

# The Latin American path towards digitization

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## Abstract

**Purpose** – Digitization is defined as the social transformation triggered by the massive adoption of digital technologies to generate, process, share and transact information. This paper seeks to present a methodology followed to calculate the Digitization Index, a concept originally developed by Booz & Company, the global management consulting firm, with the support of the authors.

**Design/methodology/approach** – This index consists of six elements capturing Ubiquity, Affordability, Reliability, Speed, Usability and Skill and 24 sub-indicators measuring tangible parameters of perceived digitization metrics.

**Findings** – The index indicates that countries are clustered as Digitally Constrained, Emerging, Transitional or Advanced, with varying degrees of contribution of digitization to economic growth. The Index is used to assess the situation of Latin American countries in terms of their progression to digitally advanced societies. In this context, the areas to focus on in the formulation of Latin America digital agenda are outlined.

**Originality/value** – Until now, most indices that measure progress towards this new era have focused primarily on metrics such as wireless telephony penetration, access to the internet and broadband adoption. The paper argues that these indices, even those that are more comprehensive in scope (Network Readiness Index by the World Economic Forum, or the Digital Opportunity Index by the International Telecommunication Union) capture only a portion of the ongoing transformations.

**Keywords** Broadband networks, Developing countries, Economic development, Government policy, Information society, Statistical analysis

**Paper type** Research paper

## 1. Introduction

Technological revolutions are marked by innovations that shape industrial production and drive long-term economic growth. The ongoing revolution, often called the “Digital Era”, builds on the advancements of information and communications technologies and shares common characteristics with other major leaps in recent history. Until now, most indices that measure progress towards this new era have focused primarily on metrics such as wireless telephony penetration, access to the internet and broadband adoption. We argue that these indices, even those that are more comprehensive in scope (Network Readiness Index by the World Economic Forum, or the Digital Opportunity Index by the International Telecommunication Union) capture only a portion of the ongoing transformations. In particular, the transition to digitally intensive societies is associated not only with technology adoption, but also with the use of these technologies (e.g. new applications and services), the quality and capacity of networks, and their affordability. Furthermore, as recent literature is indicating, full economic impact of ICT can only be fulfilled by tackling the complementarities between infrastructure deployment and skill development (Bresnahan *et al.*, 2002).

The Digitization Index represents an attempt to quantitatively measure cross-country progress along the digitization development path. This index consists of six elements and 24

indicators measuring tangible parameters of perceived digitization metrics, namely Ubiquity, Affordability, Reliability, Speed, Usability and Skill. This index allows for an initial ranking and, subsequently, a more meaningful clustering of national economies into different categories. Based on the total index score and the components' scores, countries are labeled as digitally Constrained, Emerging, Transitional or Advanced. The key identifiers of each category are explained in detail resulting in a suggestive policy approach on the necessary changes required for the advancement from one category to another.

After introducing the Digitization Index, the ranking of 184 countries around the world is provided (chapter 2). In this context, an in-depth view of the state of digitization among Latin American countries is presented (chapter 3). The objective is not only to understand how Latin American stands when compared with other regions of the world, but also to understand how the region has made progress over time, and underline the areas of policy focus going forward (chapter 4). In addition, the paper provides an assessment of digitization to economic growth. It reviews models developed to assess the economic impact of digitization, both at the general level, and within each country cluster (chapter 5). On this basis, the contribution of digitization to the economic development of Latin America is estimated (chapter 6).

## 2. The Digitization Index

The concept of digitization has principally been pioneered by Booz & Company, the global management consulting firm, through a number of research pieces (Friedrich *et al.*, 2011a; Friedrich *et al.*, 2011b; Raad, 2011). While most of the research literature measuring adoption of ICT focuses on discrete technology platforms, we argue that the holistic adoption and usage of information technology results in enhanced effects that go beyond the contribution of specific platforms[1]. Furthermore, to achieve a significant impact, digitization has to be widely adopted within the economic and social fabric of a given country. Along these lines, the Digitization Index quantifies the cumulative effect of adoption and usage of information and communication technologies, once they are widely utilized by individuals, economic enterprises and societies, embedded in processes of delivery of goods and services (e.g. eCommerce), and relied on to deliver public services (e.g. education, eHealth, eGovernment).

While the digitization process and the relevant policies are rarely orchestrated through a holistic framework (South Korea represents a classic case where *ex ante* pro-digitization policy outgrew local demand for these services), there are several milestones identified that accelerate or impede its progress. In particular, network access and the ubiquity of access media is perhaps, the first step towards achieving a basic level of digital infrastructure in a country. The existence of network equipment without wireless or wired infrastructure has limited meaning and use. Therefore ubiquity is the first component that allows individuals and enterprises to have universal access to digital services and applications.

Beyond the deployment of networks, subscribers never adopt a technology immediately. Mass adoption starts to appear once the technologies mature and access prices fall. This is frequently accelerated by mandates for network sharing, deployment of alternative platforms or the auctioning of spectrum bands. The concept of affordability is therefore crucial for the digitization process. The existence of affordable network links is the basis for launching new applications, services and pervasive information exchange.

Internet and mobile networks have been developed based on a series of protocols that guarantee a level of quality in the services provided on the application layer. Nevertheless most access media require vast investments to perform reliably. In terms of broadband access, national network links (undersea/transoceanic cables, city-level/country-level internet exchanges and backbone infrastructure) and "last mile" connections are crucial for the overall network performance. For mobile access, population and land coverage, as well as the quality of links between the base stations critically affect the service delivery. The concept of network reliability is considered a key element of the digitization process as it may hinder adoption and prevent the use of applications that depend on isochronicity, latency and lag.

Network throughput, or as usually mentioned, speed is by definition important for network access. Simple applications like voice and email usage require basic access speeds but others (multimedia and video applications, cloud services, etc.) depend on higher speeds. Effectively digitization should also be measured on network speeds.

Once the technical requirements are in place, affordable, ubiquitous, reliable and high-speed networks serve individuals and firms. The importance of this infrastructure derives from everyday activities and depends on the applications that people actually use. Services can provide information to active and passive users. For example, the user reviews posted at information portals represent a passive mode of information retrieval. Other services require active engagement, like blogging, social media, online shopping or e-government applications. All these parameters of digitization form the concept of usability. Mere existence of the networks and terminals (mobiles, tablets, laptops, readers, computers or servers) is just not enough. Usability transforms the “dummy binaries” into meaningful elements of our lives.

Lastly, people are key in shaping social transformations. The education level of each society, its beliefs and institutions have a significant effect on the online “culture” that it will create. While parts of the online elements are globalized, the applications that affect people are usually location specific and target majorities. Technical skill is therefore a crucial metric of the ability of individuals to incorporate digital services in their lives and businesses.

These six elements combined shape the adoption path to social digitization. They are composed of several subcomponents that allow to proxy their effects on each layer. A detailed analysis of the elements and the methodology followed to calculate the index follows (see Table I).

Affordability is calculated by the relative costs of all underlying infrastructures. In this context, fixed, mobile and broadband service charges are considered together with connection fees. Each of the components (fixed, mobile and broadband) is given equal weight to account for the sample heterogeneity and the varying adoption in different socio economic conditions.

