Broadband in Latin America

Beyond Connectivity

Valeria Jordán
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Wilson Peres
Editors

UNITED NATIONS

ECLAC

IDRC CRDI

@LIS2 - Alliance for the Information Society in Latin America and the Caribbean, phase 2

inclusion innovation development

Programme financed by the European Union

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Economic Commission for Latin America and the Caribbean (ECLAC)
Santiago, Chile, December 2013

Libros de la CEPAL

120

The preparation of this document was coordinated by Valeria Jordán and Wilson Peres, of the Economic Commission for Latin America and the Caribbean (ECLAC), and Hernán Galperin, from the Regional Dialogue on the Information Society (DIRSI), in the framework of the project "Inclusive political dialogue and exchange of experiences", under the Alliance for the Information Society programme phase 2 (@LIS2), which is jointly financed by ECLAC and the European Union and implemented by the Division of Production, Productivity and Management of ECLAC.

The opinions expressed in this document, which has not undergone editorial review, are the sole responsibility of the authors and may not coincide with the views of the United Nations.

This document was produced with the financial assistance of the European Union. The opinions expressed herein do not necessarily reflect the official opinion of the European Union.

This work was conducted with the help of a grant from the International Development Research Centre, Ottawa, Canada.

This document may be downloaded at www.cepal.org/Socinfo.

United Nations publication
ISBN: 978-92-1-121836-7 • 978-92-1-056012-2
LC/G.2583-P
Sales No. E.14.II.G.7

Printed at United Nations, Santiago, Chile • 2013-644

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Foreword

In November 2010, the editors of this book published *Fast-tracking the digital revolution: Broadband for Latin America and the Caribbean*, which put forth that broadband is the cornerstone of a system for economic, organizational and social innovation that, in conjunction with complementary assets (infrastructure, skills, production structure), was driving a positive dynamic across all economic and social sectors.

They noted that achieving that synergy called for a new policy approach with a comprehensive, flexible, long-term view combining the objectives of greater productivity, innovation, social inclusion and sustainability. This approach needed for the State to play an active role, building capacities that would enable it to design instruments and coordinate actions for addressing the challenges of the information society.

The editors saw that technological change was gathering momentum, particularly in information and communication technologies (ICTs). Their judgment was borne out by the growing penetration of 3G telephony among the population, expanding access to broadband and the spread of new technologies, such as cloud computing and big data analytics. There was a clear need to step up efforts in order to meet the demands of a hyperconnected world.

The countries of Latin America and the Caribbean have responded to this call. The region's public and private sectors have boosted investment in the infrastructure needed to deploy new networks and in programmes which encourage broadband use by individuals and businesses.

Despite this progress, the efforts have not been enough. Although access to fixed and mobile broadband has expanded, the digital divide with the advanced countries is still far from closed. And broadband use is concentrated in applications for personal use and basic ICTs for business. The impact on productivity is, therefore, low.

There are still significant economic, territorial and gender disparities in terms of access, and bridging these gaps is going too slowly. Digital policies currently in force do not attach due importance to making infrastructure building and mass uptake of broadband part of national industrial policy strategies.

This is crucial, because the structural change advocated by the Economic Commission for Latin America and the Caribbean (ECLAC) depends on a close link between digital strategies, broadband development and sectoral industrial policy design. Only then will it be possible to make significant strides towards a new, more knowledge-intensive production structure that can generate the high-quality jobs needed for making steady progress towards greater equality and more sustainable economic and social development.

This publication, the result of a joint effort by the Regional Dialogue on the Information Society (DIRSI) and the Division of Production, Productivity and Management of ECLAC, was undertaken as part of a research and policy proposal programme on issues relating to the information society. ECLAC has been working on this effort since 2009, with financial support from the European Union through the Inclusive Political Dialogue and Exchange of Experiences Project of the @LIS2 Programme (Alliance for the Information Society phase 2).

DIRSI and ECLAC have made this publication available to governments and citizens of the countries of the region in an effort to provide an overview of the latest broadband developments in Latin America and of the new economic and social challenges and opportunities coming from ever faster technological change.

