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Accelerating the development of Latin American digital ecosystem and implications for broadband policy

Raul Katz [a,*], Fernando Callorda [b]

[a] Columbia Institute for Tele-Information, Columbia Business School, United States
[b] Economics Department, Universidad de San Andres, Argentina

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ABSTRACT

In the past ten years the Latin American and Caribbean region has been advancing in terms of various digitization metrics, such as the deployment of broadband infrastructure, and the adoption of the Internet and social media. However, despite the significant progress in terms of digitization of consumption,[1] the region faces still some important development challenges of its digital economy. This paper attempts to identify what the future challenges are for Latin America and the Caribbean, which raises a number of research and policy questions: (1) How close is consumer digitization in Latin America and the Caribbean to the levels observed in industrialized countries? (2) How should Latin America and the Caribbean address the broadband and Internet demand gap of the non-adopting population? (3) Are current digitization trends homogeneous across countries in the region or do we observe a divergence across countries, indicating some advanced nations approaching industrialized country performance, while others lagging? (4) If infrastructure and consumer adoption of certain digital products and services is evolving at a fast pace, what are the upcoming digitization challenges? (5) If broadband is a critical lever for the development of digitization, what are the policies to be implemented by Latin American and Caribbean governments to maximize investment for deployment of last generation technologies and promote adoption? To answer these questions the authors have developed, with support of CAF Latin American Development Bank, a comprehensive digitization index. This new index is used to assess the development of Latin America and the Caribbean region vis-à-vis industrialized countries. On this basis, an econometric model is developed to measure the economic development impact of digitization. Zeroing in on broadband as a critical lever for the development of the digital economy, a set of infrastructure investment and adoption goals is defined for different countries in the region. Finally, public policies are recommended to achieving the established goals.

1. Introduction

In the past ten years the Latin American and Caribbean region has been advancing in terms of various digitization metrics, such as the deployment of broadband infrastructure, and the adoption of the Internet and social media. In particular, by 2015 the prorated average

* Corresponding author.
E-mail addresses: raul.katz@teleadvs.com (R. Katz), f.callorda@teleadvs.com (F. Callorda).

[1] Digitization of consumption, or consumer Internet, is defined as the adoption of digital networks, products and services by individual consumers. The term is used in opposition to digitization of production, or Industrial Internet, which refers to the adoption of digital technologies and services by enterprises. See Barcena (2016). *The new digital revolution: from Consumer Internet to the Industrial Internet*. Santiago: Economic Commission for Latin America and the Caribbean.

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penetration of wireless broadband (as measure by adoption of 3G and 4G devices) in the region had reached 57.41%, [2] while 54.42% of the population regularly accessed the Internet, [3] and 47.77% [4] were members of the dominant social network, Facebook.

However, despite the significant progress in terms of digitization of consumption (defined as the adoption of digital networks, products and services by individual consumers), Latin America and the Caribbean faces still some important development challenges of its digital economy (defined as the digital transformation of traditional industries and the creation of digital industries). In particular, the digital divide remains an important feature of the region's Internet landscape: approximately 45% of the Latin American and Caribbean population remains unconnected to the Internet. Moreover, the digitization of production, defined as the assimilation of digital technologies by enterprises is still lagging, with the consequent negative impact on productivity levels. In addition, the aggregate telecommunications capital spending, while significant, is not enough to build the last generation of infrastructure, in particular fiber optics in the last mile. This is why, looking at the next decade, it is relevant to identify what the future challenges are for the region, which raises a number of research and policy questions:

- How close is consumer digitization in Latin America and the Caribbean to the levels observed in industrialized countries?
- How should Latin America and the Caribbean address the broadband and Internet demand gap of the non-adopting population?
- Are current digitization trends homogeneous across countries in the region or do we observe a divergence across countries, indicating some advanced nations approaching industrialized country performance, while others lag?
- If infrastructure and consumer adoption of certain digital products and services is evolving at a fast pace, what are the upcoming digitization challenges?
- How is industrial digitization evolving? Is the Latin American continent growing its digital industries at a sufficiently enough pace? Is human capital becoming a development bottleneck standing in the way of future digitization growth?
- And, more fundamentally, if broadband is a critical lever for the development of digitization, what are the policies to be implemented by Latin American governments to maximize investment for deployment of last generation technologies and promote adoption?

The following article attempts to answer these questions by introducing a new digitization index, which is more comprehensive and holistic than our prior efforts at measurement. [5] First, this new index is used to assess the development of Latin America and the Caribbean region vis-à-vis industrialized countries. Second, an econometric model is developed to measure the economic development impact of digitization. Third, zeroing in on broadband as a critical lever for the development of the digital economy, a set of infrastructure investment and adoption goals is defined for different countries in the region. Fourth, public policies are recommended to achieving the established goals.

1.1. A new index to assess digital ecosystems [6]

The study of a country or region stage of development in the adoption of Information and Communication Technologies has been progressing over the last twenty years. While the original focus was to assess the deployment and adoption of telecommunications and information technology infrastructure (broadband, mobile telephony, computers), research has been gradually expanding its focus to include dimensions such as the use of digital technologies (electronic commerce, electronic government, social networks) as well as the development of industries within the full digital value chain (Internet platforms, Collaborative Internet Services, etc.). In this process, a number of indices have been developed along the way, including the International Telecommunications Union's ICT Development Index, the World Bank's Knowledge Economy Index, the World Economic Forum Network Readiness Index, and the Inter-American Development Bank's Broadband Development Index. However, most of the indices developed so far tend to either address a particular aspect of the digital ecosystem, such as broadband penetration, or include a limited number of indicators. This is why a new index aimed at assessing the development of a digital ecosystem has been developed.

The development of a new index followed the methodology presented in the "Handbook on constructing composite indicators" (OECD, 2008). The starting point was a factor analysis conducted on a database of more than 150 relevant indicators to identify those more applicable to the index. Once completed, the resulting 64 indicators were categorized in eight pillars following a principal components analysis. Finally, based on the experience of ICT index construction, the weight for each pillar was determined. Once the pillars and factors were determined, each indicator was converted to an index ranging between 0 and 100, where the minimum value defined as the average value for the last available year minus two standard deviations and the maximum value defined as the average value of the last available year plus two standard deviations. This was done for all indicators, except for the technology penetration ones, where the minimum value was set at 0 and the maximum at 100. This allows comparing the evolution of the index over time as well as comparing countries. Lastly, the index by pillar and sub-pillar was calculated based on the prorated average of indices for each indicator.

The resulting index for measuring the development of a digital ecosystem is a composite metric for quantitatively assessing the eight pillars comprising the digital economy (see Exhibit 1).

According to this conceptual structure, the digital ecosystem is defined as a set of interconnected components (or pillars) operating

[2] Source: GSMA Intelligence.
[3] Source: International Telecommunications Union.
[4] Source: Owloo.
[5] See Katz and Koutroumpis (2013), Katz, Koutroumpis, and Callorda (2013 and 2014), and Katz (2015a, 2015b).
[6] Research for this section was funded by CAF Development Bank for Latin America.

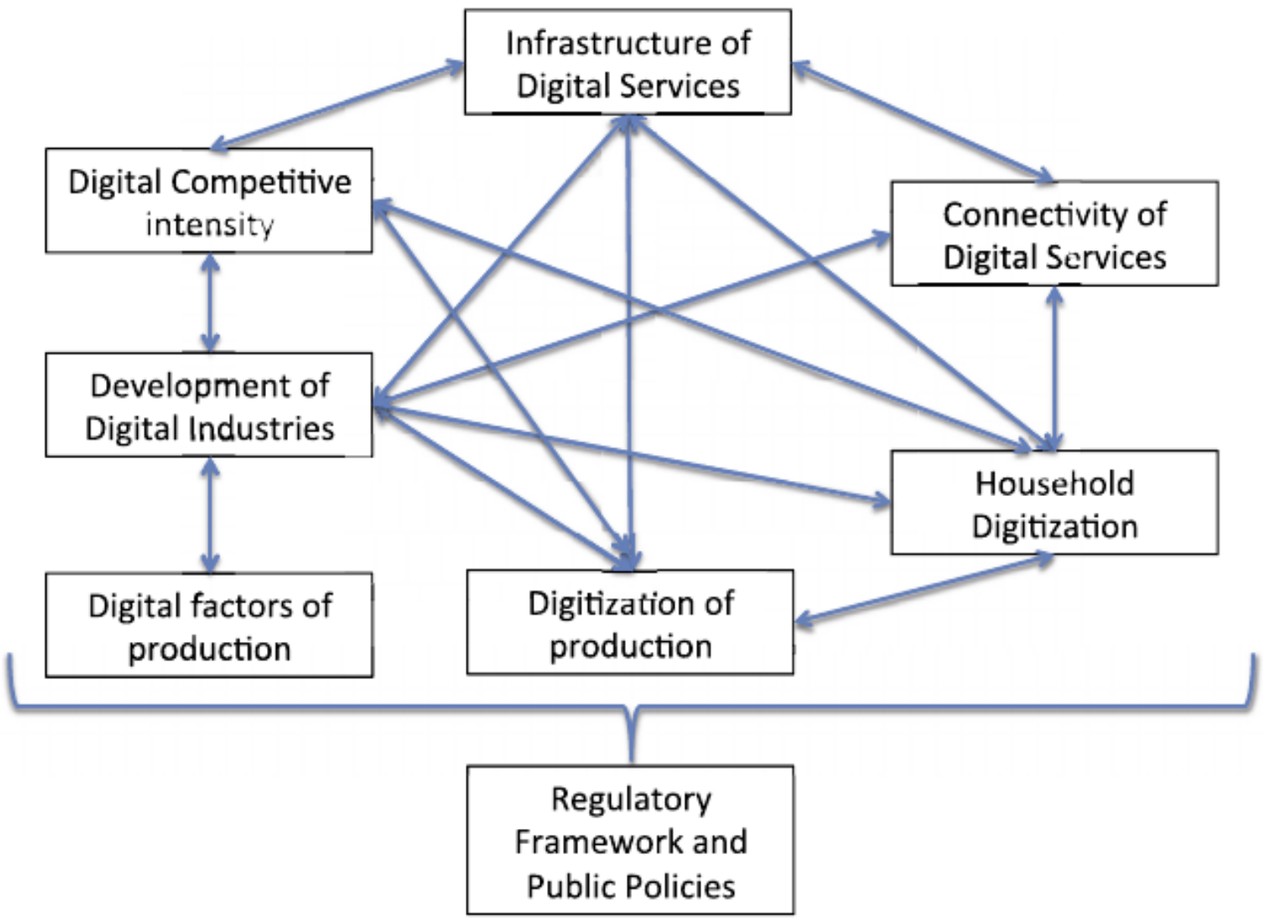

Exhibit 1. Conceptual structure of the Digital Ecosystem Development Index. Note: Links are drawn only for relatively strong causal relationships (see analysis below). Source: Authors

within a socio-economic context. For example, the development of the **infrastructure of digital services** provides individuals, businesses and public organizations access to digital content and services. It also supplies interconnectivity to players within the digital value chain (e.g. developers of digital content, Internet platforms, etc.) so they can deliver a value proposition to users. [7] **Digital connectivity** measures the adoption of terminals (computers, smartphones) and services (broadband, wireless telephony) in order to allow individuals and organizations to gain access to networks. Network access enables the use of digital products and services, which is defined as digitization. This term is used to measure not only the use of digital services by individual consumers (**household or consumer digitization**) but also its assimilation by enterprises (**digitization of production**). The demand of digital products and services by individual consumers, enterprises and governments is met by the offer supplied by **digital industries** (which comprise Internet platforms, media companies, telecommunications operators and equipment manufacturers, among others). These firms can be located within the country where demand is located or, enabled by virtual business models, can be based beyond its frontiers. In order for digital industries to operate within the country, they require conventional **factors of production** ranging from human to investment capital. Finally, for digital industries to generate static (price reductions that enhance affordability) and dynamic (product innovation) consumer benefits, they need to operate within a sustainable **competitive environment**, and receive the appropriate incentives and controls embodied in a **regulatory framework and public policies**. Conceptually, the regulatory framework and public policies pillar represents a critical enabler that facilitates the development of the ecosystem as a whole. On the other hand, the competitive environment could have been considered an additional enabler. Yet, its development is subject to demand variables and controlled by a competitive policy model. Thus, the authors believe it more valid to place it as another component of the ecosystem.