Infrastructure reliability depends on the quality of the services provided. Initially two different metrics were utilized – faults per line and investment per telecom subscriber – as quality proxies. However, during the statistical validation of the index, the first component had to be eliminated[2] mainly because of the lack of an adequate number of observations. Therefore, this component is comprised of investment per telecom subscriber (in all types of networks). This metric is sensitive to front-loaded investment projects that materialize later in time; therefore it might exhibit higher values before societies actually receive the implied benefit.

Network access derives from the adoption of mobile and fixed broadband networks. While adoption is always lower than network coverage or access, telecommunications operators usually invest in areas where higher adoption is expected. Nevertheless, regulatory interventions may incentivize network coverage in rural or underutilized areas as a means of reducing the digital divide. To account for this phenomenon, overall mobile coverage is also used, coupled with PC ownership and mobile broadband penetration. These metrics correct the potential underestimation of mobile or fixed broadband adoption and reflect the actual network access in different socio-economic contexts[3].

The measurement of Network Capacity is based on two different sources: international network links and “last mile” network service offerings. International bandwidth is crucial in order to provide adequate throughput to remote sites. This metric controls for the common phenomenon of several emerging regions of the world that experience high connection speeds for local content and services only (usually through hybrid ethernet networks), while access to remote sites is constrained by either economic or technology bottlenecks.

Additionally, we account for the percent of connections that deliver higher than 2Mbps of service.

Usage is a key component of digitization. We utilize variables ranging from the percentage of online retail versus traditional retail commerce, e-Government services, the percent of

**Table I** Indicators, and sub-indicators of the Digitization Index

<i>Indicators</i>	<i>Components</i>	<i>Sub-components</i>
Affordability	Residential fixed line cost adjusted for GDP per capita	Residential fixed line tariff (three minute call to a fixed line at peak rate) adjusted for GDP per capita Residential fixed line connection fee adjusted for GDP per capita
	Mobile cellular cost adjusted for GDP per capita	Mobile cellular prepaid tariff (one minute call off-net at peak rate) adjusted for GDP/capita Mobile cellular prepaid one-time connection fee adjusted for GDP per capita
	Fixed broadband internet access cost adjusted for GDP per capita	Monthly residential price for a fixed broadband connection
Infrastructure reliability	Investment per telecom subscriber (mobile, broadband and fixed)	Mobile investment per telecom subscriber Broadband investment per telecom subscriber Fixed line investment per telecom subscriber
Network access	Network penetration	Fixed Broadband penetration per household Mobile phone penetration
	Other penetration metrics and coverage infrastructure	3G/4G Penetration Mobile broadband penetration PC population penetration Mobile cellular network coverage
Capacity	International internet bandwidth Broadband speed	International internet bandwidth (kbps/user) Broadband speed (Peak Mbps, Average Mbps)
Usage	Internet retail	Internet retail as percent of total retail
	e-Government	E-government web measure index
	Individuals using the internet	Percentage of individuals using the internet
Human capital	Non-voice services as percent of wireless ARPU	Non-voice (data, message, VAS) spending as percentage of wireless ARPU
	Social network visitors	Dominant social network unique visitors per month per capita
Human capital	SMS usage	SMS usage per subscriber
	Engineers	Engineers as a percentage of total population
	Skilled labor	Labor force with more than a secondary education as a percentage of the total labor force

Source: Adapted from Sabbag *et al.* (2012)

individuals that report some kind of internet usage (especially for countries that connections are not necessarily dedicated), social media adoption and usage (a metric that reflects both the social and the economic benefits realized primarily by advertising campaigns), SMS usage (a simple data proxy) and the percent of total mobile connection revenues per user that are dedicated to data services only. All these variables shed light in different usage patterns and help understand how these values range across a wide variation of income, educational and social contexts.

Human capital contributes to digitization and is affected by it. However, existing conditions or country fixed effects help shape the capacity, focus and speed of services that will be offered. This process depends both on the numbers of people that can offer them (proxied by technical staff or engineers) and by the qualities and skills of the people using them. Therefore in this metric we combine the impact of digitization on its suppliers and its target audience.

The various sources of data used to create the Digitization Index are included in Table II.

The Digitization Index has been constructed following a typical methodology for composite index validity assessment[4]. First the theoretical framework of the index is set up and the variables are selected. This includes all six components that describe the digitization process. Then a multivariate analysis is performed in order to analyze the underlying structure of the data. In particular the process helps choose the statistically valid

**Table II** Data sources of the indicators of the Digitization Index

Name of indicator	Description of indicator	Source
Affordability	Residential fixed line tariff (three minute call to a fixed line at peak rate) adjusted for GDP per capita Residential fixed line connection fee adjusted for GDP per capita Mobile cellular prepaid tariff (1 minute call off-net at peak rate) adjusted for GDP/capita Mobile cellular prepaid one-time connection fee adjusted for GDP per capita	ITU
Infrastructure reliability	Monthly residential price for a fixed broadband connection Mobile investment per telecom subscriber Broadband investment per telecom subscriber Fixed line investment per telecom subscriber	World Bank
Network access	Fixed Broadband penetration per household Mobile Phone penetration 3G/4G Penetration Mobile broadband penetration PC Population penetration	ITU Wireless Intelligence Wireless Intelligence
Capacity	Mobile cellular network coverage International internet bandwidth (kbps/user) Broadband speed (Peak Mbps, Average Mbps)	ITU Akamai
Usage	Internet retail as percent of total retail E-government Web measure index Percentage of individuals using the internet Non-voice (data, message, VAS) spending as percentage of wireless ARPU	Euromonitor UN ITU Wireless Intelligence
Human capital	Dominant Social Network Unique Visitors per month Per Capita SMS usage per subscriber Engineers as a percentage of total population Labor force with more than a secondary education as a percentage of the total labor force	Internet World Stats WCDM / Wireless Intelligence/ITU UNESCO World Bank

sub-indicators in each component that are both adequately different from each other and measure accurately the latent phenomenon. This process includes the principal components' and factor analysis of all components[5]. Data have been normalized (in the case of tariffs, adjusting by GDP per capita) to meet these criteria and allow for spatial and temporal comparisons. At this point, the second component of infrastructure reliability had to be dropped as it failed the factor analysis thresholds[6].

The Digitization Index has been calculated for 184 countries and all years between 2004 and 2011. The top 20 country scores are included in Table III (ranked for year 2011).

Norway tops the charts, in 2004, and since 2007. In 2005 and 2006 Korea was the leader due to its high performance in the affordability and the usage scores. A cluster of countries with similar scores follows Norway: Denmark, Switzerland, the UK, Luxemburg, Iceland and Finland. It is interesting to note that, when excluding the UK, countries with less than 8 million of population appear in the top-7. Then Sweden, Korea, Hong Kong, the US and Canada make another closely ranked cluster. Luxemburg has made a remarkable progress in this period because the country doubled its share of broadband connections with more than 2MB of speed and it significantly increased the international internet bandwidth per user. A mostly European cluster with Belgium, France, Portugal, Austria and Germany follows with Australia, Singapore and Japan in between.