Alicia Bárcena
Executive Secretary
Economic Commission for Latin
America and the Caribbean (ECLAC)

Chapter IV

Broadband, digitization and development

Raúl L. Katz[1]

A. Broadband and economic growth

This chapter presents the findings of a series of studies conducted since 2009 on the contribution of broadband to development in Latin America.[2] A first set of results focuses on measuring the economic impact of broadband on GDP growth, job creation and increases in average household income. A second set evaluates the contribution of broadband in terms of applications, services and content by means of a digitization index that measures both technology adoption in a country and the use of services associated with it —for example, e-government, e-commerce and social networking. On the basis of these findings, policy recommendations aimed at maximizing broadband's economic impact are proposed.

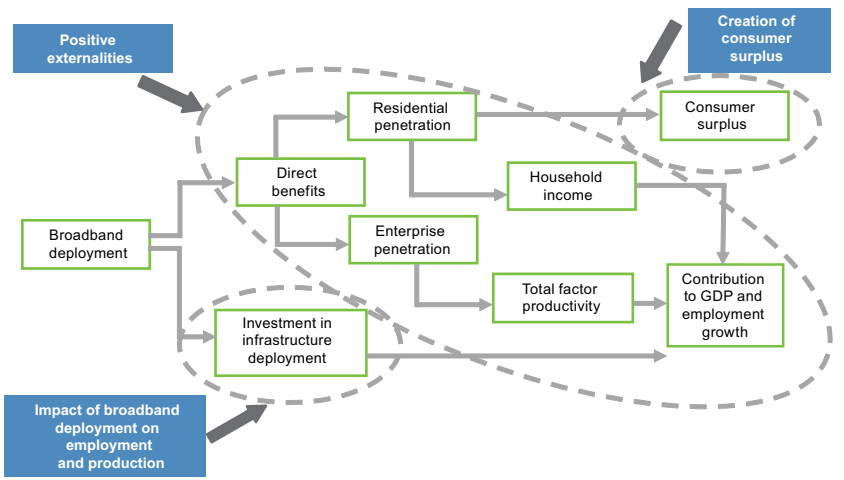
Broadband, as a general purpose technology, contributes to economic growth through a number of effects (see diagram IV.1). First, the deployment of telecommunications networks yields effects similar

[1] Raúl L. Katz is an adjunct professor in the Finance and Economics Division at Columbia Business School and Director of Business Strategy Research at Columbia Institute for Tele-Information. He is also president of Telecom Advisory Services, LLC.

[2] The studies were conducted within the framework of research programmes undertaken for ECLAC, the International Telecommunication Union (ITU), the World Economic Forum, the Governments of Colombia and Costa Rica, and associations of telecommunications operators.

to those generated by any infrastructure project: broadband deployment creates jobs and impacts the economy as a whole through multiplier effects. Second, broadband use has a spillover effect on the entire economic system, which is felt by both businesses and residential users. On one hand, the use of broadband by the production sector results in increased productivity, thereby helping to raise GDP. On the other, its residential adoption increases real household income, reducing poverty and contributing, in turn, to economic growth.

Diagram IV.1
ECONOMIC IMPACT OF BROADBAND



Source: Prepared by the author.

Beyond these effects, residential users who purchase broadband benefit in terms of consumer surplus, which is the difference between what consumers are willing to pay for the service and the market price. This effect, though not included in the calculation of GDP, is important because it represents an improvement in access to information, entertainment and public services.

The following three sections describe the findings of the author's studies in Latin America to date. The first presents a model for measuring the impact of broadband on GDP growth in the region as a whole, followed by disaggregated results for Colombia and Panama. The second section contains measurements of the impact of broadband on job creation in Chile, Colombia and the Dominican Republic. The last section presents the findings of studies assessing the impact of broadband on the increase in average household income in Costa Rica and Colombia.