Given that the digital ecosystem embodies a complex interaction among its eight components, the measurement of its development requires the creation of an index composed of eight pillars, each of which is a composite sub-index based on multiple indicators. In total, the Digital Ecosystem Development Index is based on 64 indicators [8] (see Exhibit 2).

This index has been used to measure the development of the Latin America and Caribbean region in relation to other regions of the world, as well to understand the progress achieved so far and the nature of the challenges facing ahead.

2. The Latin American and the Caribbean digital ecosystem

The Latin America and the Caribbean region exhibits a Digital Ecosystem Development Index of 45.47 (on a scale of 0–100), which puts the region in an intermediate position worldwide (see Exhibit 3).

While the Digital Ecosystem Development Index for Latin America and the Caribbean has been growing at a 6.83% rate since 2004, the region still lags significantly the industrialized world. In fact, the Index for the region has been increasing faster than the average of the OECD countries (CAGR: 5.30%), and yet Latin America and the Caribbean lags considerably in most pillars (see Exhibit 4).

As Exhibit 4 demonstrates, with the noted exception of competitive intensity of the digital ecosystem, Latin America and the

[7] Telecommunications services provide value insofar that they allow consumer access to the Internet.
[8] All indicators and their source are included in the appendix.

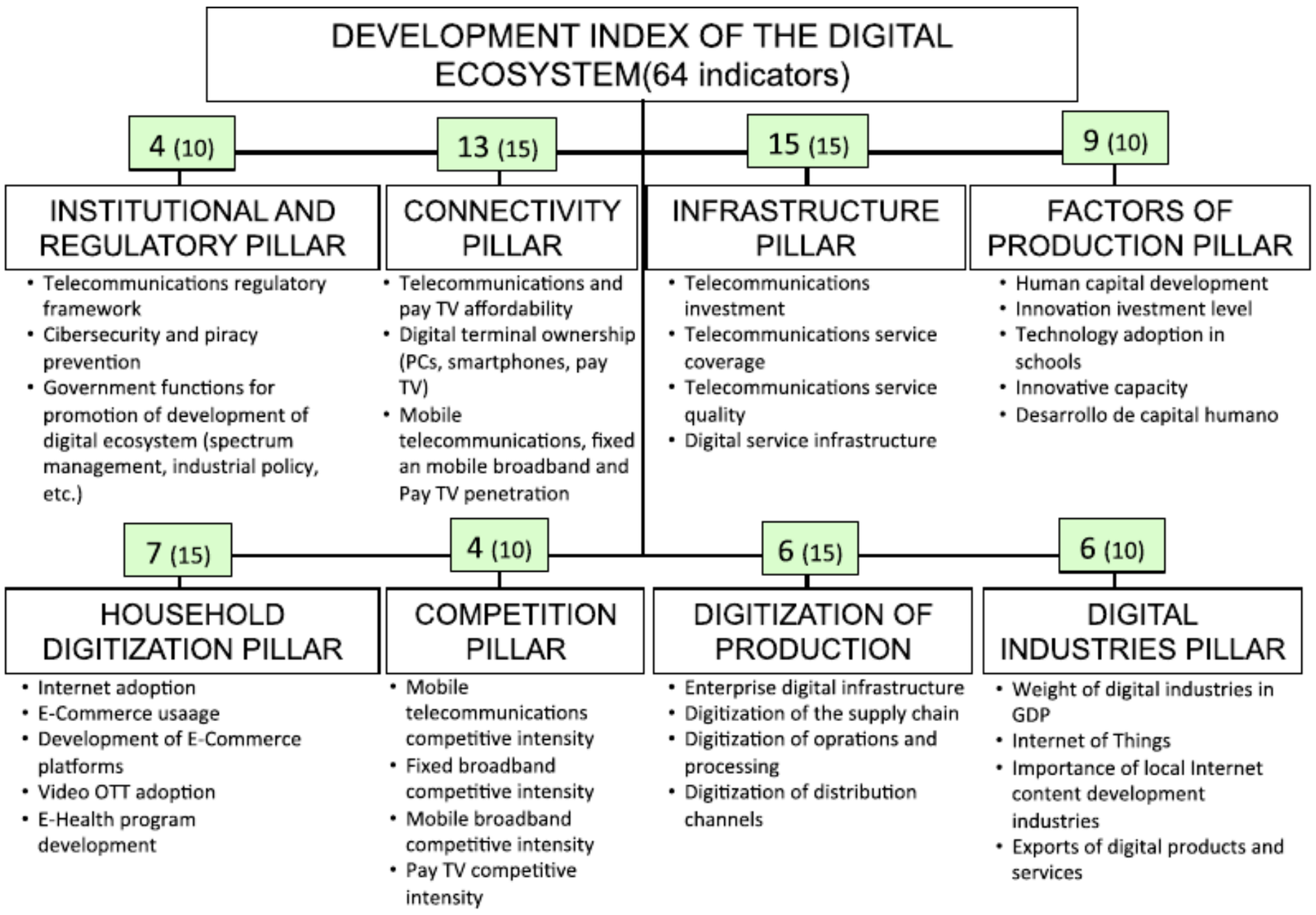

Exhibit 2. Structure of the Development Index of the Digital Ecosystem. Note: Numbers in bold indicate total number of indicators within each pillar (some examples are included below each box), while the numbers in brackets represent the relative weight of the pillar for calculation of the index.
Source: Authors

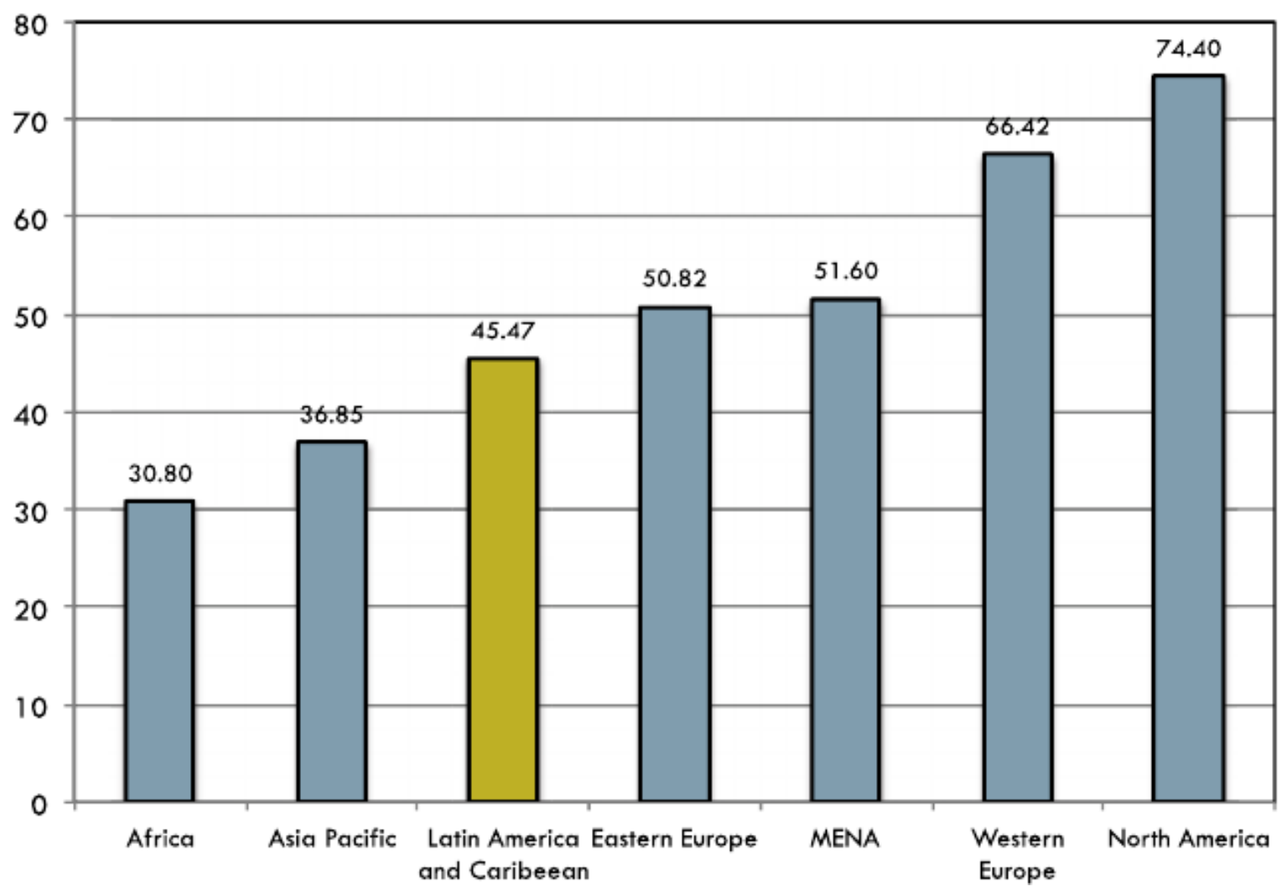

Exhibit 3. Comparative Development of the Digital Ecosystem (2015). Note: Countries included in each region are those with GDP per capita higher than US$ 5000 and a population of 5,000,000 or more, which include Australia, China, South Korea, India, Japan, Malaysia, New Zealand, Singapore, and Thailand for Asia Pacific, Canada and United States for North America, Cote d'Ivoire, Egypt, Kenya and South Africa for Africa, Azerbaijan, Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Kazakhstan, Latvia, Poland, Romania, Russian Federation, Slovakia, Slovenia, and Turkey for Eastern Europe, Austria, Belgium, Denmark, Finland, Germany, Greece, Iceland, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom for Western Europe, Israel, Lebanon Saudi Arabia and United Arab Emirates for Middle East and North Africa, and Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad Tobago, Uruguay, and Venezuela for Latin America and the Caribbean.
Source: Authors

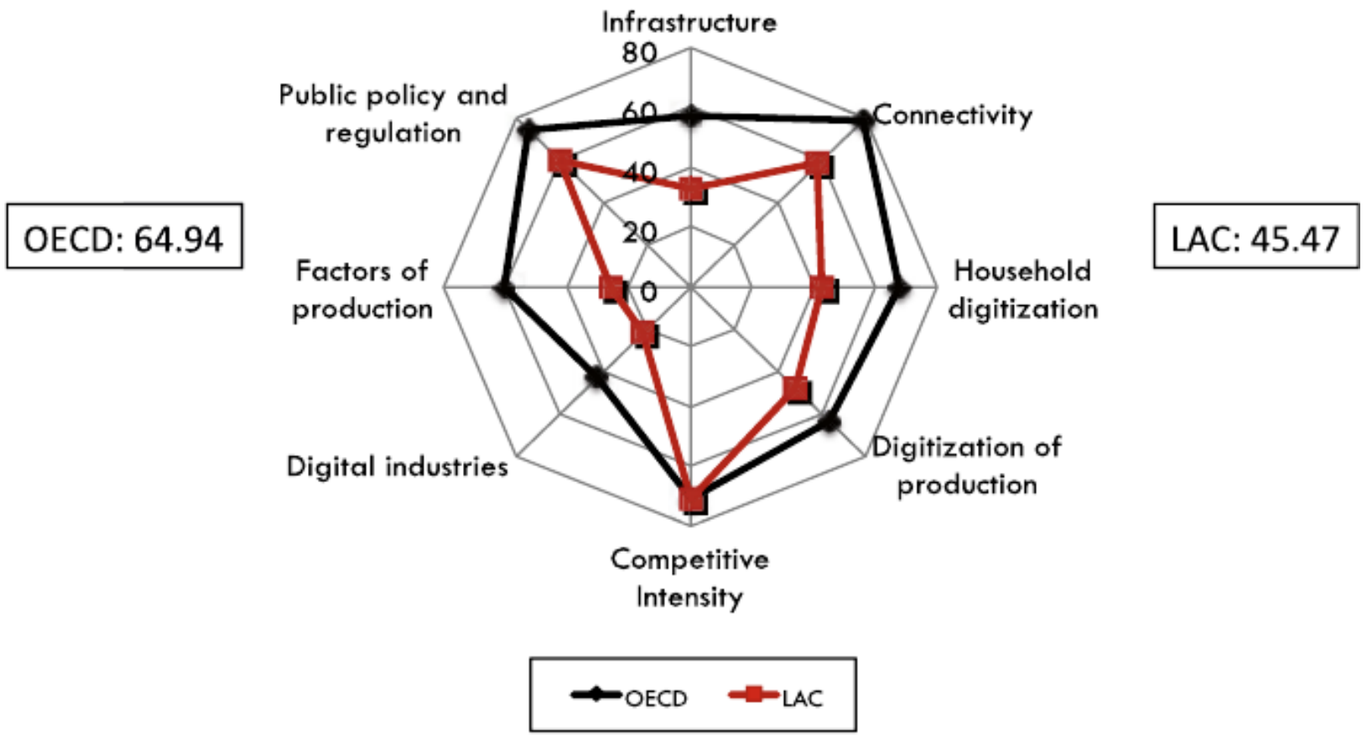

Exhibit 4. Latin America and the Caribbean versus OECD: Digital ecosystem development Index (2015).
Source: Authors

Caribbean lags the OECD in all other pillars, most notably digital factors of production, and infrastructure.