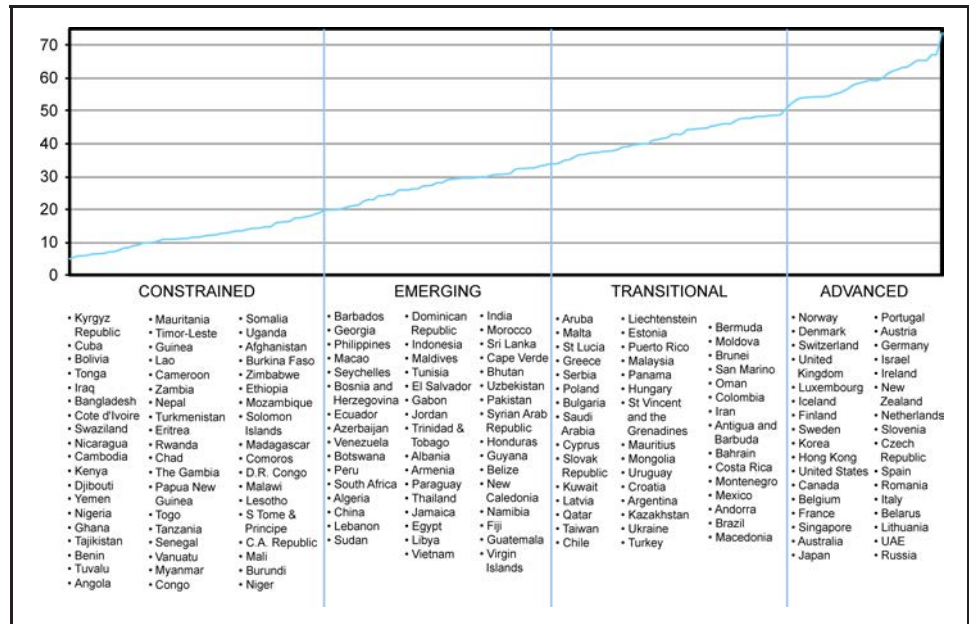
The calculation of the Digitization Index for 184 countries in 2011 reveals that countries tend to follow a development path that could be grouped into four phases. The high cluster includes Advanced countries, the medium Transitional, the low Emerging and the very low Constrained (see Figure 1).

*Constrained* economies – those with a digitization score below 20 – face challenges in realizing basic digitization building blocks such as widespread access and affordability. In these nations, services remain expensive and limited in reach.

**Table III** Top-20 countries of the Digitization Index

Ranking	Country	2004	2011
1	Norway	58.73	73.69
2	Denmark	52.66	67.46
3	Switzerland	50.34	67.08
4	The UK	50.54	65.52
5	Luxemburg	37.81	*65.38
6	Iceland	49.90	65.33
7	Finland	45.54	64.36
8	Sweden	51.08	63.39
9	Korea	58.38	63.21
10	Hong Kong, China	47.18	62.61
11	The USA	47.60	62.10
12	Canada	46.39	61.36
13	Belgium	47.75	60.11
14	France	43.61	59.33
15	Singapore	55.14	59.31
16	Australia	47.69	59.27
17	Japan	51.40	58.75
18	Portugal	38.73	58.39
19	Austria	43.49	57.91
20	Germany	43.33	56.88

Note: \*Computed out of five components

**Figure 1** Four clusters of Digitization (2011)

*Emerging* economies – those with a score between 20 and 35 – largely have addressed the affordability challenge and have achieved significant progress in providing affordable and widespread access. However, the reliability of services in emerging digitization nations remains below par and capacity is limited. Usability remains low, with online commerce constituting less than 0.5 percent of the total retail market.

*Transitional* is the next digitization stage, encompassing those countries with a digitization score in the range of 35 to 50. Countries in the transitional stage have addressed the reliability challenge, providing citizens with access to ubiquitous, affordable and reasonably



reliable services. Alongside, the jump in reliability, transitional countries show minor advances in the speed, usability and skill indices.

*Advanced* is the most mature stage of digitization, achieved with a score greater than 50. These countries have made significant strides in addressing ICT usability and developing a talent base to take advantage of available technologies, products, and services, while improving the speed and quality of digital services[7].

As expected, the average and range of level of digitization varies significantly by region (see Table IV). It is also striking that index variation is often higher within each region than across regions (Africa, Asia/Pacific).

The cross-country comparison of the Digitization Index allows drawing several key findings. Countries follow four states: constrained, emerging, transitional, and advanced. Digitization development varies markedly by region of the world. All OECD and middle-income countries have successfully addressed the access and affordability challenge, indicating that the digital divide, especially for middle-income countries, relies in tackling reliability and usage. The affordability and capacity components tend to rapidly drop at low GDP levels, indicating a big gap between mature and low-income countries.

### 3. The state of digitization in Latin America

Having introduced the concept of digitization and reviewed its overall development by continent, we will now turn to examine the situation in Latin America. As indicated in Table IV, Latin America and the Caribbean exhibit an average digitization index of 34.63. However, it is important to point out that the average masks a wide divergence across countries (see Table V).

As Table V indicates, there are no advanced digitization countries (>50) in the region, although Chile appears to be close to achieving that level. Furthermore, eight countries belong to the transitional category (35-50): Chile, Panama, Uruguay, Argentina, Colombia, Costa Rica, Mexico and Brazil in that order. Seven countries are placed in the emerging category (20-35): Ecuador, Venezuela, Peru, Dominican Republic, El Salvador, Paraguay and Honduras. Finally, three countries (Cuba, Bolivia and Nicaragua) pertain to the constrained category (<20).

Additionally, the digitization index across Latin American countries indicates a second level of country clustering within the transitional and emerging levels: a transitional “advanced”, and an emerging “advanced” levels. For example, within the emerging level, Venezuela, Ecuador, and Peru are on the verge of reaching the transitional stage, while the remaining countries remain at the lower end of the distribution. Each cluster of countries exhibits a fairly consistent score at the digitization component level (see Table VI).

The range of the scores by component provides a basis to determine the key challenges faced by each of the country clusters. The transitional “advanced” countries have

	<i>Number of countries</i>	<i>Index (average weighted by population)</i>	<i>Minimum</i>	<i>Maximum</i>
North America	3	62.02	39.85	62.10
Western Europe	20	58.51	39.14	73.69
Eastern Europe	20	44.88	29.19	54.55
East Asia and Pacific	22	32.85	10.29	63.21
Middle East and North Africa	22	30.83	15.76	56.05
Latin America and Caribbean	30	34.63	17.70	48.82
Sub-Saharan Africa	42	12.42	4.86	42.96
CIS and Russia	11	42.40	12.24	53.80
South Asia	14	24.63	7.91	29.67
Total	184	32.13	6.17	73.69

**Table V** Level of digitization (2011)

<i>Stage</i>	<i>Country</i>	<i>Index</i>
<i>Transitional</i>	Chile	45.33
	Panama	44.29
	Uruguay	42.78
	Argentina	41.32
	Colombia	38.33
	Costa Rica	37.33
<i>Emerging</i>	Mexico	37.05
	Brazil	36.61
	Ecuador	32.75
	Venezuela	32.60*
	Peru	32.20
	Dominican Republic	29.93
	El Salvador	29.56
	Paraguay	28.68
	Honduras	22.98*
<i>Constrained</i>	Cuba	19.87
	Bolivia	19.85*
	Nicaragua	17.70*

**Note:** \*Computed out of five rather than six components due to missing data

successfully tackled the affordability and, to some degree, the network access challenge. Affordability and network access scores for Chile, Panama, Argentina, and Uruguay are on the upper range indicating that prices (primarily wireless) have declined substantially and device adoption (again primarily wireless) has reached close to universal levels. On the other hand, hurdles for transitional “advanced” countries, as indicated by lower scores, remain primarily in the infrastructure reliability and human capital domains, and secondarily, within usage and network capacity. Moving to the next group, the emerging “advanced” countries urgently face challenges in infrastructure reliability, capacity, usage, and human capital. With the exception of affordability (which reflects the decline in wireless prices), the ranges in other sub-indicator scores are quite lower. Maybe the only exception in this regard is the human capital score, which would indicate no substantial differences between any of the countries in the transitional category. This analysis, extended to the other groupings provides a fairly targeted assessment of digitization development targets across the region (see Table VII).