1. GDP growth

The first analysis of the economic impact of broadband in Latin America was conducted by Katz (2011a) on the basis of a cross-sample of countries. In the absence of time series, the analysis employed the ordinary least squares method, using a sample of pooled data for the years 2004 and 2009. Two methodological problems arose in this analysis. First, as panel data could not be used, it was not possible to isolate the characteristics of each country in the model results, which could have created a problem of "omitted variable". This problem was mitigated, however, by including variables such as broadband development and degree of economic openness in the model. The second problem with this type of model stems from endogeneity between growth of GDP per capita and broadband penetration. Ideally, it would be possible to build a multiple-structure model based on simultaneous equations in order to endogenize the development of broadband as a function of per capita GDP, prices, competition and degree of telecommunications industry regulation. Again, lack of data did not allow the construction of such a model at the time. The solution was to lag the variable "development of broadband" by one year. With these caveats, the model generated the results shown in table IV.1.

Table IV.1
LATIN AMERICA: CONTRIBUTION OF BROADBAND TO GDP GROWTH

GDP growth	Coefficient	Standard error	t-statistic	P>[t]	95% confidence interval	
Growth in broadband penetration for 2001-2003 and 2004-2006	0.0158715	0.0080104	1.98	0.054	-0.0002942	0.0320372
Average investment/ GDP for 2004-006 and 2007-2009	-0.0471624	0.1689699	-0.28	0.782	-0.3881575	0.2938328
Population growth in 2004-2006 and 2007-2009	-0.4469177	1.40418	-0.32	0.752	-3.280668	2.386832
Higher education (2002)	0.2139614	0.1108325	1.93	0.060	-0.0097076	0.4376304
Per capita GDP at the start of 2003 and 2006	-0.0006957	0.0001806	-3.85	0.000	-0.0010602	-0.0003313
Average globalization rate for 2001-2003 and 2004-2006	-0.0653024	0.1929498	-0.34	0.737	-0.4546908	0.324086
Constant	13.02883	12.04659	1.08	0.286	-11.28217	37.33982

Table IV.1 (concluded)

Number of observations	49
F(6,42)	7.18
Prob>F	0.0000
R^2	0.3814
Root MSE	7.024

Source: R. Katz, "The impact of broadband on economic growth", *Fast-tracking the digital revolution: Broadband for Latin America and the Caribbean* (LC/R.2167), V. Jordán, H Galperin and W Peres, Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2011.

The results show that, when controlling for education level and initial per capita GDP level, a 1% increase in broadband penetration raises GDP by 0.0158%. The broadband penetration coefficient is positive in sign and statistically significant. This finding is consistent with the result generated by Koutroumpis (2009) in a study of OECD countries, in which, using a simultaneous equations model, showed that in countries where broadband penetration averaged under 14%, a 1% increase in penetration contributed 0.008% to GDP growth.

In 2011, increased availability of disaggregated data made it possible to conduct studies at the national level. The first one was carried out in Colombia with department-level data for 2006-2010 (Katz and Callorda, 2011). This study analyses the impact of fixed broadband on departmental GDP growth, controlling for initial level of economic development, population growth and human capital level (average years of education) (see table IV.2).

Table IV.2
COLOMBIA: CONTRIBUTION OF BROADBAND TO GDP GROWTH

	Total	Low penetration	High penetration
Growth in broadband access (percentage)	0.0036542*** (0.001282)	0.0039548*** (0.0014167)	0.0039453*** (0.0012952)
Population growth (percentage)	0.8734808 (0.9599308)	-0.7848735 (1.019278)	4.585921** (1.948842)
Years of education	-3.538593 (5.127222)	-1.878803 (11.28887)	3.668626 (3.831199)
GDP in 2003 (millions of pesos)	0.0056116 (0.0284458)	-0.2697321 (0.3899207)	-0.0432453* (0.0360005)
Adjusted R^2	0.1649	0.2088	0.2093
Prob > F	0.0103	0.0778	0.0086
Number of observations	132	64	68

Source: R. Katz and F. Callorda, Medición de Impacto del Plan Vive Digital en Colombia y de la Masificación de Internet en la Estrategia de Gobierno en Línea, Bogota, Centro de Investigación de la Telecomunicaciones (CINTEL), 2011.
Note: The robustness of the model was evaluated on the basis of tests of independence between variables, normality and covariance. In addition, the analysis was extended by performing the Doornik-Hansen multivariate normality test. In all cases, the validity of the impact estimation models was found to be over 99%. ***, ** and * indicate significance levels of 1%, 10% and 15%, respectively.

