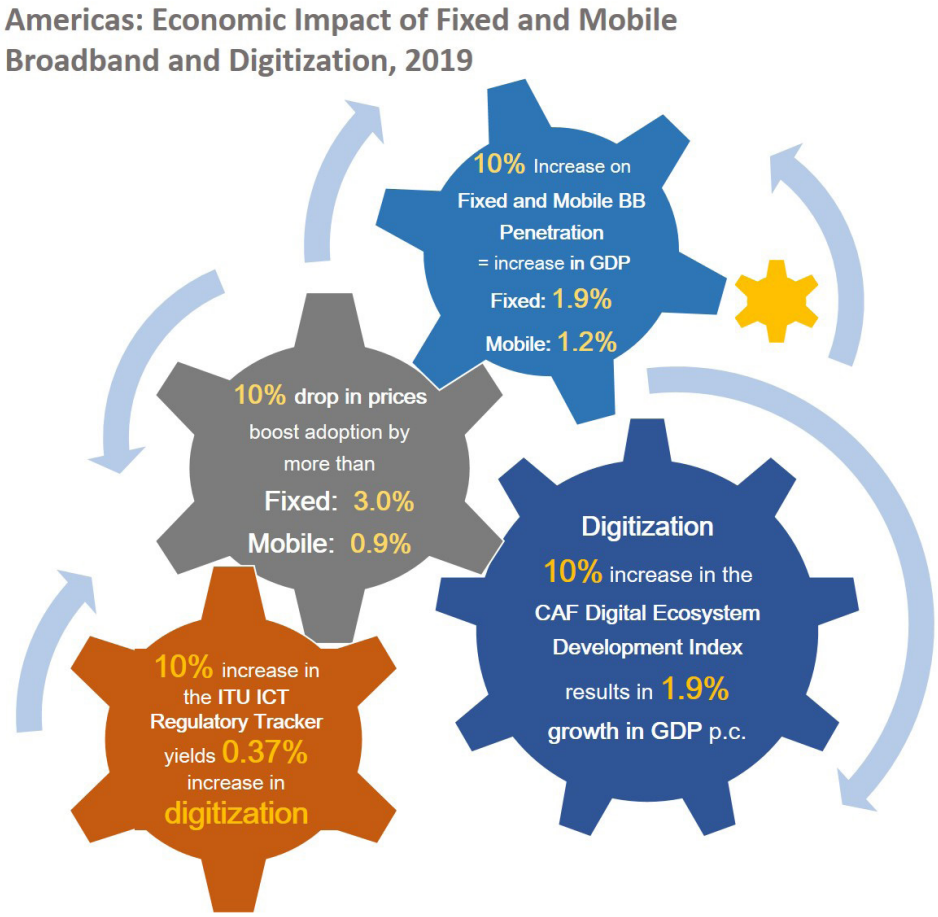
Econometric models were first run for the United States and Canada that increased the prorated value of each variable, and then for Latin America and the Caribbean to test the economic impact of broadband (fixed and mobile) and digitization. The evidence yielded by the econometric analysis confirms the hypotheses (Table 17).

Table 17: Summary of econometric model results

Hypothesis	10% increase: Impact on GDP per capita growth	
	Americas region (includes United States of America and Canada)	Latin America and the Caribbean
Economic impact of fixed broadband will be higher in the Americas region (which includes the United States of America and Canada) than in Latin America and the Caribbean (returns to scale effect).	1.9	1.6
Economic impact of mobile broadband will be higher in Latin America and the Caribbean than in the Americas region (which incl. the United States of America and Canada) (Saturation effect).	1.2	1.7
Economic impact of digital ecosystem will be higher in the Americas region (which includes the United States of America and Canada) than in Latin America and the Caribbean (returns to scale effect)	1.9	1.7

The conclusions of the Americas region analyses are depicted in Figure 5.

Figure 5: Main findings for the Americas region



Source: ITU

In the impact analyses of the policy and regulatory framework supporting the growth of markets for digital services and applications, regulation and regulatory authorities were targeted to test the development of the digital economy.