As the targets in Table VII indicate, the two dominant imperatives across the region are infrastructure reliability and human capital. This would imply, first, that the level of investment in ICT in Latin America is not commensurate to the achievements in network access (e.g. penetration). This could mean that, unless investment is increased, network saturation will aggravate as a result of both penetration and usage. Additionally, human capital remains a persistent need to support the development of increasingly digitized societies.

It is important to mention that, while affordability appears to be a less important target overall it does not necessarily mean that pricing of all services is at affordable levels. Since the affordability component comprises pricing data for wireline, wireless, and broadband, affordable wireless tariffs have a positive impact on the overall value of the affordability component.

#### 4. Assessing the Latin American path to digitization

How fast is the Latin American region moving towards advanced stages of digitization? Is the rate of change similar to that of other emerging economies? Figure 2 shows the evolution of the average digitization index for all regions around the world.

As Figure 2 shows, Latin America has been increasing its level of digitization at a compound annual growth rate of 6.48 percent since 2004, a level comparable to East Asia and Pacific (5.63 percent) and Eastern Europe (7.84 percent). However, since 2010, digitization has increased dramatically in the region. At 10.42 percent growth year on year, Latin America is



**Table VI** Digitization sub-indicators by cluster (2011)

Cluster	Digitization index		Affordability		Infrastructure reliability		Network access		Capacity		Usage		Human capital	
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Transitional Advanced (Chile, Panama, Uruguay, Argentina)	41.32-45.33	43.43	87.00-91.09	88.92	5.76-15.96	11.21	51.13-56.67	52.93	30.06-47.74	42.26	39.55-48.19	44.08	12.09-26.88	21.16
Transitional (Colombia, Costa Rica, Mexico, Brazil)	36.61-38.33	37.33	85.96-91.62	88.25	5.50-9.08	7.47	37.91-49.86	42.92	29.73-37.53	34.29	31.05-34.11	32.70	9.82-26.45	18.36
Emerging Advanced (Ecuador, Venezuela, Peru)	32.20-32.75	32.52	73.33-90.71	79.66	1.64-9.30	5.17	42.55-47.05	45.16	6.30-28.46	15.03	23.43-42.23	31.62	19.74-35.68	27.71
Emerging (D. Republic, El Salvador, Paraguay, Honduras)	22.98-29.93	27.79	60.10-85.49	73.27	3.39-14.12	7.83	35.26-42.72	40.41	5.13-12.09	8.36	21.19-35.20	26.22	9.11-19.12	14.20
Constrained (Cuba, Bolivia, Nicaragua)	17.70-19.87	19.14	32.85-54.32	43.70	2.09-2.48	2.28	26.85-41.56	36.37	1.17-13.73	6.67	16.81-19.38	17.97	10.71-15.06	12.88

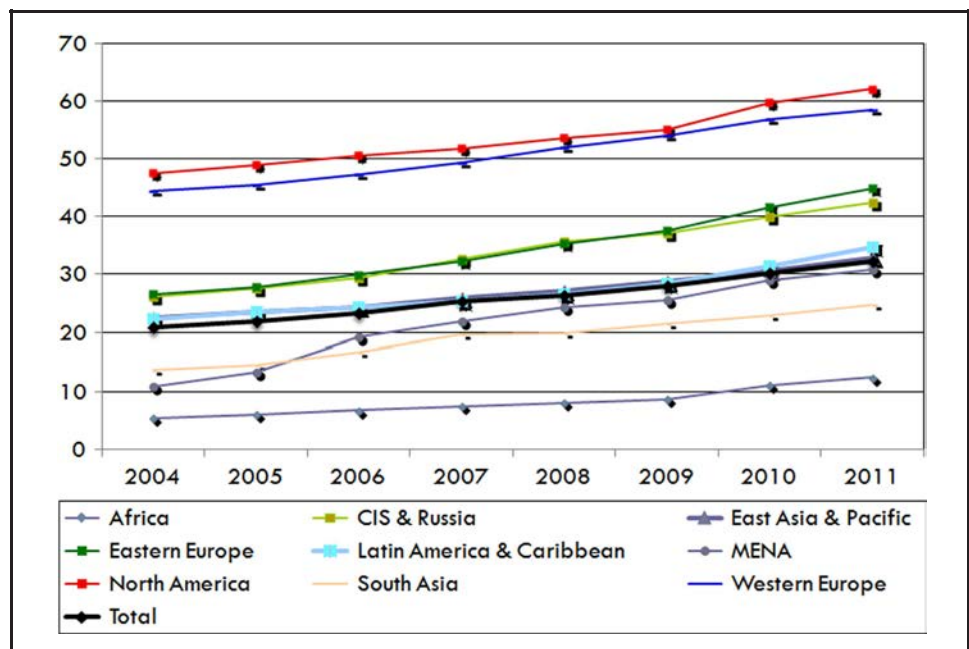
**Note:** The two values are the minimum and maximum

**Table VII** Digitization development targets by cluster

Cluster	Targets fulfilled (*)	Primary development targets (*)	Secondary development targets (*)
Transitional "Advanced" (Chile, Panama, Uruguay, Argentina)	Affordability Network access	Infrastructure reliability Human capital	Usage Network capacity
Transitional (Colombia, Costa Rica, Mexico, Brazil)	Affordability	Infrastructure reliability Human capital Network capacity	Network access Usage
Emerging "Advanced" (Ecuador, Venezuela, Peru)	Affordability	Infrastructure reliability Human capital Network capacity Usage	Network access
Emerging (D. Republic, El Salvador, Paraguay, Honduras)	Infrastructure reliability Human capital Network capacity Usage	Affordability Network access	
Constrained (Cuba, Bolivia, Nicaragua)	Affordability Infrastructure reliability Human capital Network capacity Usage Network access		

**Notes:** \*A "fulfilled target" is defined as an area where a developmental goal has been achieved as determined by the score in specific sub-indicator area. Similarly, primary and secondary targets are identified by the score in that particular sub-indicator. If the score is significantly low, that area has been highlighted as a primary target