The model shows that an increase in broadband connections has a positive effect on GDP growth: if connections increased 10%, GDP would increase 0.037%. This effect is less than was found in the model for the region as a whole, mainly because the average rate of broadband penetration in Colombia is below the average for Latin America. This suggests the existence of a returns to scale effect —i.e. economic impact increases with higher levels of penetration.

Growth of broadband connections is the only independent variable that is significant in explaining the growth of GDP in all specifications, both for departments with high penetration and for departments with low penetration (columns 3 and 4). The coefficients for departments with high and low penetration are similar because in no case was penetration more than 20% (hence, by international standards, all departments have low penetration). The model explains between 15% and 20% of the variance in the dependent variable, indicating that there are other factors affecting the evolution of GDP.[3] Nevertheless, the coefficient for impact of broadband growth is significant and consistent in all specifications.

For Panama, as more information was available, Katz and Koutroumpis (2012a) used a multiple-structure model originally developed by Roller and Waverman (2001) for fixed-line telephony and subsequently adapted by Koutroumpis (2009) for broadband and by Gruber and Koutroumpis (2011) for mobile telephony. The model comprises four equations: a production function, which models the aggregate operation of the economy, and demand, supply and output functions, which model the broadband market, controlling for reverse causality.

In the aggregate production function, GDP is linked to the stock of fixed capital (excluding ICT infrastructure), the supply of skilled labour and fixed broadband infrastructure, proxied by broadband penetration. The demand function links broadband penetration to the price of basic service —the number of subscribers depending on the price of broadband access— and average individual consumption estimated on the basis of GDP per capita. The supply function links aggregate broadband sales revenues to broadband price levels, GDP per capita and degree of urbanization in the country. To the extent that fixed broadband deployment is correlated with greater urban population concentration, the supply of the service should reflect this structural variable. The output equation links the annual change in fixed broadband penetration with broadband sales revenue, and this change is used as an indicator of annual capital investment in broadband.[4]

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[3] Lack of department-level data for these variables prevents their inclusion in the regression model.

[4] This assumes a stable and constant relationship between sales and investment, which often does not occur. Information on fixed capital formation in telecommunications, which would be a more appropriate variable, was not available.

Based on these models (see table IV.3), fixed broadband infrastructure had a significant impact on growth between 2000 and 2010. Its average annual contribution to GDP growth was estimated at 0.045% for every 1% increase in penetration.

Table IV.3
PANAMA: CONTRIBUTION OF BROADBAND TO GDP GROWTH

Aggregate production function:

$$GDP_{it}=a_1K_{it}+a_2L_{it}+a_3BB\_Pen_{it}+\mathcal{E}_{1it} \quad (1)$$

Demand function:

$$BB\_Pen_{it}=b_1BBPr_{it}+b_2GDPC_{it}+\mathcal{E}_{2it} \quad (2)$$

Supply function:

$$BB\_Rev_{it}=c_1GDPC_{it}+c_2Urb_{it}+\mathcal{E}_{3it} \quad (3)$$

Output function:

$$\Delta BB\_Pen_{it}=d_1BB\_Rev_{it}+\mathcal{E}_{4it} \quad (4)$$

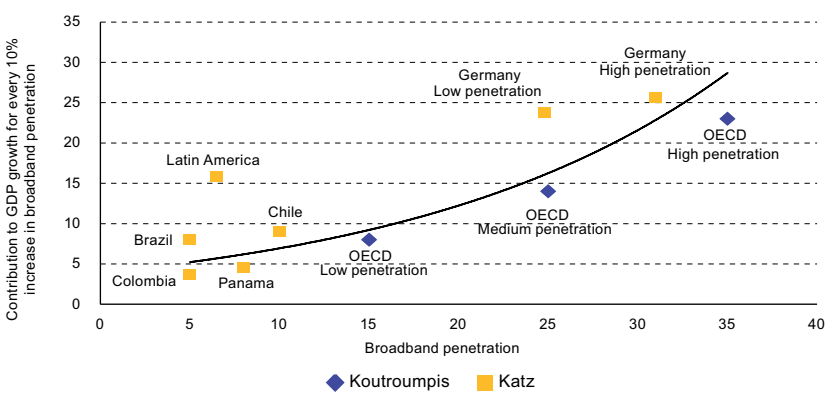
Variables	Fixed broadband model
Growth (GDP_{it})	
Labour force with secondary education (L_{it})	1.148***
Fixed capital stock (K_{it})	0.234***
Fixed broadband penetration (BB_Pen_{it})	0.045***
Constant	-
Demand (BB_Pen_{it})	
Fixed broadband price ($BBPr_{it}$)	-2.121***
GDP per capita ($GDPC_{it}$)	2.443***
Constant	-18.536**
Supply (BB_Rev_{it})	
GDP per capita ($GDPC_{it}$)	0.556***
Urbanization (Urb_{it})	0.374***
Constant	13.910***
Output (ΔBB_Pen_{it})	
Broadband revenue (BB_Rev_{it})	4.606***
Constant	-95.451***
Year effects	SÍ
Observations	40
R^2	
Growth	0.99
Demand	0.92
Supply	0.97
Output	0.40

Source: R. Katz and P. Koutroumpis, The Economic Impact of Broadband: Case Studies of the Philippines and Panama, Geneva, International Telecommunication Union, 2012.
Note: The symbols ***, ** and * indicate significance levels of 1%, 10% and 15%, respectively.

Comparison of the results for Colombia and Panama confirms, first, the existence of returns to scale. The economic contribution of broadband is greater in Panama, where, in 2010, fixed broadband penetration was 7.8% versus 4.8% in Colombia. Beyond this comparative result, the multiple-structure model for Panama yields other conclusions. In addition to the contribution of capital, a 1% increase in skilled labour would increase GDP by 1.15%. The model also shows the relative importance of broadband subscription rates: a 10% decrease in broadband price would increase broadband penetration by more than 21%.

The interpretation of the model results suggests the existence of returns to scale from broadband. This type of effect had already been identified for other ICTs, such as telephony (Roller and Waverman, 2001). Comparison of the results of different estimates of the economic contribution of broadband as a function of penetration shows evident returns to scale (see figure IV.1).[5]

Figure IV.1
COMPARATIVE CONTRIBUTION OF BROADBAND TO ECONOMIC GROWTH
(Percentages)



Source: R. Katz, *The Impact of Broadband on the Economy: Research to Date and Policy Issues*, The Impact of Broadband on the Economy Broadband Series, Geneva, International Telecommunication Union (ITU), 2012.
Note: The trend line does not reflect observations for Latin America.

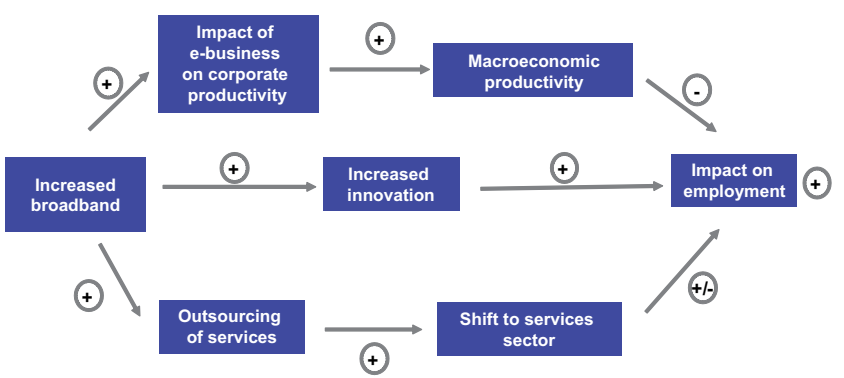
In summary, although the results are based on differently specified models, the greater the broadband penetration, the greater impact its expansion will have on GDP growth. The public policy implications are clear: maximizing the economic impact of broadband is contingent on significantly increasing its penetration.