All models were run for north America and for the Latin America and Caribbean. In this case, the results also validated the positive impact of the policy and regulatory variable. An increase of 10% in the ICT Regulatory Tracker yields a positive increase in the CAF Ecosystem Development Index of 0.37 per cent for North America and 0.308 per cent for Latin America and the Caribbean in the subsequent time period. A second set of regressions shows that of all the components of the ICT Regulatory Tracker, the regulatory regime component appears to be the main path of impact of the digital ecosystem development index. This analysis provided further evidence of the importance of the regulatory and institutional variable in driving the digital ecosystem growth.

Annex A: List of data sources for models testing the economic impact of fixed and mobile broadband

Indicator	Source
GDP per capita (PPP)	IMF
Fixed broadband subscriber penetration	ITU- OVUM
Capital- Gross capital formation (percentage of GDP)	World Bank
Education- School enrolment, tertiary (per cent gross)	World Bank
Fixed telephone subscribers	ITU
Rural population (per cent of total population)	World Bank
Fixed broadband price	ITU
HHI fixed broadband	OVUM
Fixed broadband revenue	ITU- OVUM
Mobile broadband unique subscribers penetration	GSMA
Mobile unique subscribers penetration	GSMA
Mobile Broadband Price/ARPU	ITU- GSMA
HHI mobile broadband	GSMA
Mobile broadband revenue	GSMA

Annex B: Indicators included in CAF Digital Ecosystem Development Index and data sources

Pillar	Sub-pillar	Indicator	Source
Infrastructure	Investment	Telecommunications investment per capita in current prices – five year average (USD PPP)	World Bank; ITU
Infrastructure	Quality of service	Average fixed broadband download speed (Mbit/s)	Akamai
Infrastructure	Quality of service	Average mobile broadband download speed (Average Mbit/s)	Akamai
Infrastructure	Quality of service	Fixed broadband connections with download speed higher than 4 Mbit/s (percentage)	Akamai
Infrastructure	Quality of service	Fixed broadband connections with download speed higher than 10 Mbit/s (percentage)	Akamai
Infrastructure	Quality of service	Fixed broadband connections with download speed higher than 15 Mbit/s (percentage)	Akamai
Infrastructure	Quality of service	Fibre optic broadband connections as a percentage of total fixed broadband connections	ITU; FTTH; OECD
Infrastructure	Quality of service	International broadband bandwidth per Internet user (bit/s)	ITU
Infrastructure	Coverage	Fixed broadband coverage (% of households)	Eurostat, CAF Ideal; OECD
Infrastructure	Coverage	2G coverage	ITU
Infrastructure	Coverage	3G coverage	ITU
Infrastructure	Coverage	4G coverage	ITU
Infrastructure	Service infrastructure	IXPs per 1 000 000 population	Packet Clearing House; UNCTAD
Infrastructure	Service infrastructure	Number of secure servers (per 1,000,000 population)	World Bank
Infrastructure	Service infrastructure	Number of satellites (per 1 000 000 population)	N2yo.com
Connectivity	Affordability	Monthly fixed broadband subscription as percentage of GDP per capita	ITU
Connectivity	Affordability	Monthly mobile broadband Smartphone subscription (500 MB cap, prepaid) as percentage of GDP per capita	ITU
Connectivity	Affordability	Monthly mobile broadband PC subscription (1 GB cap, postpaid) as percentage of GDP per capita	ITU
Connectivity	Affordability	Monthly pay TV subscription as percentage of GDP per capita	Business Bureau; CAF; PwC; TAS