**Figure 2** Regional Digitization Index (2004-2011)



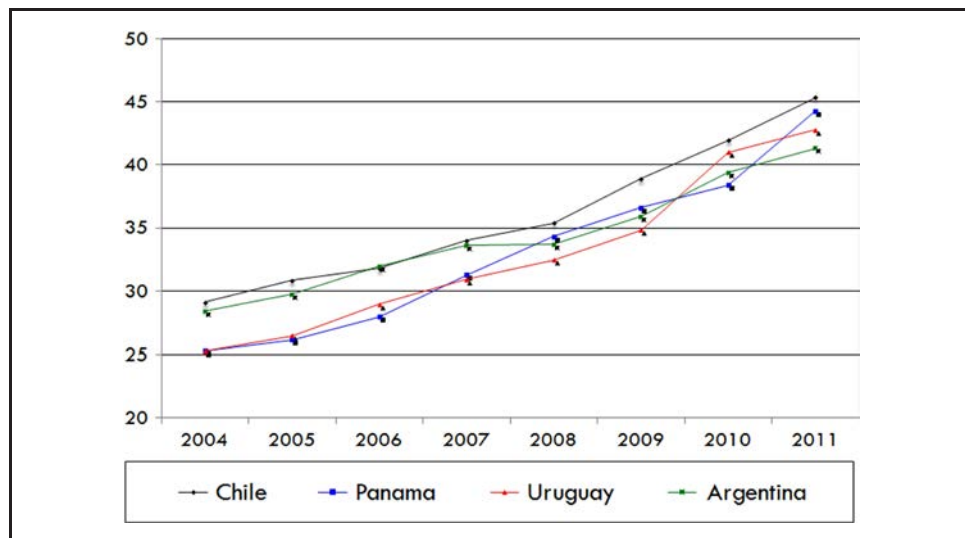
the second fastest growing region, behind Africa. However, even at that rate, given the starting base and growth rate of the developed world, it is apparent that, unless a dramatic change in policy initiatives is set in motion, the region will not be able to catch up with the developed world.

To determine potential policies that could be beneficial to the development of digitization in Latin America, we will now turn to assessing the impact of individual country experience and practices. For this purpose, it is necessary to examine the path followed by specific Latin American countries in reaching their current stage. Do all countries in the region follow a gradual, consistent developmental path toward digitization, or are there any idiosyncratic features (e.g. speed of digitization growth, leap-frogging) that can be linked to either structural variables (e.g. the composition of the economy, the level of economic development) or policy initiatives (e.g. the implementation of a national digital agenda)? In other words, are there any policy initiatives that have proven successful in furthering the development of digitization of countries in the region? In order to identify the initiatives, the 15 scores of the index for the period 2004-2011 for all Latin American countries were calculated.

At first view, the transitional countries in Latin America exhibit a consistent, yet gradual, change in levels of digitization (see Figure 3).

As Figure 3 indicates, all transitional countries have consistently increased their digitization level over the past eight years, following a convergent growth pattern. Along these lines, the rate of increase varies from country to country. For example, while Chile increased its index by ten points over the eight-year period, Panama and Uruguay witnessed a 15-point increase since 2004, and Argentina's index grew by approximately 15 points since that same year. Can these paths be linked to a specific policy initiative implemented in each country? Chile started focusing on the development of the country's digitization in 2007 with the launch of its first iteration of the Digital Agenda. The focused set of pro-digitization policies resulted in an acceleration of the index driven by device and service penetration, as well as the speed of broadband access. In the case of Uruguay, this country has been gradually increasing its digitization index, although a surge occurred in 2009 when the country deployed a direct data transmission link to the US, which increased international bandwidth ten-fold. This was coupled with the implementation of a massive broadband and ICT initiative, focused on the education sector. Argentina, on the other hand, benefits substantially from a significant improvement of the economy that took place after 2008, combined with an increase in broadband bandwidth, which yielded an augmentation of internet adoption. These variables were stimulated as well by the impact of the national broadband plan "Argentina Conectada". Finally, Panama achieved a substantial improvement in the affordability index due to a strong 16 decline of wireless prices. In 2010, Panama also benefitted from the deployment of an international data transmission link that almost doubled the capacity of other countries such as Argentina. To sum up, the two

**Figure 3** "Advanced" transitional countries: comparative evolution of digitization (2004-2011)



common levers that have substantially impacted digitization in “advanced” transitional countries are the formulation of a national digital/broadband agenda, and, in particular, the deployment of international transmission data links.

Turning now to the other transitional countries, the convergent trend is even clearer with the ramp-up of Colombia and Brazil (see Figure 4).

These countries have all increased their digitization index primarily driven by an improvement in the affordability index. For example, Colombia witnessed in 2004 a 50 percent reduction of the wireline installation fee, and a 75 percent decline of a pre-paid call prices. Driven by the elasticity of demand derived from this price decline, the digitization index jumped seven-points as a result of increasing adoption. This is why after 2005 the dominant improvement in Colombia registered in the network access component. Likewise, in Brazil, the improvement in digitization was driven by wireless price declines generated by enhanced competition, and the broadband price reduction as a result of the introduction of the “Popular Bandwidth Plan” prompted by the National Broadband Plan. In Costa Rica, the ramp-up in digitization occurred in 2011, when wireless market liberalization led to a significant increase in wireless broadband penetration. Mexico, on the other hand, did not show a significant change in the digitization components in this period, except for an important increase in broadband speed in 2010.

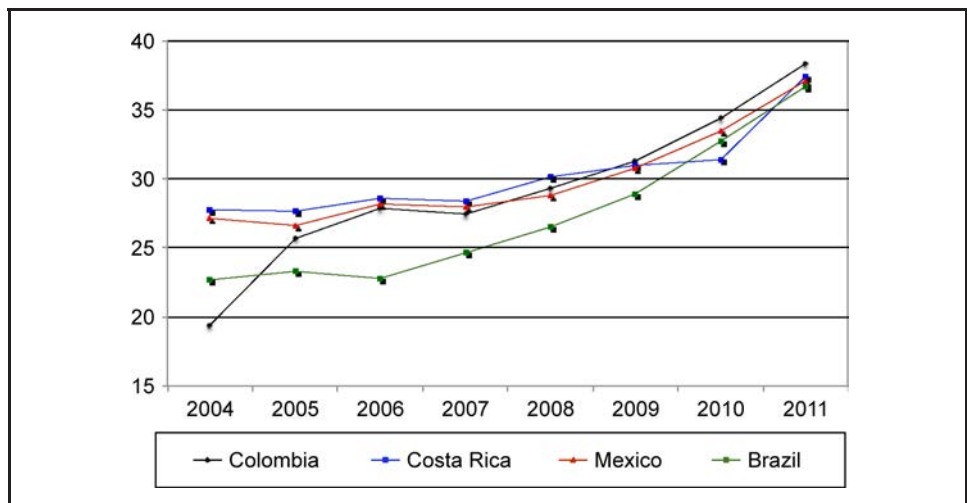
In the case of Emerging Digitization Countries, the convergence trend is also apparent, with one exception (see Figure 5).

The dominant factor in the improvement in digitization of emerging countries is the increase in network access driven by price reductions, combined with some country-specific factors. For example, Ecuador increased its index by 15 points in eight years as a result of price declines and an increase in international broadband capacity. Peru also registered a price decline, coupled with an increase in average broadband speeds. Similarly, Paraguay also exhibited a constant decrease in tariffs, although that was combined with an improvement in wireless non-voice usage. This was also the case of Venezuela. Honduras, on the other hand, improved its position mainly through an increase in wireless adoption, both voice and broadband.