[5] The significant effects in the case of Panama (not shown in this figure) are due to the importance of broadband in a service-based economy oriented mainly towards commerce and financial services.

2. Job creation

In addition to its impact on economic growth, broadband contributes to job creation, although its effects in this area are more complex. First, increased broadband penetration can increase productivity, which in the short term may lead to net job loss (an effect that has been verified by the author for labour-intensive industrial sectors). Second, by incorporating new sectors of the population into the broadband market, the technology contributes to the creation of new businesses through an innovation effect, which generates new jobs. Lastly, broadband can lead to the outsourcing of certain business functions, which can create jobs as outsourcing firms are established, but it can also lead to the loss of opportunities if business functions in the country under consideration are transferred to other locations. The sum of these three effects is shown in diagram IV.2.

Diagram IV.2
HOW BROADBAND CONTRIBUTES TO JOB CREATION



Source: Adapted by the author from a model developed by M. Fornefeld, G. Delaunay and D. Elixmann, "The impact of broadband on growth and productivity", study for the European Commission, Directorate General for Information Society and Media, 2008.

It is not possible on the basis of the available information to measure the individual impact of each of these three effects, so the analyses had to be limited to measurement of aggregate impact. The job creation potencial of broadband was estimated for Chile, Colombia and the Dominican Republic.

To estimate the impact of broadband in Chile, a study was conducted using quarterly panel data controlled for fixed effects reflecting specific features of each region of the country that have an impact on the labour market (industrial sectors, education levels). Information was compiled for

all regions (except the Santiago metropolitan region, for which quarterly data were not available) for the period from 2001 to the fourth quarter of 2009 (see table IV.4).

Table IV.4
CHILE: IMPACT OF BROADBAND ON JOB CREATION
(12 regions, 2001-2009)

	Coefficient	Standard error	t-statistic	P>|t|	95% confidence interval
Economic activity index [a]	0.0003509	0.0000595	5.90	0.000	0.0002338
Change in broadband penetration	0.0018118	0.0004708	3.85	0.000	0.0008853
Constant	0.8682527	0.0079638	109.03	0.000	0.85258283

Number of observations	324
F(2,310)	60.89
Prob>F	0.0000
R^2	0.2820

Source: R. Katz, "The impact of broadband on economic growth", *Fast-tracking the digital revolution: Broadband for Latin America and the Caribbean* (LC/R.2167), V. Jordán, H Galperin and W Peres, Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2011.
[a] Control variable.

The model results indicate that in Chile a 10% increase in broadband penetration would increase the employment rate by 0.018 points. The increase in broadband penetration appears to be statistically significant in explaining the employment rate trend during the period under consideration.

A similar analysis was performed for Colombia. In this case, a model was constructed at the departmental level, and the relationship between the growth of broadband connections and the rate of employment growth was analysed, controlling for population growth and initial level of economic development. The model was applied first to the country as a whole, and the information was then disaggregated by department and level of penetration (high or low).

In these models, the effect is statistically significant at the national level and for low-penetration departments; in departments with high penetration, the coefficient is significant at 24%. Population growth, on the other hand, seems to have an effect only in high-penetration departments (with a positive coefficient), possibly because the innovation effect mentioned above makes it easier to enter the market in those departments. Initial GDP seems to have no effect on employment growth.