Furthermore, consistently with economic development differences, Latin America and the Caribbean comprise countries with widely different digital ecosystems (see Exhibit 5).

In general terms, countries can be grouped in three levels in terms of their development of a digital ecosystem: advanced (with an index higher than 50), intermediate (with an index ranging between 40 and 50), and limited (with an index below 40). As Exhibit 5 indicates, the Latin American and Caribbean region comprises countries with widely different levels of development. Eight countries are in the advanced level group (Chile, Barbados, Colombia, Uruguay, Trinidad Tobago, Argentina and Brazil), although only one (Chile) has an index closer to the OECD average. Four countries belong to the intermediate category (Mexico, Panama, Venezuela and Ecuador) while five are in the limited development group (Dominican Republic, Peru, Paraguay, Jamaica, and Bolivia).

As it would be expected, the development of a digital ecosystem is correlated with economic development, not only within the Latin American and the Caribbean sample (left exhibit) but also for the sample of 74 countries around the world (right exhibit) (see Exhibit 6).

In order to assess the existence and strength of the causal link between digital ecosystem development and economic development, an endogenous growth model based on the Cobb-Douglas production function was specified linking the stock of fixed capital, labor force and the digital ecosystem development index. The model also controls for GDP per capita for previous year to account for inertia effects:

$$( ) = \quad ( ) \quad ^{1-}( ) \quad ( )$$

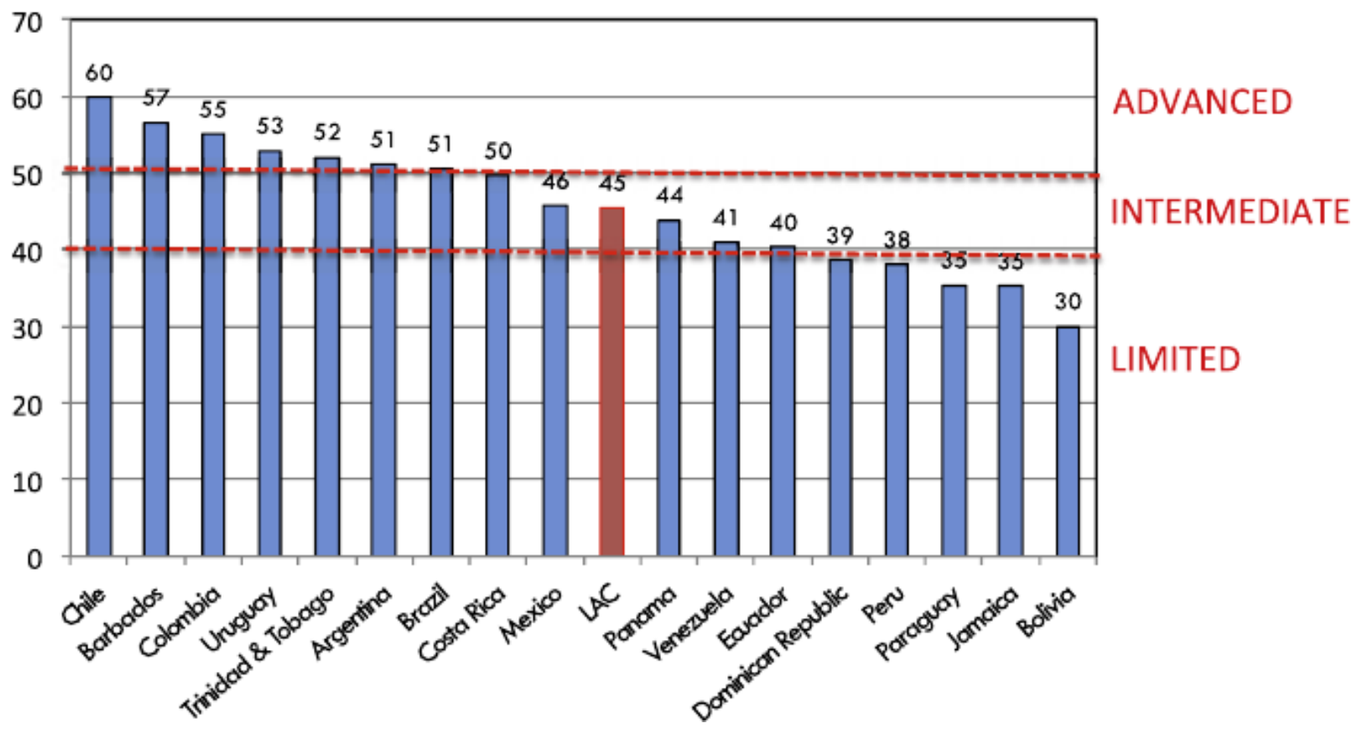

Exhibit 5. Latin America: Digital ecosystem development Index (2015).
Source: Authors

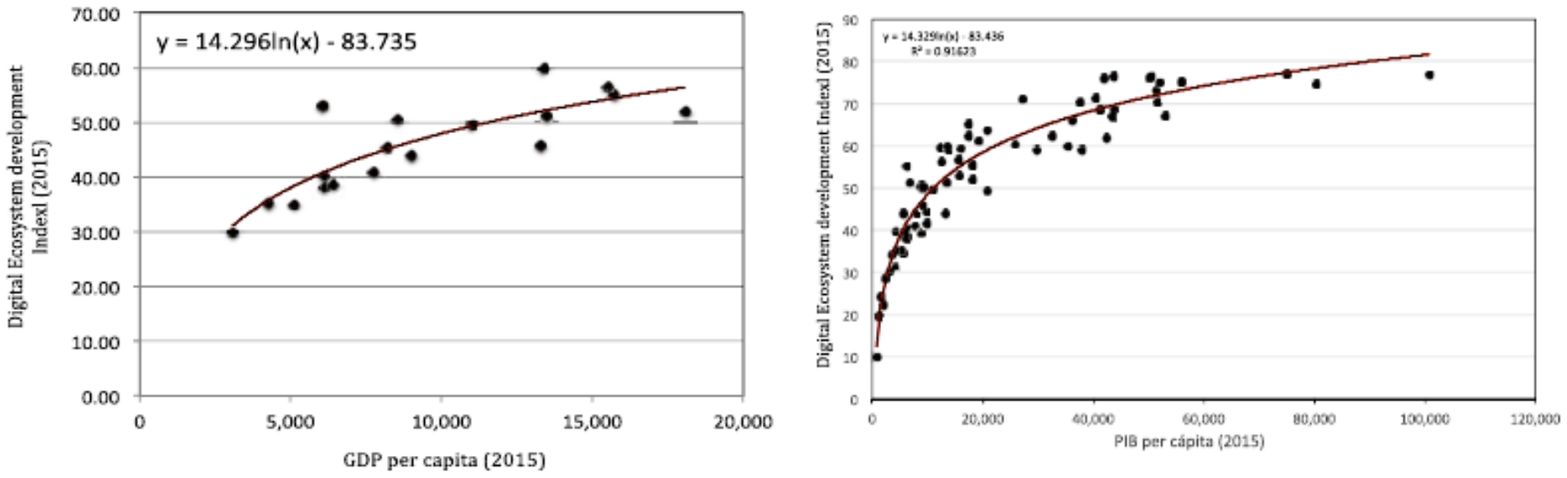

Exhibit 6. . Correlation between GDP per capita and Digital Ecosystem Development Index (2015). Latin America and Caribeean Countries All 74 World Countries.
Source: Authors

Exhibit 7
Latin America and the Caribbean: Economic impact of the digital ecosystem (2005–2015).

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Digital ecosystem development index	23.72	24.73	26.44	30.09	31.46	33.95	36.06	39.42	41.44	43.93	45.47	–
GDP contribution (billion US$)	19.438	12.562	24.140	56.652	21.739	35.612	34.551	59.006	32.669	39.287	22.998	358.653
GDP contribution (%Total GDP)	0.83%	0.44%	0.72%	1.44%	0.48%	0.83%	0.65%	0.97%	0.53%	0.63%	0.37%	7.88%

Source: Authors

By converting all equation terms to logarithms, the level of impact of each independent variable on the growth of the digital ecosystem was estimated:

$$(\quad) = {}_1\quad(\ )+ {}_2\quad(\ )+ {}_3\quad(\ )+$$

Where:

K $_{(t)}$ measures the level of fixed capital formation
L $_{(t)}$ measures labor force
A $_{(t)}$ measures the digital ecosystem development index
the subscript (i) refers to each country, while the subscript (t) refers to each period

The model was run for 73 countries (excluding Costa Rica due to missing values) for the period 2004–2015, which results in 803 observations, and includes fixed effects by country. According to the model, an increase of 1% in the Digital Ecosystem Development Index results in a 0.13% growth in GDP per capita. [9] This means, for example, that an increase in the Digital Ecosystem Development Index from 50 to 51 will yield an increase of per capita GDP of 0.26% (accounting both for direct and indirect effects on output).

The model was also run for OECD and non-OECD countries to test for a "return to scale" effect. The results indicate that the impact of the digital ecosystem on more advanced economies is higher than emerging countries. Thus, an increase of 1% in the Digital Ecosystem Development Index yields an increase on 0.14% in per capita GDP for OECD countries, while the impact of a similar change in non-OECD countries will be 0.10%. In other words, the higher the economic development, the stronger the contribution of the digital ecosystem on economic growth. Considering the growth of the digital ecosystem in Latin America and the Caribbean between 2004 and 2015, its cumulative contribution to GDP is 7.88% (or US$ 359 billion) (see Exhibit 7).

As the analysis indicates, the historical contribution of the digital ecosystem to the Latin American and Caribbean economies has been highly significant. This finding raises the importance of the digital economy on driving the future development of the region. The definition of public policies aimed at stimulating the growth of the digital economy requires identifying the key priorities (or levers) to emphasize going forward.

3. Broadband as a lever in the development of the digital ecosystem

While the concept of digital ecosystem is based on eight pillars, it is important to emphasize that not all of them are equally important in driving its growth. The definition of policy priorities requires the identification of those pillars or sub-components that are most important in driving its future development. For this purpose, a correlational analysis was done to identify the strongest relationship

[9] All model results are included in Appendix A.