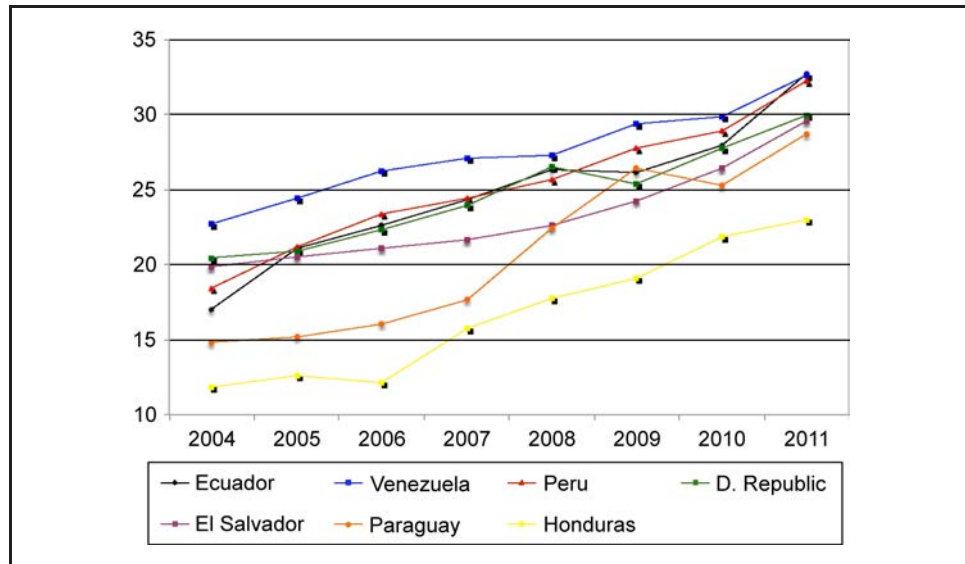
Convergence is also the trend in constrained Latin American countries (see Figure 6).

No common factor is driving the increase in digitization among constrained Latin America countries. For example, while Cuba has wireless coverage of 80 percent, service penetration is practically nil. On the other hand, Bolivia’s index has been improving as a result of the low tariffs of wireless broadband, while Nicaragua is improving digitization by virtue of wireless penetration.

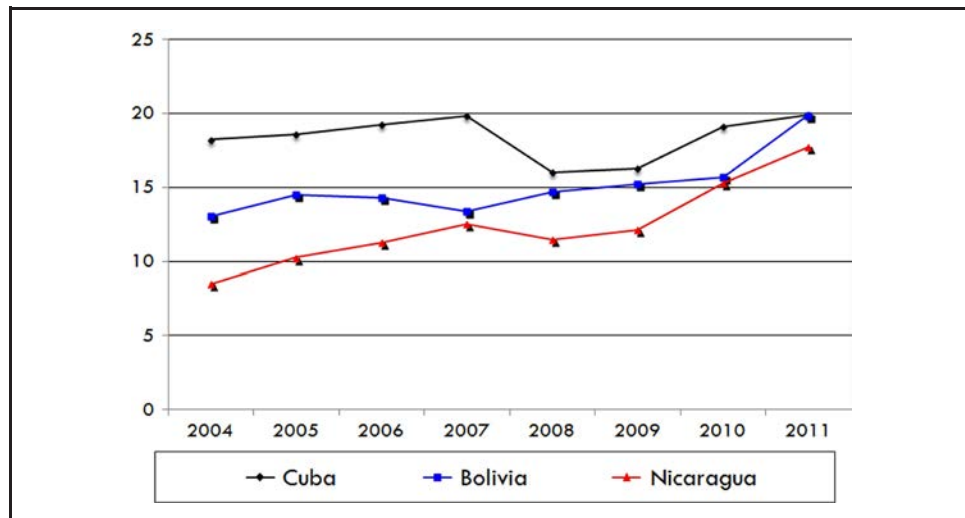
**Figure 4** Transitional countries: comparative evolution of digitization (2004-2011)



**Figure 5** Emerging countries: comparative evolution of digitization (2004-2011)



**Figure 6** Constrained countries: comparative evolution of digitization (2004-2011)



In conclusion, while all Latin American countries are increasing their digitization index, they appear to follow different paths to digitization. “Advanced” Transitional countries, having tackled the affordability and network access hurdles, continue progressing by emphasizing international connectivity and the implementation of national broadband/digital agendas/plans. The remaining transitional countries improve their digitization level primarily by emphasizing the affordability lever. Emerging countries are improving their digitization performance as a result of an increase in network access driven by price reductions, while digitally constrained countries are marginally improving through the increase of wireless adoption, a basic building block.

When it comes to rate of digitization growth, “advanced” transitional countries follow a gradual progression, albeit at a lower rate than other transitional countries. In general terms, more digitally advanced countries tend to grow their digital infrastructure at a rate slower than the less advanced countries, a convergence effect. For example, while transitional countries grew their digitization index by 6.81 percent between 2004 and 2011, emerging

grew at a Compound Annual Growth Rate (CAGR) of 7.83 percent[8]. However, as will be shown in the following, the economic contribution of digitization in countries with higher level of development is greater because of the structure of their economies.

Some Latin American countries, such as Panama, Uruguay, and Colombia undergo quantum leap changes (close to 20 points in eight years) in digitization triggered by specific policy initiatives, such as telecom market liberalization with spill-over impact on the ICT ecosystem, a combination of active government involvement and private sector participation, and centralized state planning. A second tier of fast growing digitization countries (15 points in eight years) includes Chile, Brazil, Ecuador, Peru, and Paraguay.

Data analysis indicates that the pace of digitization and movement between stages is accelerating at a rapid pace. Countries such as Chile, Panama, Uruguay and Argentina took nearly five years on average to move from the emerging to the transitional stage (between 2004 and 2009). If they continue growing at the same rate, they would be the first cluster of countries in the region to reach the advanced stage in 2014. On the other hand, of the countries that in 2004 had a constrained status, Colombia was the only one that leap-frogged to the transitional stage in 2011. Most of the other constrained countries could only move to the emerging stage (Ecuador, El Salvador, Paraguay, Peru and Honduras), and lastly some of them made no significant progress between 2004 and 2011 (Cuba, Bolivia and Nicaragua).

Overall, the rate of change of the index across countries indicates a gradual acceleration in the development of digitization in the region. Between 2004 and 2007, of the 18 Latin American countries under analysis only four moved one stage (from the constrained level to the emerging level); in the ensuing four-year period of 2007 to 2011, ten countries progressed to the next level of digitization development (eight from the emerging to the transitional, and two from the constrained to the emerging level). From 2004 to 2007, the average growth in the digitization score was four points. From 2007 through 2011, the average jump was eight points. Lastly, only Colombia experienced a two stage jump in the period from 2004 to 2011.

The acceleration stems from a number of factors. The region now can follow the path that developed nations already blazed, learning from their best practices. They also can take advantage of mature technologies and markets, and the resulting price reductions. Furthermore, the acceleration between stages may derive from increased market liberalization, growing affordability of technologies, growing availability of skills, and the government plans to develop ICT in the region. In sum, Latin America is moving toward higher stages of digitization at an ever-increasing pace.