Pillar	Sub-pillar	Indicator	Source
Connectivity	Penetration	Fixed broadband penetration (connections per 100 households)	ITU
Connectivity	Penetration	Mobile broadband penetration (connections per 100 population)	ITU
Connectivity	Penetration	Unique mobile broadband users (per 100 population)	GSMA
Connectivity	Penetration	Pay TV penetration (connections per 100 households)	Business Bureau; CAF; PwC; TAS; ITU; Convergencia
Connectivity	Ownership	Penetration of computers (% of households)	ITU
Connectivity	Ownership	Smartphone users (per 100 population)	GSMA
Connectivity	Ownership	Percentage of population with access to electric energy	World Bank
Household digitization	Internet use	Percentage of population using the Internet	ITU
Household digitization	Internet use	Penetration of dominant social network (users per 100 population)	OWLOO
Household digitization	Internet use	Mobile data ARPU as percentage of total ARPU	GSMA
Household digitization	E-government	E-government index	ONU
Household digitization	E-commerce	Internet commerce as percentage of total retail commerce	Euromonitor
Household digitization	Telemedicine	National health policy (binary variables)	WHO
Household digitization	OTTs	Video on demand penetration (per cent households)	PWC
Digitization of production	Digital infrastructure	Per cent enterprises with Internet access	UNCTADstat; TAS; Eurostats
Digitization of production	Digital supply chain	Per cent enterprises using Internet for electronic banking	UNCTADstat; TAS; Eurostats
Digitization of production	Digital supply chain	Per cent enterprises using Internet for purchasing inputs	UNCTADstat; TAS; Eurostats
Digitization of production	Digital distribution	Per cent enterprises that sell products over the Internet	UNCTADstat; TAS; Eurostats
Digitization of production	Digital processing	Per cent workforce using the Internet	UNCTADstat; TAS; Eurostats
Digitization of production	Digital processing	Per cent workforce using computers	UNCTADstat; TAS; Eurostats

Pillar	Sub-pillar	Indicator	Source
Competitive intensity	Competition level	HHI fixed broadband	Convergencia; Regulators; TAS
Competitive intensity	Competition level	HHI mobile broadband	GSMA; Regulators
Competitive intensity	Competition level	HHI pay TV	Convergencia; Dataxis; Ofcom; TAS; Reguladores
Competitive intensity	Competition level	HHI mobile telephony	GSMA; Regulators
Digital industries	Exports	High technology exports (USD per capita in current prices)	World Bank
Digital industries	Exports	ICT services exports (USD per capita in current prices)	World Bank
Digital industries	Weight of digital industries	Digital ecosystem sales as a percentage of GDP	PWC; TAS; ITU
Digital industries	Weight of digital industries	Telecommunications operators revenues per capita (USD in current prices)	ITU
Digital industries	Weight of digital industries	Computer software spending (per cent of GDP)	INSEAD
Digital industries	Internet of Things	M2M connections (per 100 population)	ITU; OECD
Digital industries	Content production	Wikipedia pages edited per month (per million population between 15 and 69 years old)	INSEAD
Factors of digital production	Human capital	Education years expectancy (years)	World Bank; UNESCO
Factors of digital production	Human capital	Tertiary school enrollment (per cent population)	World Bank; UNESCO
Factors of digital production	Schools	Per cent educational establishments with Internet access	UNESCO; CEPAL
Factors of digital production	Schools	Computers per students ratio	UNESCO; CEPAL
Factors of digital production	Innovation	USPTO patents per country (per 1 000 000 population)	USPTO
Factors of digital production	Innovation	Intellectual property revenues (USD per capita PPA in current prices)	World Bank
Factors of digital production	Investment in innovation	R&D spending (per cent of GDP)	World Bank; UNESCO
Factors of digital production	Economic development	GDP per capita (USD current prices)	IMF
Factors of digital production	Economic development	Electric energy consumption (kWh per capita)	World Bank

Pillar	Sub-pillar	Indicator	Source
Institutional and regulatory	Cyber-security and piracy	Per cent of non-licensed installed software	BSA, The software alliance
Institutional and regulatory	Cyber-security and piracy	Commercial value of non-licensed software (as per cent of GDP)	BSA, The software alliance
Institutional and regulatory	Government role	Per cent of regulatory agency attributions based on ITU regulatory tracker	ITU; TAS
Institutional and regulatory	Government role	Per cent of regulatory agency functions based on ITU regulatory tracker	ITU; TAS
-	-	Population	World Bank
-	-	Exchange rate PPP	IMF
-	-	Number of households	ITU
-	-	GDP per capita for first quintile (USD in current prices)	IMF; World Mundial

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