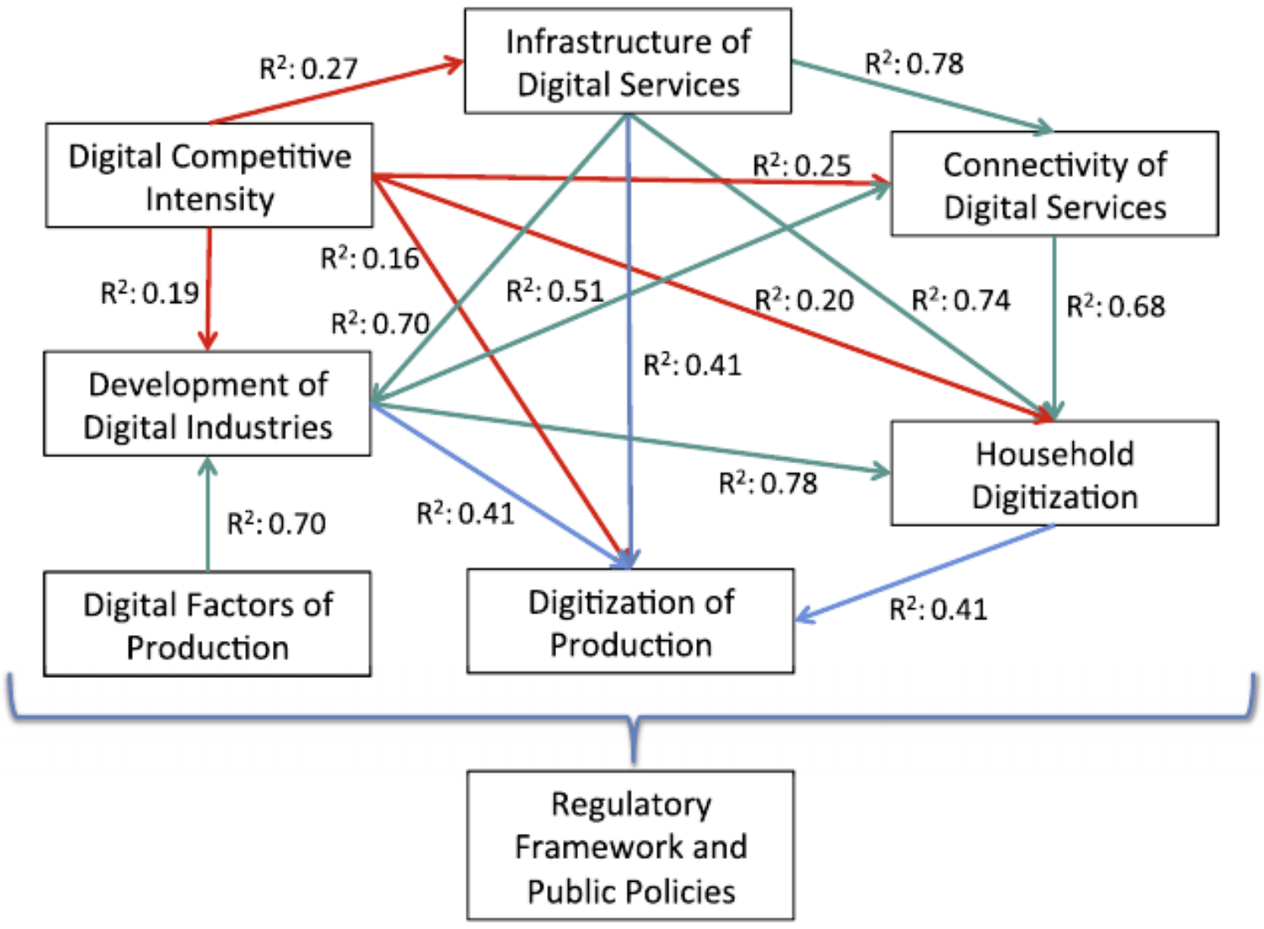

Exhibit 8. Digital ecosystem development index: Correlation coefficients among pillars.
Source: Authors

between pairs of components (see Exhibit 8).

As Exhibit 8 indicates, the strongest coefficient links the infrastructure pillar to the connectivity one indicating, as expected, that without appropriate network deployment, access cannot be fulfilled. Within this context, broadband represents the most critical indicator in both pillars: under infrastructure, investment and broadband network deployment (explaining 75% of the value) are the dominant variables, while within connectivity, fixed and mobile broadband adoption remains the primary driver (explaining 60% of the value). In other words, the development of the digital ecosystem is, first and foremost, driven by the development of broadband. The implication of this finding is that future policies aimed at the development of the digital ecosystem have to be focused initially on broadband deployment and demand stimulation.

3.1. Broadband investment

While broadband technology deployment has made significant progress in the Latin American and Caribbean region in the last

Exhibit 9
Latin America and the Caribbean versus OECD: Broadband infrastructure metrics.

	Fiber Optics as % of Broadband Lines		4G Coverage (% population)		Fixed Broadband Average Download Speed (Mbps)		International bandwidth per Internet User (bps)	
	2004	2015	2012	2015	2004	2015	2004	2015
Argentina	0.07	1.88	56.15	65.00	0.82	4.54	316	31,094
Bolivia	0.01	1.18	1.11	2.50	0.22	1.81	44	9121
Brazil	0.11	8.18	40.00	56.72	0.44	3.67	147	25,259
Chile	0.07	26.20	65.65	76.00	0.79	5.70	798	83,351
Colombia	0.18	1.95	38.89	81.00	0.26	4.39	130	60,312
Costa Rica	0.01	0.76	35.42	41.00	0.51	3.20	48	36,388
Dominican Republic	0.00	0.46	74.64	86.40	0.35	2.31	121	18,996
Ecuador	0.19	4.89	19.58	49.63	0.39	4.13	36	27,621
Mexico	0.16	7.37	50.10	58.00	0.73	5.45	104	11,809
Panama	0.93	4.78	8.64	10.00	0.35	3.44	284	39,449
Paraguay	1.01	5.27			0.08	1.52	27	8,426
Peru	0.12	0.58	53.56	62.00	0.59	4.54	207	17,529
Uruguay	0.00	59.74	43.19	50.00	0.41	6.18	301	47,234
Venezuela	0.00	0.01			0.66	1.60	51	10,151
LATAM	**0.15**	**6.52**	**44.72**	**55.57**	**0.53**	**4.09**	**154**	**24,182**
OECD	**2.57**	**16.80**	**77.39**	**89.98**	**2.41**	**11.11**	**3,674**	**92,154**

(*) Five year cumulated investment per capita in US$ adjusted for purchasing power parity.
Source: International telecommunications Union; Akamai

Exhibit 10
Latin America and the Caribbean versus OECD: Telecommunications investment [a].

	2004	2015
Argentina	$ 392	$ 437
Bolivia	$ 179	$ 516
Brazil	$ 436	$ 433
Chile	$ 486	$ 1,131
Colombia	$ 362	$ 601
Costa Rica	$ 498	$ 1,012
Dominican Republic	$ 525	$ 309
Ecuador	$ 57	$ 195
Mexico	$ 402	$ 422
Panama	$ 402	$ 540
Paraguay	$ 211	$ 411
Peru	$ 125	$ 361
Uruguay	$ 592	$ 574
Venezuela	$ 379	$ 620
LATAM	**$ 367**	**$ 472**
OECD	**$ 747**	**$ 852**

[a] Five year cumulated investment per capita in US$ adjusted for purchasing power parity.
Source: analysis by the authors with data from the International Telecommunications Union

Exhibit 11
Latin America and the Caribbean: Broadband demand Gap (2015).

Country	Fixed Broadband (%)			Mobile Broadband (3G) (%)		
	Coverage	Penetration	Demand Gap	Coverage	Penetration	Demand Gap
Argentina	95.98	58.69	37.29	90.00	65.35	24.65
Bolivia	41.37	7.16	34.21	34.00	34.79	0.00
Brazil	97.00	41.68	55.32	93.53	86.64	6.89
Chile	98.66	57.51	41.15	90.00	57.53	32.47
Colombia	96.00	42.63	53.37	100.00	42.08	57.92
Costa Rica	94.86	40.43	54.43	99.00	99.37	0.00
Ecuador	87.00	45.18	41.82	91.86	35.26	56.6
Mexico	92.00	52.54	39.46	89.00	49.66	39.34
Panamá	- - -	34.19	- - -	79.00	33.15	45.85
Paraguay	- - -	12.55	- - -	66.00	41.56	24.44
Perú	- - -	28.68	- - -	90.67	36.46	54.21
Trinidad Tobago	- - -	67.98	- - -	- - -	31.90	- - -
Uruguay	100	65.66	34.34	90	77.68	12.32
Venezuela	- - -	36.55	- - -	- - -	43.23	- - -
Latin America	93.96	40.57	53.39	97.74	57.41	40.33

Note: Given that penetration is measured in terms of number of connections, and some users could have more than one connection, the demand gap might be higher than the calculated.
Source: Analysis by the authors based on data from The International Telecommunications Union, GSMA Intelligence, and regulatory agencies.

decade, current metrics lag significantly those of OECD countries (see Exhibit 9).

As depicted in Exhibit 9, Latin America and Caribbean countries lag the OECD between 24% for fixed broadband download speed and 73% for international bandwidth per Internet user. In particular, the deployment lag regarding last generation infrastructure such as fiber optics and 4G can be linked to an investment shortfall (see Exhibit 10).

As stated in Exhibit 10, total public and private telecommunications investment in Latin American and the Caribbean telecommunications per capita (five years cumulative) is US$ 462.80, almost half of what is invested in the OECD countries.

3.2. Broadband demand

There are two types of barriers preventing an increase in broadband penetration. The first one is supply: citizens do not acquire broadband service simply because they lack service in the area where they live or work. This barrier is called the supply gap. The second one is called the demand gap. While the supply gap measures the portion of the population of a given country that cannot access broadband because of lack of service, the demand gap focuses on the potential users that could buy broadband service (since operators offer it in their territory, either through fixed or wireless networks), but do not. While the digital divide represents the sum of both supply and demand gaps, the policy initiatives aimed at addressing each of them are different.

The broadband supply gap in Latin American and the Caribbean countries is 6% for fixed broadband and 2.26% for mobile broadband (3G). On the other hand, the demand gap is much larger: 53.59% for fixed broadband and 40.33% for mobile broadband (see Exhibit 11)

Four success factors are critical for increasing broadband service penetration. In order to reduce the supply gap, the key factor entails structuring the right mechanisms that would stimulate the deployment of networks in regions that are still uncovered. The economics of

Exhibit 12
Latin America and the Caribbean: Percentage of Households mentioning affordability as a reason for not purchasing broadband.

Country	Percentage	Source
Argentina	18%	Instituto Nacional de Estadística y Censo (2015)
Brazil	37%	Comitê Gestor da Internet (2015)
Chile	13%	Subsecretaria de Telecomunicaciones (2015)
Colombia	40%	Ministerio de Tecnologías de Informaci ón y Comunicaciones (2010)
Costa Rica	60%	Ministerio de Ambiente y Energía (2011)
Mexico	43%	Instituto Nacional de Estadística y Geografía (2015)
Puerto Rico	16%	Puerto Rico Telecommunications Regulatory Board (2012)

Source: Compiled by the authors

Exhibit 13
Latin America and the Caribbean: Percentage of Households mentioning digital literacy as a reason for not purchasing broadband.

Country	Percentage	Year
Argentina	19%	2015
Brazil	41%	2015
Chile	47%	2015
Colombia	46%	2015
Guatemala	38%	2015
Mexico	33%	2015
Nicaragua	58%	2015

Source: Compiled by the authors from ITU World Telecommunications ICT indicators database 2016, section ICT Household Access and Individual Use

broadband networks (more specifically, the capital required for deployment and the costs of operating the technology) are constrained in low-density regions, particularly those inhabited by underprivileged population. With a low (or even negative) return on investment, private sector broadband service providers have no economic incentive to deploy the technology in rural and isolated areas. Under these conditions, governments are responsible for intervening to address this supply failure.

On the other hand, the residential broadband demand gap is the result of three challenges [10]:

- Limited affordability: certain portions of the population either cannot afford a device or purchase the subscription needed to access the Internet;
- Limited awareness of the potential of the broadband service or lack of digital literacy; and
- Lack of cultural relevance or interest: the value proposition of applications, services, and content provided by the Internet does not fulfill a need of the adopting population.

Each of these three barriers are driven by one or a combination of at least five structural variables:

- **Income levels**: disadvantaged socio-demographic groups, measured by income, have limited capacity to afford the acquisition of broadband. Furthermore, affordability has been found to be correlated with limited awareness and lack of cultural relevance of content. Research indicates that lack of cultural relevance, as a barrier in developed countries, is prevalent in very circumscribed socio-demographic categories. For example, in the United Kingdom, the non-broadband households that cite lack of relevance to explain non-adoption of broadband tend to belong to lower income demographics with people over 65 years old (OFCOM, 2012). In a study conducted in Spain (ONTSI, 2012), lack of relevance of Internet content was found to be inversely proportional to income levels.
- **Education levels**: the education attained by potential users influences the degree of digital literacy and is related to interest in accessing the Internet. Beyond the direct relationship between income and broadband adoption, the influence of education is quite relevant. Particularly, in households above the sixth income decile (where affordability represents less of a barrier), education becomes a determining factor. The higher the educational achievement of the head of household, the higher broadband adoption is. The study of the education variable reveals the complex interrelationship it has with the affordability factor. At lower income levels, the affordability variable is stronger than the educational one in predicting adoption. On the other hand, at income levels higher than the sixth decile, demand is less elastic to income, and educational achievement becomes preeminent.
- **Age**: similarly, the age variable is inversely related to digital literacy and content relevance. Studies conducted in the developed world have all pointed out to the existence of a generation gap linked to limited digital literacy. In the United Kingdom and the United States, the average age of a non-adopting household is over 65 years old (OFCOM, 2012). Research in the emerging world (Katz and Galperin, 2012; Universidad Alberto Hurtado, 2009; INEI, 2012) suggests the existence of a threshold of 30 years old, after which Internet use tends to decline significantly. The difference between the 30-year threshold for Internet usage and persisting

[10] Other barriers, such lack of trust in the Internet, might also exist.