## 5. Socio-economic impact of digitization

Similarly to what has been estimated for wireless telephony and broadband technology (Czernich *et al.*, 2011, Koutroumpis, 2009; Gruber and Koutroumpis, 2011; Katz, 2012; Katz and Koutroumpis, 2012), digitization is expected to have an impact on the economy. To test this hypothesis, an endogenous growth model that links Gross Domestic Product to the Fixed Stock of Capital, Labor Force and the Digitization index as a proxy of technology progress was constructed for 151 countries. This model for economic output stems from the simple Cobb-Douglas form[9]:  $Y = A(t)K^{1-b}L^b$  where  $A(t)$  represents the level of technology progress (in our case the Digitization Index),  $K$  corresponds to the fixed capital formation and  $L$  to the labor force.

$$\log(GDP_{it}) = a_1 \log(K_{it}) + a_2 \log(L_{it}) + a_3 \log(D_{it}) + \varepsilon_{it} \quad (1)$$

The causality tests[10] indicate that our estimates may be biased and for this purpose we use a lagged variable for Digitization. This change does not completely address the problem but helps mitigate its consequences on the estimated coefficients. The new formula is now:

$$\log(GDP_{it}) = a_1 \log(K_{it}) + a_2 \log(L_{it}) + a_3 \log(D_{it-1}) + \varepsilon_{it} \quad (2)$$

The index is a weighted average of different indicators that might be endogenous to GDP, like broadband and mobile penetration. However their impact on the metric – these two



metrics combined account for 5 percent of the index – seems insignificant. Additionally it is hard to find an instrument that could possibly control for this effect. Given the small effect we expect it has on GDP we extended the analysis controlling for country and year fixed effects to help mitigate potential problems and account for the heterogeneity of our sample (see Table VIII).

All variables in both models are significant at the 1 percent level. As expected, the capital formation is positive. Labor contribution to GDP is also consistent; quality is often crucial in this case but the overarching concept is largely accepted. The lagged Index is found to have a positive effect indicating a strong effect on economic output. Our calculations suggest that there is a measureable input from digitization on country level growth both on a direct level and indirectly. This is captured by the different components of the metric that help measure the existence of network infrastructure and their affordability to the use of social media and online retail performance[11].

From a quantitative standpoint this estimate is also valuable. According to the lagged model, a ten-point increase in the Digitization Index[12] has approximately a 2.84 percent impact on GDP for the period 2004-2011 resulting on an annualized effect of 0.40 percent[13]. These effects are higher than the ones found in earlier works for broadband penetration[14]. For example Koutroumpis (2009) estimated an annualized effect of 0.24 percent on GDP growth for a ten point increase in broadband adoption for a European sample between 2002-2007, while Katz *et al.* (2010) found a contribution of 0.23 percent for Germany, and Gruber and Koutroumpis (2011) found a 0.20 percent for wireless telephony for the period 1990-2007. We believe the higher impact results from the fact that Digitization is a rather holistic approach compared to previous works, as it allows to estimate the actual contribution on GDP from a combined infrastructure, capacity, skill, quality and usage point. This significant finding stipulates that the full economic impact of ICT is achieved through the cumulative adoption of all technologies, in addition to the assimilation and usage in the production and social fabric. Achieving broadband penetration is only one aspect of required policies; maximization of economic impact can only be achieved through a holistic set of policies ranging from telecoms to computing to adoption of internet and eCommerce. In a monetary equivalent, the impact of a ten-point increase is a €1.8 trillion added output on the world economy.

Given this estimate, one would be interested to explore whether economic contribution is also related to the level of digitization. This relates to the hypothesis of increasing returns to scale in network technologies as the new markets and spillover effects contribute to this phenomenon. The initial idea is that countries with lower scores are often the ones that lack basic access, skills and usage that would prevent them from experiencing important effects on their economies. For this purpose, the sample of 151 countries was broken into four different clusters. Four dummy variables were created (high, medium, low and very low) that take the value of 1 if the country is within the Digitization scores of interest or 0 if not. After that, the dummy variable was multiplied by the digitization index of each country, to see the differences within each group. For the advanced cluster the threshold is 50, for the transitional 35-50, for the emerging 20-35 and for the constrained 0-20.

**Table VIII** Economic impact of digitization

<i>GDP (GDP<sub>it</sub>)</i>	(1) <i>Model without lags</i>	(2) <i>Model with lags</i>
Fixed Capital Stock (Kit)	0.1632*	0.1598*
Labor (Lit)	0.1406*	0.1471*
Digitization Index (Dit-1)	0.0814*	0.0768*
Constant	18.23*	18.32*
Year effects	Yes	Yes
Country effects	Yes	Yes
Observations	783	652
R-squared	0.9051	0.9098

Note: \* Denotes statistical significance at the 1 percent level

Returning to the model used in equation (1), it is now transformed to account for this scalable approach. The new unlagged (3) and lagged (4) models are:

$$\log(GDP_{it}) = a_1 \log(K_{it}) + a_2 \log(L_{it}) + high^* \log(D_{it}) + med^* \log(D_{it}) + low^* \log(D_{it}) + vlow^* \log(D_{it}) + \varepsilon_{it} \quad (3)$$

$$\log(GDP_{it}) = a_1 \log(K_{it}) + a_2 \log(L_{it}) + high^* \log(D_{it-1}) + med^* \log(D_{it-1}) + low^* \log(D_{it-1}) + vlow^* \log(D_{it-1}) + \varepsilon_{it} \quad (4)$$

The results presented in Table IX are a partial confirmation of the increasing returns hypothesis, although they might also indicate that decreasing returns start to emerge at the transitional level of digitization (in the model without lags, the presumed saturation point emerges at the advanced level). The advanced and transitional countries' cluster have a less pronounced effect on economic output compared to the constrained and emerging groups. In particular, Transitional and Emerging stages are very closely tied and rather distinct from the constrained clusters. Evidently, there is still considerable heterogeneity within these clusters that might have an impact on the results. Nevertheless, a picture starts to emerge from a macro perspective: there might be a scalable approach in this process and the returns appear to be largely increasing after a digitization score in the region of 20, with a saturation point emerging at around 35.

From a quantitative standpoint this estimate is also valuable. According to the lagged model, ten-point increase in the Digitization Index has the following impact:

- *Advanced*: 2.26 percent compound impact on GDP for the period 2004-2011 results on an annualized effect of 0.32 percent.
- *Transitional*: 2.59 percent compound impact on GDP for the period 2004-2011 results on an annualized effect of 0.37 percent.
- *Constrained*: 2.66 percent compound impact on GDP for the period 2004-2011 yields an annualized effect of 0.37 percent.
- *Emerging*: 2.44 percent compound impact on GDP for the period 2004-2010 leads to an annualized effect of 0.34 percent.

These results are reflecting changes in the complementarity of factors, as measured by the sub-indicators. As such, a potential additional research could tackle the specification of independent estimates of individual sub-indicators.