Exhibit 14
Latin America and the Caribbean: Percentage of Households mentioning cultural relevance or lack of need as a reason for not purchasing broadband.

Country	Lack of need	No cultural relevance	Year
Argentina	- - -	72.00%	2015
Brazil	47.00%	5.80%	2015
Chile	36.10%	- - -	2015
Colombia	49.00%	- - -	2015
Guatemala	57.00%	- - -	2015
Mexico	51.00%	- - -	2015
Nicaragua	31.00%	- - -	2015
Panama	27.00%	- - -	2015

Source: Compiled by the authors from ITU World Telecommunications ICT indicators database 2016, section ICT Household Access and Individual Use

broadband penetration at the 35 to 44 age bracket is explained by the presence of children in the household. Children tend to act as change agents in a household, stimulating Internet usage and sustaining broadband adoption. This indirect influence cancels some of the generational gap identified in numerous studies.

- **Ethnicity**: as a result of linguistic and/or cultural structural factors, ethnic group belonging can impact the level of interest in accessing the Internet. Along these lines, the lack of content in local languages could represent a major barrier for adoption.
- **Gender**: differences in education or insertion in the labor market between male and female population can have an impact on broadband adoption. For example, a gender gap was detected in some countries (see Universidad Alberto Hurtado, 2009 for Chile; INEI, 2012 for Peru; and Gobierno de Costa Rica and Rectoría de Telecomunicaciones, 2011 for Costa Rica). However, research by Hilbert (2011) has indicated that the gender gap disappears when control variables such as income and education are included in the analysis.

In addition, non-adoption of broadband could be explained by concerns regarding data privacy. While this factor has been found to explain approximately 10% of non-users of electronic commerce among Internet subscribers, it could be hypothesized that privacy concerns also prevents some users from outright broadband usage.

A compilation of research on adoption barriers in Latin America indicates that affordability remains a preeminent variable in explaining the non-adoption of broadband (see Exhibit 12).

As the data in Exhibit 12 suggests, the economic barrier remains a key factor in limiting broadband adoption. However, it would seem that in developed countries with higher household incomes, the economic barrier takes second seat to either low digital literacy or cultural inadequacy.

Digital literacy is the ability to navigate, evaluate, and create information effectively and critically using a range of digital technologies. Research around digital literacy is concerned not just with being literate at using a computer, but also with wider aspects associated with learning how to find, use, summarize, evaluate, create, and communicate information effectively while using digital technologies. Digital literacy does not replace traditional forms of literacy; it builds upon the foundation of traditional forms of literacy. Again, research studies on broadband adoption barriers in Latin America reveal that digital literacy is a critical variable explaining non-adoption (see Exhibit 13).

Finally, since broadband is a platform used to access Internet content, applications, and services, the relevance of such content offers an incentive to purchase a subscription. Conversely, the lack of cultural relevance could serve as a barrier to adoption. Cultural relevance could be conceptualized either in terms of content suited to the interests of the adopting population or in terms of language used for interacting with applications/services or consuming content. As prices for broadband service decline, the cultural relevance factor gains in importance. In other words, from a policy standpoint, once the economic obstacles are tackled and affordability becomes less of an explanatory factor of non-adoption, the lack of relevance or interest variable gains weight. Studies indicate that, while being less important than affordability and digital literacy, cultural relevance remains a barrier to broadband adoption (see Exhibit 14).

The lack of cultural relevance or “lack of need” barrier presents some complexity in terms of its understanding. Two interpretation options are open. One option is that the consumer has evaluated the offerings in terms of applications, services and content and has not found them relevant to his or her needs. Under this premise, policy initiatives should be oriented towards increasing the perceived value of broadband by expanding the range and utility of offerings (these are called “demand pull” policies). The second option is that the consumer does not have enough information to make a decision of adopting broadband.

In at least one study conducted in a developed country, the linguistic factor contributed to the lack of relevance. That was identified in the United States among the Hispanic population that had recently immigrated to the country (Lopez, Gonzalez-Barrera, Patten, 2013). It is important to consider, however, that, as in the United States, the linguistic barrier is strongly correlated with economic and educational factors. Therefore, it is still difficult to tease out the socio-demographic variables in order to isolate the linguistic factors. The language barrier has been identified in Latin America as well. For example, in Peru, only 8% of those individuals whose first language was not Spanish are Internet users. That percentage increased to 40% amongst native Spanish-speakers.

4. Broadband development objectives for the Latin American and Caribbean

Considering that the objective is for Latin American and the Caribbean region to reach a digital ecosystem development comparable

to that of the OECD countries, this has implications for broadband development. Furthermore, assuming that an acceleration of telecommunications investment to fund deployment of fiber optics in the last mile and achieve full coverage of 4G, coupled with the stimulation of broadband adoption are the two priority actions, it is necessary to define what the goals would be to be fulfilled in five years for Latin America and the Caribbean.

Exhibit 15 presents the development objectives for four indicators of broadband development: overall investment, fiber deployment, 4G coverage, and fixed broadband download speed.

The implied growth metrics for broadband deployment for some countries are fairly ambitious (Argentina, Brazil, Colombia, and Mexico among others), both in terms of last generation infrastructure coverage and quality of service:

- Increase telecommunications investment per capita from US$472 to US$ 788
- Increase deployment of last mile fiber optics from 6.52% of total broadband lines to 15.37%
- Grow 4G population coverage from 59.63% to 84.03%
- Increase fixed broadband average download speed from 4.14 Mbpss to 10.18 Mbpss

Beyond the metrics displayed in Exhibit 15, other broadband deployment goals for Latin America and the Caribbean include the following:

- Increase Mobile broadband download speed from 2.94 Mbps to 7.39 Mbps (a consequence of 4G deployment)
- Increase percentage of broadband lines with download speed in excess of 10 Mbps from 3.26% to 31.19%
- Increase international bandwidth per Internet user from 45,325 Kbps to 105,434 kbps

All in all, these targets imply practically doubling the investment amounts in telecommunications infrastructure to accelerate the deployment of fiber optics in the last mile, achieve close to complete population coverage of 4G networks, and deploy additional submarine cable capacity and national backbone networks. In light of these objectives, it necessary to consider their policy and regulatory implications, discussed in the next section.

Beyond increasing broadband deployment, another development objective for Latin American and Caribbean countries should focus on demand stimulation. Considering that affordability is one of the preeminent barriers explaining the broadband demand gap, Exhibit 16 presents current and targeted affordability goals (explained by price of broadband plans as a percentage of monthly per capita income).

Affordability data for 2004 and 2015 indicates that prices have been consistently declining for all countries in the region. In some cases, mobile broadband data prices have already reached or exceeded the OECD average (for example, Argentina, Chile, and Costa Rica). On the other hand, fixed broadband prices have to continue declining along their annual rate to reach affordability thresholds.

5. Policy implications

5.1. A reduction in public contributions to increase in investment [11]

As stated above, if Latin America and Caribbean countries have to deploy last generation broadband infrastructure, they need to practically double their telecommunications investment. As stated above, total public and private telecommunications investment in telecommunications per capita (five years cumulative) is US$ 462.80. This metric is based on an annual investment of $ 29.29 billion (for 2014).[12] This amount represents 19.8% of total industry sales of US$ 144.80 billion, which in and of itself is a healthy ratio for capital investment. For example, CAPEX/Revenues for North American carriers is 14% and Western Europe 20%. This means that, under current market conditions, it would be unreasonable to think that the private sector increases its capital spending. Moreover, recognizing the public sector constraints that currently characterize Latin American economies, one should not expect the investment shortfall to be addressed by public funds.

In this context, changes in the regulatory framework could help address in part the investment challenge. Of the US$ 29.29 billion of capital spending, US$ 26.59 billion is focused on equipment purchasing and capital works, while US$ 2.70 billion is used to pay for spectrum licenses and permits. In addition, US$ 5.73 billion from the industry value added is used to pay for special taxes and contributions (such as municipal taxes for tower deployment, and funds for operations of the regulatory agency). Three initiatives to be taken could act as an incentive to increase telecommunications spending:

- Reduction of spectrum costs, special taxes and contribution
- Simplification of procedures and elimination of barriers to network deployment (such as municipal authorizations to dig fixed broadband trenches or deploy cellular towers): it is estimated that the frictional costs (such as delays in obtaining necessary permits) resulting from network deployment approximates 5% of construction costs
- Reduction of network equipment import duties (for example, import of switches routers and modems is subject to 20% import duty in Argentina, 16% in Brazil and Uruguay, and 20% in Venezuela)

[11] The analysis included in this section is based on Katz, Flores-Roux, and Callorda (2017).
[12] Includes Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Paraguay, Peru, Uruguay, and Venezuela.

Exhibit 15
Latin America and the Caribbean: Broadband Deployment objectives.

	Telecommunications Investment per capita[a]		Fiber Optics as % of Broadband Lines		4G Coverage		Fixed Broadband Average Download Speed	
	2015	2020	2015	2020	2015	2020	2015	2020
Argentina	$ 437	$ 852	1.88	16.80	65.00	87.26	4.54	11.11
Bolivia	$ 516	$ 516	1.18	5.81	2.50	55.08	1.81	4.61
Brazil	$ 433	$ 852	8.18	16.80	56.72	87.26	3.67	11.11
Chile	$ 1131	$ 1131	26.20	26.20	76.00	87.26	5.70	11.11
Colombia	$ 601	$ 852	1.95	16.80	81.00	87.26	4.39	11.11
Costa Rica	$ 1,012	$ 1,012	0.76	16.60	41.00	87.26	3.20	11.11
Dominican Republic	$ 309	$ 439	0.46	5.81	86.40	86.40	2.31	4.61
Ecuador	$ 195	$ 634	4.89	7.48	49.63	71.56	4.13	4.67
Mexico	$ 422	$ 852	7.37	16.80	58.00	87.26	5.45	11.11
Panama	$ 540	$ 634	4.78	7.48	10.00	71.56	3.44	4.67
Paraguay	$ 411	$ 439	5.27	5.81	- - -	55.08	1.52	4.61
Peru	$ 361	$ 463	0.58	16.80	62.00	87.26	4.54	11.11
Uruguay	$ 574	$ 852	59.74	59.74	50.00	87.00	6.18	11.11
Venezuela	$ 620	$ 634	0.01	7.48	- - -	71.56	1.60	4.67
LATAM	**$ 472**	**$ 789**	**6.52**	**15.37**	**59.63**	**84.03**	**4.14**	**10.18**

Note: The Latam average reflects only the countries included in the table.
[a] Five year cumulated investment per capita in US$ adjusted for purchasing power parity.
Source: Analysis by the authors based on data from the International Telecommunications Union, GSMA Intelligence, Akamai, and regulatory authorities

Exhibit 16
Latin America and the Caribbean: Broadband Affordability objectives (Cost of Plan as percentage of per capita GDP).

	Fixed Broadband Plan			Smartphone Data Plan (prepaid, 500 MB cap)		
	2004	2015	2020	2011	2015	2020
Argentina	4.52 %	3.66 %	1.03 %	2.18 %	0.89 %	0.89 %
Bolivia	23.22 %	5.55 %	3.11 %	12.53 %	2.24 %	2.24 %
Brazil	5.90 %	1.26 %	1.03 %	25.88 %	1.05 %	0.96 %
Chile	5.32 %	2.33 %	1.03 %	6.80 %	0.55 %	0.55 %
Colombia	7.48 %	2.66 %	1.03 %	21.77 %	2.95 %	0.96 %
Costa Rica	3.73 %	2.00 %	1.03 %	2.27 %	0.90 %	0.90 %
Dominican Republic	8.39 %	3.75 %	3.11 %	31.02 %	4.67 %	2.80 %
Ecuador	11.25 %	3.95 %	2.90 %	12.87 %	3.92 %	1.66 %
Mexico	8.36 %	2.93 %	1.03 %	4.87 %	1.98 %	0.96 %
Panama	2.56 %	1.45 %	1.45 %	1.89 %	1.36 %	1.36 %
Paraguay	19.23 %	8.12 %	3.11 %	12.70 %	2.18 %	2.18 %
Peru	14.66 %	2.15 %	2.15 %	7.79 %	1.85 %	1.85 %
Uruguay	4.99 %	1.37 %	1.03 %	1.26 %	0.28 %	0.28 %
Venezuela	5.55 %	3.60 %	2.90 %	3.76 %	5.72 %	1.66 %
LATAM	9.08 %	3.91 %		14.58 %	2.30 %	
OCDE	2.01 %	1.03 %		1.81 %	0.96 %	

The affordability target has already been achieved.
Source: Analysis by the authors based on data from the International telecommunications Union.

A combination of all three initiatives could increase telecommunications investment between 4.81% and 10.19% (assuming that approximately 70% of the reduction of contributions is transferred to investment, while the remainder will be used to increase margins). It should be noted that a decrease in special taxes and contributions would not necessarily imply a reduction of State revenues, since an increase in network deployment will drive an increase in revenues and, consequently taxes collected on earnings (Katz, Flores-Roux, and Mariscal, 2010).

5.2. Is there enough competitive intensity in broadband industries?

Broadband pricing is one of the critical levers to stimulate adoption. This factor is of preeminent importance given that the

Exhibit 17
Latin America and the Caribbean: Mobile broadband market Structure (2016).

Country	Market Share					HHI
	Operator 1	Operator 2	Operator 3	Operator 4	Other	
Argentina	36.13	29.77	34.09	–	–	3,354
Bolivia	31.71	20.37	41.92	–	–	3,594
Brazil	31.11	27.70	24.82	14.69	1.15	2,559
Chile	31.21	40.92	25.62	2.25	–	3,310
Colombia	62.62	18.15	18.52	0.72	–	4,594
Costa Rica	35.04	36.66	28.30	–	–	3,373
Ecuador	59.59	26.93	16.48	–	–	4,119
El Salvador	42.60	33.83	18.70	4.87	–	3,333
Guatemala	44.53	42.03	13.44	–	–	3,930
Honduras	35.64	64.38	–	–	–	5,412
Mexico	69.78	20.44	9.78	–	–	5,383
Nicaragua	49.51	50.49	–	–	–	5,000
Panamá	36.78	12.32	39.34	12.56	–	3,137
Paraguay	35.45	8.48	50.97	5.11	–	3,953
Perú	36.09	51.93	6.86	5.12	–	4,072
Trinidad Tobago	50.00	50.00	–	–	–	5,005
Uruguay	48.53	36.69	14.77	–	–	3,919
Venezuela	32.19	13.43	54.38	–	–	4,174

Source; Analysis by the authors based on data from GSMA Intelligence.

broadband demand gap in Latin America and the Caribbean is significant. Is there enough competitive intensity to drive prices down? Obviously, the key question in the context of a capital-intensive industry such as telecommunications is what is the appropriate number of players to yield sufficient competitive intensity. [13] Research has shown that the relation between competition and innovation is not linear but takes the form on an inverted "U", whereby innovation and competition are related until reaching an optimal point, beyond which the competitive incentive tends to decline (Aghion Griffith, 2005). Along those lines, research has formalized the concept that, in principle, "four (players) are few and six are too many" (Selten, 1973), or "two players are few and four are too many" (Huck, Norman, and Oechssler (2004). In general terms, researchers are agreeing that in telecommunications (especially in broadband), an optimal market structure should include between three and four players. When translated to a Herfindahl-Hirschman Index, an optimal market structure in Latin America would translate into 4,000 for mobile broadband, and 1,800 for fixed broadband. [14]

In this context, in 2015 some Latin American and Caribbean countries exhibited a higher than optimal industry concentration. In the case of mobile broadband, Colombia, Ecuador, Honduras, Mexico, Nicaragua, Peru, Trinidad Tobago and Venezuela depicted high concentration indices in 2015 (see Exhibit 17).

In the case of fixed broadband, all countries in the region exhibit industries that are highly concentrated (see Exhibit 18).

In particular, the fixed broadband industries in Chile, Costa Rica, Ecuador, Mexico, Panama, Paraguay, Peru, Trinidad Tobago, Uruguay, and Venezuela are highly concentrated.

Beyond the competitive stimuli, the reduction of broadband service prices can be achieved through a number of targeted public policy initiatives. These initiatives are generally implemented with the objective of achieving universal broadband adoption. The underlying rationale for these policies is that, beyond a competition model, government policies should be implemented to further price reductions of broadband in order to make it accessible to segments of the population affected by limited affordability.

One approach relies on state-owned telecommunications operators to offer, under their public service imperative, a low-priced broadband service. Obviously, this option is only viable in those countries that have not completely privatized their telecommunications industry. Under this option, a state-owned broadband provider assumes responsibility, as a public service entity, for providing a low-price broadband service. The advantage of this option is that, in addition to fulfilling the objective of tackling the economic barrier, the offering can act as an incentive for other private operators to launch their own more affordable service.

For example, in May 2011, government-owned telco Antel in Uruguay launched its "Servicio Universal Hogares" – or "Internet for All" - plan, aiming to bring Internet access to every home in Uruguay. For a one-time payment of US$30 – the cost of a modem - all fixed line phone customers qualified for free ADSL service. The package offered a basic connection of 256 Kbps and targeted the low-income segment to which the price of broadband represented a barrier to connectivity. At the time, homes and businesses with basic Internet connections paid approximately US$ 150 monthly. Similarly, the Uruguayan government also planned to reach schools and educational institutions with Fiber-to-the-Home (FTTH) technology.

In June 2011, Antel announced plans to connect more than 80,000 Uruguayan households with FTTH by the end of the year. This project initially targeted higher-income, urban areas but incorporated plans to reach the lower socioeconomic groups. The rollout

[13] As the EU Commission Regulation states, "a mere finding that a market is concentrated does not necessarily warrant a finding that its structure is conducive to collective dominance in the form of tacit coordination" *(*Commission regulation. Guidelines on market analysis and the assessment of Significant Market Power, 2002 O.J. (C.165) at 19, paragraph 100.).

[14] Both values were derived by assessing the relationship between the HHI and pricing for Latin American countries.

Exhibit 18
Latin America and the Caribbean: Fixed broadband market Structure (2015).

Country	HHI
Argentina	2,793
Bolivia	2,168
Brazil	2,514
Chile	3,053
Colombia	2,151
Costa Rica	3,044
Ecuador	3,504
Mexico	4,232
Panamá	4,266
Paraguay	3,194
Perú	7,300
Trinidad Tobago	4,367
Uruguay	9,781
Venezuela	6,735

Source: Analysis by the authors based on data from Convergencia Research

Exhibit 19
Uruguay: "Social" broadband Plans (2016).

Price	Performance	Details
US$ 2.20	256 Mbyte	30 calendar days from date of purchase
US$ 4.50	512 Mbyte	30 calendar days from date of purchase
US$ 9.00	1024 Mbyte	60 calendar days from date of purchase

Source: Antel

incorporated US$100 million investment and a partnership with the Chinese technology firm ZTE. Described as "the most ambitious broadband effort in Latin America," the FTTH project as well as the opening of the Bicentenario submarine cable in early 2012 increased broadband access, speed, and service quality.

The December 2011 launch of its commercial LTE services allowed the telco to offer broadband connections to those regions not yet impacted by the FTTH rollout as well as those customers who could not afford the connectivity costs of fixed Internet. Antel offered customers two package plans from which to choose. By signing a 2-year contract, customers could pay US$ 90 per month for 30 GB. For US$ 76 per month plus an additional $6 in modem rental fees, customers could access 15 GB through a 15-day auto-renew contract. [15]

In time, the *Universal Hogares* plan expanded, bringing customers faster speeds for lower prices. As of February 2014, the telco offers the following extensions beyond the fixed wireless plan that comes with 1 GB per month at no charge (see Exhibit 19).

Beyond service pricing, broadband economic adoption obstacles are linked to device prices. Three types of programs have been implemented to overcome the personal computer ownership barrier. The first one focuses on the provision of subsidies to reduce the acquisition price of devices. The target in this case could be households at the lower end of the socio-demographic pyramid, primary school to university students, and SMEs (especially micro-enterprises). The second program typically targets students in primary education, with governments distributing "One Computer per Child." In this case, public school students receive computers free of charge. The third type of initiative entails a reduction of the access price by eliminating or decreasing taxes paid at time of purchasing. Levies affected by this measure could range from sales tax, import duties, and even sector-specific levies. All three of these programs have been implemented in countries like Argentina, Brazil, and Uruguay, among others.

6. The digital ecosystem development imperative

Despite the significant advances achieved in terms of some of the pillars of the digital ecosystem outlined above, the Latin America and the Caribbean region needs to accelerate its development, aiming at achieving a position comparable to that of developed economies. This is predicated on three economic imperatives.

First, the short-term outlook for the region's economic growth is not very attractive. In 2015, the economies of Latin America

[15] Sources: Budde, Paul. "Uruguay - Telecoms, Mobile, Broadband and Forecasts." *Market Research*. N.p., 25 Nov. 2012. Web. <http://www.marketresearch.com/Paul-Budde-Communication-Pty-Ltd-v1533/Uruguay-Telecoms-Mobile-Broadband-Forecasts-7256999/>. "Broadband Internet Access Worldwide." *Encyclopedia*. NationMaster, 2006. Web. <http://www.nationmaster.com/encyclopedia/Broadband-Internet-access-worldwide>. Prescott, Roberta. "Uruguay's Antel Eyes Mobile Broadband Opportunities with LTE." *RCR Wireless News Americas*. N.p., 20 Apr. 2012. Web. <http://www.rcrwireless.com/americas/20120420/carriers/uruguays-antel-eyes-mobile-broadband-opportunities-when-launching-lte/>. "Universal Hogares Rural." *Antel*. N.p., n.d. Web. 27 Feb. 2014. <https://www.antel.com.uy/antel/personas-y-hogares/internet/planes/internet-rural/universal-hogares->.

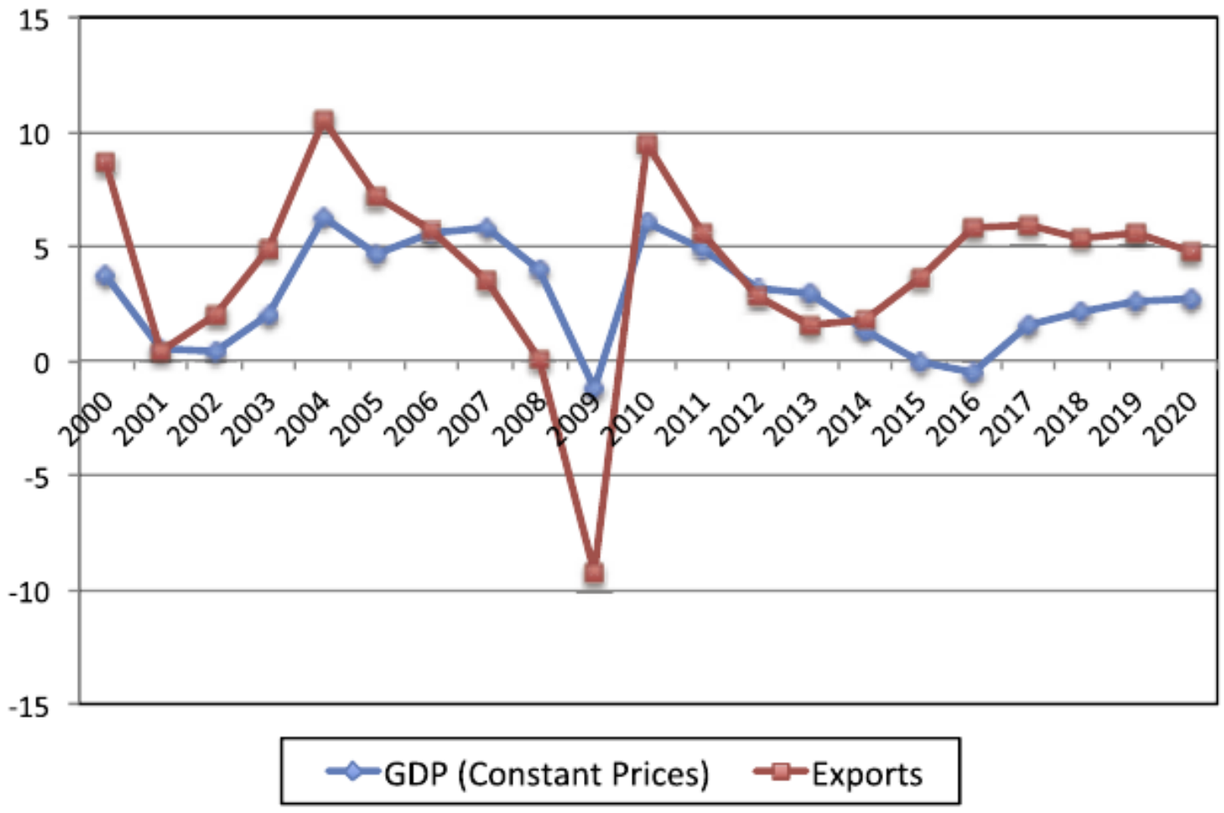

Exhibit 20. Latin America. Year-on year rate of change.
Source: International Monetary Fund

contracted −0.4%, and grew only 0.2% in 2016. This was due in large part to the decrease in world commodity prices. [16] Only by the end of 2017 is the Latin American GDP growth rate expected to reach levels comparable to those recorded in 2011 (see Exhibit 20).