By relying on the coefficients calculated for the worldwide sample, the impact of digitization on the Latin American economies has been quantified. Between 2008 and 2011, the Latin American region (17 countries considered) grew USD 1.289 trillion (the difference at current USD between 4.199 trillion and 5.488). At the same time, the growth in digitization in Latin

**Table IX** Estimates on the scalable economic impact of digitization

<i>GDP (GDP<sub>it</sub>)</i>	(3) <i>Model without lags</i>	(4) <i>Model with lags</i>
Fixed Capital Stock (Kit)	0.1595*	0.1564*
Labor (Lit)	0.1338*	0.1437*
Digitization (Dit-1)		
High (Advanced)	0.0681*	0.0612*
Medium (Transitional)	0.0777*	0.0699*
Low (Emerging)	0.0774*	0.0718*
Very low (Constrained)	0.0751*	0.0658*
Constant	18.28*	18.28*
Year effects	Yes	Yes
Country effects	Yes	Yes
Observations	783	652
R-squared within	0.9036	0.9077

Note: \* Denotes statistical significance at the 1 percent level

American economies contributed to an increase of USD 105 billion. As a result, it is estimated that the share of growth in the GDP that can be attributed to digitization is 8.13 percent. For the period between 2010 and 2011, the share of GDP growth is 6.66 percent. These estimates represent a strong evidence of the economic relevance of digitization and the importance of adopting strong pro-digitization policies in the region.

## 6. Conclusion

To sum up, the digitization index represents a powerful instrument to measure not only the deployment and adoption of information technologies in a discrete fashion, but to incorporate usage processes, representing the holistic dimension of impact. Along these lines, the Latin American region appears to be moving relatively fast in terms of increasing its level of digitization. However, as mentioned previously, the aggregate regional rate masks a substantial divergence across countries, with some on the verge of attaining “advanced” status (Chile, Panama, Argentina and Uruguay, in particular), while others remain well below the transitional status. At the same time, the analysis indicates the importance of adopting prodigitization policies for leap-frogging developmental stages. As an example, Colombia propelled itself from a constrained status in 2004 to transitional in 2011, increasing 19 points in eight years.

Second, the challenges facing each cluster of countries are of a different nature. The transitional “advanced” countries have successfully tackled the affordability (primarily wireless, less so in broadband) and, to some degree, the network access challenge. Hurdles remain primarily in the infrastructure reliability and human capital domains, and secondarily, within usage and network capacity. On the other hand, the emerging “advanced” countries urgently face challenges in infrastructure reliability, capacity, usage, and human capital, while emerging countries need to focus on all levers of digitization.

Third, the index also allows the identification of specific developmental paths towards digitization. In this context, some countries exhibit a higher rate of digitization change than the rest of the region. In particular, Argentina, Chile, Colombia, Panama, and Uruguay appear to be the regional “fast movers”. The speed of change in all of these countries is driven by the adoption of specific pro-digitization policies.

Fourth, digitization appears to have a higher contribution to economic growth than discrete technologies. This points out to a multiplying factor that captures the enhanced impact of a developed technology eco-system. The econometric models allow the estimation of the economic contribution of digitization. In the case of Latin America, it is estimated that the share of growth in the GDP between 2008 and 2011 that can be attributed to digitization is 8.13 percent.

The public policy implications of these findings for Latin America are several. First, the enhanced impact of digitization *vis-à-vis* broadband requires tackling the formulation of ICT policies in a comprehensive and holistic manner, covering all areas of the eco-system. This drives the need to insert broadband planning within the larger ICT infrastructure and usage context provided by digital agendas. Second, digitization policies need to initially focus on affordability (for example, achieve broadband monthly fee/GDP per capita <0.12), and access (targeting, as minimum, 22 percent broadband penetration, at least 70 + percent of population using a PC, and 40 percent penetration of broadband wireless). However, policies need to complement the deployment of networks, by emphasizing usage, targeting to reach 15 percent of eCommerce transactions/retail, an eGovernment web measurement index higher than 30, and internet adoption higher than 30 percent. Fourth, countries that aim at achieving a quantum leap in digitization (20 points rise of the index in five years) need to combine four levers: telecom market liberalization with spill-over impact on eco-system, usage promotion policies, a combination of active government involvement and private sector participation, and centralized convergent state planning. Fifth, digitization promotion policies need to be combined with industrial sector related policies aimed at generating the spill-over ICT impact on economic growth and job creation.

## Notes

1. Perhaps a good analogy to this hypothesis is the case of the first and second Industrial Revolutions, where dramatic productivity improvements resulted from the combined effects of deployment of transportation infrastructure (roads, canals), the introduction of first steam and then internal combustion engines, the commoditization of energy, and changes in manufacturing processes.
2. The factor analysis is explained in the next section.
3. For example, in Senegal mobile penetration was almost 80 percent in 2011 and fixed broadband access less than 1 percent. Nevertheless, mobile broadband coverage exceeds 30 percent, almost 30 times higher than actual broadband usage. Therefore the network access is already there but the adoption metrics fail to reflect it. On the other hand, fixed broadband coverage is almost impossible to measure. This is why fixed broadband adoption is used as a proxy of this variable (see Katz and Koutroumpis, 2012).
4. See the OECD Handbook for constructing composite indicators by Nardo *et al.* (2005).
5. Kaiser criterion and Cronbach coefficient alpha.
6. Two tests were performed to assess the adequacy of the sample: the Cronbach Alpha is 0.74 and the KMO statistic 0.75 (all subcomponents above 0.71), allowing us to proceed with the subsequent analysis of the index. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is a statistic for comparing the magnitudes of the observed correlation coefficients to the magnitudes of the partial correlation coefficients. The concept is that the partial correlations should not be very large if one is to expect distinct factors to emerge from the factor analysis. A KMO statistic is computed for each individual sub-indicator, and their sum is the overall KMO statistic. This statistic varies from 0 to 1.0, and should be 0.60 or higher to proceed with factor analysis though realistically it should exceed 0.80 if the results of the principal component analysis are to be reliable. If not, it is recommended to drop the sub-indicators with the lowest individual KMO statistic values, until results rise above 0.60.
7. The differences across groupings are useful in establishing stages along a developmental path in the aggregate.
8. The digitization index for constrained countries grew at 6.19%, since they are confronted with very basic problems such as increasing wireless penetration.
9. In addition, country and year fixed effects were used.
10. To test for inverse causality, the model was rerun by switching GDP and the Digitization Index with the results indicating a potential reverse causality. In addition, the model was tested through a Granger Causality Test, which did not allow to discard the reverse causality.
11. Given that the digitization index is a proxy for technological progress, and considering some of the indicators used to construct the digitization index, we tested for the presence of collinearity between the index and the other covariates, relying on the variance decomposition proportions in Belsey *et al.* (1990). The test for collinearity indicates that our sample lies well below the threshold suggested by the literature. In particular our model has a condition number of 20.44, whereas the concern levels, according to Belsey *et al.* start with condition numbers above 30.
12. A ten-point increase would generate a growth of the digitization index from an average value of 27 to 37. The 37 percent increase by the impact effect of 0.0768 generates a 2.84 percent impact on GDP.
13. We use as a base case of an "average" country whose Digitization Index increased by ten points.
14. Annual Growth Rate (CAGR) attributed to digitization derives from formula (1):

$$CAGR = \left[ \left( \frac{\frac{Digitization_{2011} - Digitization_{2004}}{100 - Digitization_{2011}}}{\frac{Digitization_{2011}}{100 - Digitization_{2011}}} \right)^* \hat{a}_3 + 1 \right]^{1/7}$$

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