According to projections from the International Monetary Fund in Exhibit 20, the volume of Latin American exports resumed its 2011 growth level by 2016, while only by 2021 will the GDP be growing at rates close to those of 2013. In this context, in order to stimulate future economic growth, the region faces a fundamental challenge in terms of the need to increase the contribution of productivity and competitiveness. The analysis of the contribution of productivity to the economic growth of the largest Latin American countries for the last fifteen years shows that, although labor productivity has contributed to gross product growth, the impact of the knowledge economy (which includes human capital, ICT capital and multifactor productivity) has been very low or directly negative (see Exhibit 21).

With the exception of the Chilean case where labor productivity has grown twice the number of hours worked, in the other Latin American countries analyzed the explanatory variable of output growth lies in the number of hours. In other words, with the exception of Chile, GDP growth is determined by the number of hours worked and not by productivity per hour. Even so, the growth of Chilean labor productivity is significantly lower than that of an industrialized country like South Korea (which is 4.4). In sum, in a context where productivity growth rates are far removed from what would be necessary to reach a healthy economic growth rate, it is observed that most of the increase in productivity is being determined by labor productivity, and that the contribution of investment in information and communication technologies (as triggered by development of the digital ecosystem) is seriously behind. Herein lies the great Latin American challenge. Against a backdrop of falling commodity prices, one of the most important levers to stimulate economic growth is productivity growth. For it to increase, the digital ecosystem must grow. An idea of the scale of the challenge is given by the contribution of the knowledge economy to the growth of labor productivity: in a country of advanced digitization like South Korea this reached 3.1 between 1995 and 2012; the average of the five largest countries in Latin America is −0.3.

Second, as a consequence of the rapid economic growth achieved in the last decade, Latin America has dramatically increased its expenditure on social welfare. In order to sustain its social expenditure, Latin America needs to increase its productivity. A comparative analysis between social expenditure (as percent of the GDP) versus labor productivity indicates that welfare spending for Latin America is unsustainable if productivity does not grow (see Exhibit 22).

In that context, the acceleration of growth of the digital ecosystem is a fundamental factor that will enable the growth in productivity, which in turn will sustain the increase in social spending.

Third, the need to improve productivity is not only supported by the imperative to sustain the level of social expenditures. The automation of production, particularly in manufacturing both in the United States and some European countries, is resulting in a paradigm shift in the location of production facilities. The original paradigm driving the out-shoring of manufacturing as a result of labor cost differentials is gradually disappearing as a result of four factors. First, automation is reducing labor costs in industrialized countries, which in turn diminishes the gap between developed and emerging nations. Second, automation also reduces the proportion of labor costs of the total costs of manufacturing. Third, a reduction of transportation costs and improvement in logistics reduces the need for multinational corporations to establish subsidiaries close to emerging markets. Fourth, as identified in some industries, the proximity of manufacturing

[16] Economic Commission for Latin America and the Caribbean. Economías de Am´erica Latina y el Caribe crecer´an solo 0.2% en 2016 en complejo escenario global. Santiago: December 17, 2015.

Exhibit 21
Contributions to product growth (1995–2012) (average annual growth in percentage points).

		Argentina	Brazil	Chile	Colombia	Mexico
1	Production	3.2	2.8	3.9	3.2	2.0
2	Hours worked	2.1	2.0	1.3	1.6	1.0
	Labor productivity (1/2)	**1.1**	**0.8**	**2.6**	**1.6**	**1.0**
	Contributions from:					
4	Composition of labor (education level, age and gender)	-0.1	1.1	0.7	0.4	0.3
5	ICT capital per hour	0.4	0.7	0.4	0.5	0.4
6	Multifactorial productivity[a]	-0.8	-1.6	-0.8	-2.2	-0.9
	Contribution of knowledge economy to labor productivity (4) (5) (6)	**-0.5**	**0.2**	**0.3**	**-1.3**	**-0.2**

[a] In its basic formulation, productivity is measured in terms of labor productivity (production divided by the number of hours worked). The productivity of all factors is measured in terms of inputs of capital, labor and raw materials. This measure provides a better guide to the efficiency of an economy as it checks for changes in inputs.
Source: Economic Commission for Latin American and the Caribbean (ECLAC), based on data from LA KLEMS.

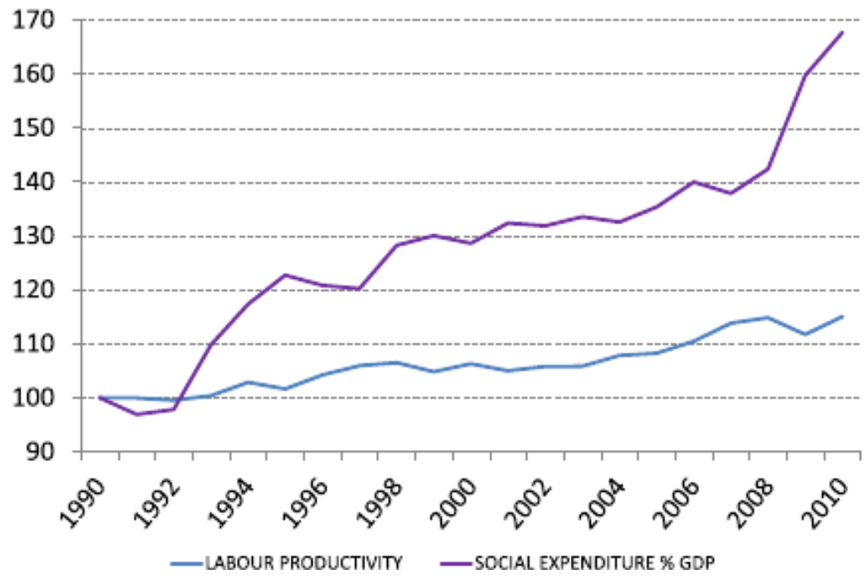

Exhibit 22. Latin America and the Caribbean: Social Expenditure versus Labor productivity (1990 index = 100).
Source: Cimoli (2017).

and R D has become a source competitive advantage. Driven by these four factors, the original comparative advantage of emerging regions such as Latin America (large domestic markets needed to be served locally, and labor cost differentials) is eroding. In light of this, Latin America needs to accelerate the development of its digital ecosystem in order to catch up with the trends being fostered by industrial policies in advanced nations (embodied by Industry 4.0 initiatives in Germany, Spain, and Korea, as among others).

7. Conclusion

The universe of Latin America and Caribbean nations is not homogeneous when it comes to the challenges faced regarding broadband penetration. Thus, the policy recommendations should not be considered as uniform across countries. In the aggregate, Latin American and Caribbean countries can be categorized into two groups: advanced and developing (see Exhibit 23).

In general trends, some Latin American and Caribbean countries (Argentina, Brazil, Chile, Colombia, Costa Rica) tend to be advanced in terms of supply and penetration of broadband services. On the other hand, other countries (Bolivia, Paraguay) are still at a limited stage of broadband development both in terms of supply and demand. Finally, a number of countries (Peru, Ecuador) exhibit advanced coverage of the population combined with low penetration. Broadband policies need to be defined for each group. The following are structured around the promotion of enhanced supply and the stimulation of demand. Cognizant that supply and demand stimulation policies could be implemented in all three country groupings, each group has a dominant imperative: advanced countries need to focus on policy initiatives that promote next generation broadband network deployment; countries at an intermediate stage of broadband development need to focus on demand stimulation policies around digital literacy; finally, countries with limited broadband development need to emphasize affordability initiatives.

Advanced Latin American countries exhibiting high coverage and adoption are facing the challenge of building a forward-looking world-class infrastructure that will position them in a leading position in terms of digitization. This entails deploying fiber optics, completing their 4G coverage and preparing to deploy 5G. Supply related policies for these countries need to recognize that few broadband providers (typically the incumbents) are capable of tackling these challenges. Along these lines, governments need to consider policies that represent appropriate incentives to warrant next generation infrastructure deployment. They typically include tax benefits, regulatory holidays.

Exhibit 23
Latin America and the Caribbean: State of broadband supply and demand (2015).

	Supply			Demand	
	Fixed Broadband Coverage	Mobile Broadband Coverage (3G)	Mobile Broadband Coverage (4G)	Fixed Broadband Penetration (households)	Mobile Broadband Penetration (pop
Latin America and Caribbean Average	93.96%	87.65%	46.82%	14.95%	29.41%
Advanced	**>80%** Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Uruguay	**>80%:** Argentina, Barbados, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Jamaica, Mexico, Peru, Uruguay	**>80%** Colombia, Dominican Republic	**>70%** Barbados,	**>70%**
Medium	**80%-40%** Bolivia	**80%-40%** Panama, Paraguay, Trinidad Tobago	**80%-40%** Argentina, Brazil, Chile, Costa Rica, Ecuador, Mexico, Peru, Trinidad Tobago, Uruguay	**70%-40%** Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Trinidad Tobago	**70%-40%** Brazil, Chile, Costa Rica,
Limited	**<40%**	**<40%** Bolivia	**<40%** Bolivia	**<40%** Bolivia, Jamaica, Panama, Paraguay, Peru, Dominican republic, Venezuela	**<40%** Argentina, Barbados, Bolivia, Colon Ecuador, Jamaica, Mexico, Panama Peru, Uruguay, Venezuela

Sources: International Telecommunications Union; GSMA Intelligence; Regulatory authorities; analysis by the authors

Countries with advanced coverage but limited penetration face classical demand gap reduction challenges, to be addressed below. First and foremost, governments have to recognize that increased service adoption is dependent on lowering the total operating cost incurred by consumers by purchasing the technology. The competition lever for stimulating price reduction has been already pulled. Beyond, competition, governments should consider reducing the taxes incurred by consumers when purchasing broadband services. In general terms, since high taxation increases the total cost of ownership of wireless services, it is correct to consider that higher wireless consumption taxes will raise the affordability barrier and reduce adoption. In this context, taxation could have a detrimental effect on the public policy strategy aimed at deploying mobile broadband. If taxes limit adoption of wireless broadband, it is relevant to ask what the ultimate impact of reduced penetration might have on economic growth. Hypothetically, it is safe to assume that a reduction in adoption as a result of incremental taxation could yield a negative impact on GDP growth. The taxation initiative could be complemented with selected targeted subsidies to be assigned to vulnerable households or residents in rural areas.

For countries that are still at the early development stages of broadband demand and supply, a combination of infrastructure deployment incentives and demand stimulation policies are required. Policy makers in these countries have to recognize that the competitive incentive will not be sufficient to generate the stimuli required to promote infrastructure investment. Assuming that governments of these countries have limited resources to inject investment in universal broadband reach, it might be necessary to rely on incumbents and provide them with the right incentives to deploy broadband networks. Infrastructure investment stimulation policies should be put in place simultaneously with demand promotion mechanisms that drive uptake to commercialize the supply availability.

Appendix A. List of Indicators of the Development Index of the Digital Ecosystem

Number	Pillar	Sub-pillar	Indicator	Source
1	Infrastructure	Investment	Telecommunications investment (US$ per capita PPP in current prices. 5 year sum)	World bank; ITU
2	Infrastructure	Service quality	Fixed broadband download speed (Mbps average)	Akamai
3	Infrastructure	Service quality	Mobile broadband download speed (Mbps average)	Akamai
4	Infrastructure	Service quality	Percentage of broadband lines with download speed > than 4 Mbpss (%)	Akamai
5	Infrastructure	Service quality	Percentage of broadband lines with download speed > than 10 Mbpss (%)	Akamai
6	Infrastructure	Service quality	Percentage of broadband lines with download speed > than 15 Mbpss (%)	Akamai
7	Infrastructure	Service quality	FTTH lines as percent of total fixed broadband lines	ITU; FTTH; OECD
8	Infrastructure	Service quality	International bandwidth per Internet user (bit/s)	ITU
9	Infrastructure	Coverage	Fixed broadband coverage (% of households)	Eurostat, CAF; OECD
10	Infrastructure	Coverage	2G network coverage	ITU
11	Infrastructure	Coverage	3G network coverage	ITU
12	Infrastructure	Coverage	4G network coverage	ITU
13	Infrastructure	Infrastructure for services	IXP per 1,000,000 population	Packet Clearing House; UNCTAD
14	Infrastructure	Infrastructure for services	Secure Internet servers (per 1,000,000 population)	World Bank
15	Infrastructure	Infrastructure for services	Number of satellites in orbit per 1,000,000 population	N2yo.com
16	Connectivity	Affordability	Average price of fixed broadband subscription as percent of monthly per capita GDP	ITU
17	Connectivity	Affordability	Price of smartphone mobile broadband (500 MB cap) as percent of monthly per capita GDP	ITU
18	Connectivity	Affordability	Price of PC mobile broadband (1 GB cap, postpaid) as percent of monthly per capita GDP	ITU
19	Connectivity	Affordability	Price of mobile telephony basket as percent of monthly per capita GDP	ITU
20	Connectivity	Affordability	Cost of pay TV as monthly GDP per capita	Business Bureau; CAF; PwC; TAS
21	Connectivity	Affordability	Mobile telephony penetration	ITU
22	Connectivity	Penetration	Fixed broadband penetration (per 100 population)	ITU
23	Connectivity	Penetration	Mobile broadband penetration (per 100 population)	ITU
24	Connectivity	Penetration	Unique mobile broadband users (users per 100 population)	GSMA
25	Connectivity	Penetration	Pay TV penetration (per 100 households)	Business Bureau; CAF; PwC; TAS; UIT; Convergencia Research
26	Connectivity	Ownership	Computer penetration (% of households)	UIT
27	Connectivity	Ownership	Smartphone users (users per 100 population)	GSMA
28	Connectivity	Ownership	Percentage of population with electricity access	World Bank
29	Household digitization	Internet use	Internet users as percent of population	UIT
30	Household digitization	Internet use	Penetration of dominant social network (users per 100 population)	OWLOO
31	Household digitization	Internet use	Mobile data ARPU as percent of total ARPU	GSMA

(*continued on next page*)

(*continued*)

Number	Pillar	Sub-pillar	Indicator	Source
32	Household digitization	Electronic government	E-government index	United Nations
33	Household digitization	Electronic commerce	Internet commerce as percent of total retail trade	Euromonitor
34	Household digitization	Telemedicine	National e-Health policy (dummy variable) P	WHO
35	Household digitization	OTTs	VOD penetration (connections per 100 households)	PWC
36	Digitization of production	Digital infrastructure	Percent enterprises accessing the Internet	UNCTADstat; TAS; Eurostat
37	Digitization of production	Supply chain digitization	Percent enterprises using Internet for e-Banking	UNCTADstat; TAS; Eurostat
38	Digitization of production	Supply chain digitization	Percent of enterprises using Internet in supply chain	UNCTADstat; TAS; Eurostat
38	Digitization of production	Sales and distribution digitization	Percent of enterprises that sell products over the Internet	UNCTADstat; TAS; Eurostat
40	Digitization of production	Processing digitization	Percent of employees using the Internet	UNCTADstat; TAS; Eurostat
41	Digitization of production	Processing digitization	Percent of employees using a computer	UNCTADstat; TAS; Eurostat
42	Competition	Competitive intensity	HHI fixed broadband	Convergencia Research; Regulators; TAS
43	Competition	Competitive intensity	HHI mobile broadband	GSMA; Regulators
44	Competition	Competitive intensity	HHI Pay TV	Convergencia Research; Dataxis; Ofcom; TAS; Regulators
45	Competition	Competitive intensity	HHI mobile telephony	GSMA; Regulators
46	Digital industries	Exports	Exports of high technology products (US$ per capita in current prices)	World Bank
47	Digital industries	Exports	Exports of high technology services (US$ per capita in current prices)	World Bank
48	Digital industries	Share of digital industries	Digital ecosystem sales as percent of GDP	PWC; TAS; UIT
49	Digital industries	Share of digital industries	Computing software spending (% of GDP))	INSEAD
50	Digital industries	IoT	M2M penetration (connections per 100 population)	UIT; OECD
51	Digital industries	Local content development	Wikipedia pages locally edited (per 1,000,000 population between 15 and 69 years old)	INSEAD
52	Factors of production	Human capital	Years of education expectancy (years)	World Bank; UNESCO
53	Factors of production	Human capital	Tertiary school students (% of total students)	World Bank; UNESCO
54	Factors of production	Schools	Percent of educational establishments with Internet access	UNESCO; CEPAL
55	Factors of production	Schools	Students per computer ratio	UNESCO; ECLAC
56	Factors of production	Innovation capacity	USPTO patents per country of residence per 1,000,000 population	USPTO
57	Factors of production	Innovation capacity	Income for use of intellectual property (US$ per capita PPP at current prices)	World Bank
58	Factors of production	Innovation investment	R D expenditures (% del PIB)	World Bank; UNESCO
59	Factors of production	Economic development	GDP per capita (US$ current prices)	IMF
60	Factors of production	Economic development	Electricity consumption (kWh per capita)	World Bank
61	Institutional and regulatory	Cyber-security and piracy	Percent of non-licensed installed software	BSA, The software alliance
62	Institutional and regulatory	Cyber-security and piracy	Commercial value of non-licensed software (as percent of GDP)	BSA, The software alliance
63	Institutional and regulatory	Regulator role	Percent attributions of regulator per the ITU Regulatory Tracker	ITU; TAS
64	Institutional and regulatory	Regulator role	Percent characteristics of regulator per the ITU Regulatory Tracker	ITU; TAS
	–	–	Population	World Bank
	–	–	Exchange rate (at purchasing parity)	IMF
	–	–	Households	ITU
	–	–	GDP per capita of first quintile (US$ current prices)	IMF; World Bank

Appendix B

Economic Impact of Digital Ecosystem Development (General Model).

Fixed-effects (within) regression				Number of obs	=	803
Group variable: c_id				Number of groups	=	73
R-sq: within = 0.9046				Obs per group: min	=	11
between = 0.9990				avg	=	11.0
overall = 0.9947				max	=	11
				F(14,716)	=	484.86
corr(u_i, Xb) = 0.9642				Prob > F	=	0.0000

ln_gdp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_gdp_l1	.7542643	.0193734	38.93	0.000	.7162288	.7922997
year_1	(omitted)					
year_2	.0220071	.0248804	0.88	0.377	-.0268402	.0708545
year_3	.0280499	.0225407	1.24	0.214	-.0162039	.0723038
year_4	.0895782	.0196888	4.55	0.000	.0509235	.128233
year_5	.0750041	.0174797	4.29	0.000	.0406865	.1093218
year_6	-.0967154	.0157805	-6.13	0.000	-.127697	-.0657337
year_7	.0426844	.0137716	3.10	0.002	.0156469	.0697219
year_8	.0763276	.012822	5.95	0.000	.0511545	.1015008
year_9	-.011353	.0119646	-0.95	0.343	-.034843	.012137
year_10	.0140856	.0116167	1.21	0.226	-.0087213	.0368925
year_11	(omitted)					
year_12	-.1177838	.0118343	-10.12	0.000	-.1408277	-.0947399
ln_digit	.1331344	.0438029	3.04	0.002	.0471369	.2191319
ln_capital	.1042871	.0199475	5.23	0.000	.0651245	.1434497
ln_labor	.0093184	.0380491	0.24	0.807	-.0653827	.0840196
_cons	1.502778	.2090728	7.19	0.000	1.092309	1.913247

Economic Impact of Digital Ecosystem Development (OECD Countries Model).

Fixed-effects (within) regression				Number of obs	=	374
Group variable: c_id				Number of groups	=	34
R-sq: within = 0.8672				Obs per group: min	=	11
between = 0.9960				avg	=	11.0
overall = 0.9844				max	=	11
				F(14,326)	=	152.08
corr(u_i, Xb) = 0.9401				Prob > F	=	0.0000

ln_gdp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_gdp_l1	.6783111	.0311395	21.78	0.000	.6170515	.7395707
year_1	(omitted)					
year_2	.1157348	.0377071	3.07	0.002	.0415548	.1899147
year_3	.1193081	.0336154	3.55	0.000	.0531776	.1854385
year_4	.2020778	.0281165	7.19	0.000	.1467653	.2573904
year_5	.1767295	.024379	7.25	0.000	.1287695	.2246894
year_6	.0378854	.0215048	1.76	0.079	-.0044204	.0801912
year_7	.1514249	.0178737	8.47	0.000	.1162626	.1865873
year_8	.1975665	.0160296	12.33	0.000	.166032	.229101
year_9	.095351	.0138964	6.86	0.000	.0680131	.1226888
year_10	.1549708	.0129485	11.97	0.000	.1294977	.1804439
year_11	.1394513	.012735	10.95	0.000	.1143981	.1645045
year_12	(omitted)					
ln_digit	.1351212	.071142	1.90	0.058	-.0048342	.2750766
ln_capital	.2105272	.0290685	7.24	0.000	.1533416	.2677127
ln_labor	-.0735908	.0502148	-1.47	0.144	-.1723767	.0251952
_cons	2.337071	.3823111	6.11	0.000	1.584963	3.089179

Economic Impact of Digital Ecosystem Development (Non-OECD Countries Model).

Fixed-effects (within) regression — Number of obs = 429
Group variable: c_id — Number of groups = 39

R-sq: within = 0.9199 — Obs per group: min = 11
between = 0.9976 — avg = 11.0
overall = 0.9885 — max = 11

F(14,376) = 308.45
corr(u_i, Xb) = 0.9227 — Prob > F = 0.0000

ln_gdp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_gdp_l1	.7279424	.0293833	24.77	0.000	.6701662	.7857187
year_1	(omitted)					
year_2	(omitted)					
year_3	.0171324	.0187807	0.91	0.362	-.0197959	.0540607
year_4	.0727325	.0210137	3.46	0.001	.0314135	.1140515
year_5	.0860892	.0245139	3.51	0.000	.0378877	.1342907
year_6	-.0940308	.0278334	-3.38	0.001	-.1487594	-.0393022
year_7	.0619157	.0296088	2.09	0.037	.0036961	.1201352
year_8	.0902686	.0324808	2.78	0.006	.0264019	.1541353
year_9	.0303863	.0362968	0.84	0.403	-.0409838	.1017565
year_10	.0285809	.0384939	0.74	0.458	-.0471093	.1042712
year_11	.0168612	.0402625	0.42	0.676	-.0623067	.0960291
year_12	.0802976	.0419082	1.92	0.056	-.1627814	.0021863
ln_digit	.1043685	.0591983	1.76	0.079	-.0120327	.220769
ln_capital	.047127	.0279347	1.69	0.092	-.0078008	.1020548
ln_labor	.0580684	.0544011	1.07	0.286	-.0489002	.165037
_cons	1.682721	.2821058	5.96	0.000	1.128018	2.237424

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