Table IV.5
COLOMBIA: IMPACT OF BROADBAND PENETRATION GROWTH ON EMPLOYMENT GROWTH

Employment rate growth (%)
Dependent variable: employment rate growth between 2006 and 2010
Independent variables: growth in broadband connections, GDP 2003 and population growth

	Total	Low penetration	High penetration
Growth in broadband connections (percentage)	0.0003004**	0.0002951**	0.0006572
	(0.0001359)	(0.0001547)	(0.0005495)
Population growth (percentage)	0.0159829	-0.2538734	0.5937073*
	(0.5114836)	(0.7899623)	(0.3761862)
GDP 2003 (millions of pesos)	0.0053431	-0.1084577	0.0003309
	(0.0077051)	(0.1308956)	(0.0090124)
Adjusted R^2	0.0110	0.0318	0.0338
Prob > F	0.0730	0.0321	0.4351
Number of observations	132	64	68

Source: R. Katz and F. Callorda, *Medición de Impacto del Plan Vive Digital en Colombia y de la Masificación de Internet en la Estrategia de Gobierno en Línea*, Bogota, Centro de Investigación de la Telecomunicaciones (CINTEL), 2011.
Note: The symbols ***, ** and * indicate significance at a level of 1%, 10% and 15%, respectively.

In the study of broadband impact on job creation in the Dominican Republic, a model was constructed using panel data for 32 provinces. Unlike the models used for Chile and Colombia, the objective was to determine the impact of broadband in reducing unemployment.

The results show the high impact of broadband (see table IV.6), with a 1% increase in penetration reducing unemployment by 0.29 percentage points. Other variables affecting the unemployment rate indirectly are, as expected, change in the number of industrial establishments between 2008 and 2009 and the importance of the construction sector in 2009. Thus, a combination of increased broadband penetration, growth in construction and an increase in the number of industrial establishments has a significant impact in reducing unemployment.

Based on the coefficients, the contribution of broadband relative to the other two variables is higher than would have been expected. Part of this effect is due to greater growth in broadband penetration in the capital, Santo Domingo, and in a resort area, Altagracia. To determine the relative contribution of broadband, it would be important to include in the model a variable reflecting the importance of this sector in each province. Such a variable is not available for all provinces, however. Hence, although the model shows that broadband plays an important role in creating jobs, it is difficult to measure its impact in relation to the development of key industrial sectors in the country.

Table IV.6
DOMINICAN REPUBLIC: IMPACT OF INCREASED BROADBAND PENETRATION ON EMPLOYMENT GROWTH

Growth in unemployment	Coefficient	Standard error	t-statistic	P>t	95% confidence interval	
Population growth	0.72442	0.24939	2.90	0.0070	0.21180	1.23704
Change in broadband penetration	–0.29529	0.13290	–2.22	0.0350	–0.56846	–0.02211
Change in number of establishments	–0.14959	0.04728	–3.16	0.0040	–0.24678	–0.05241
Value of construction industry 2009	0.69456	0.14588	4.76	0.0000	0.39469	0.99443
Change in construction 2008-2009	–0.64299	0.12787	–5.03	0.0000	–0.90583	–0.38015
Constant	0.74317	0.37360	1.99	0.0570	–0.02477	1.51111

Number of observations	32
F(5,26)	12.70
Prob>F	0.0000
R^2	0.4175

Source: R. Katz, *The Impact of Broadband on the Economy: Research to Date and Policy Issues*, The Impact of Broadband on the Economy Broadband Series, Geneva, International Telecommunication Union (ITU), 2012.

3. Growth of household income

This third economic effect of broadband is important since an increase in the growth of average household income has an impact on poverty reduction in a country. This aspect is crucial because, although it has been shown that broadband contributes to GDP growth, it is important to ensure that this growth does not favour only the higher-income population, resulting in greater social polarization (Fernandez-Ardevol and Vázquez Grenno, 2011). Studies in Costa Rica and Colombia have looked at this question.

In a study assessing the economic impact of Costa Rica's national broadband strategy, Katz (2011) conducted an analysis based on the National Household Survey between 2005 and 2009. Panel data with random effects were used for estimates where the results by region are specific to a given period (see table IV.7).[6]

[6] At the same time, the White method was used to correct for potential error bias and thus to increase the statistical significance of the coefficients.

Table IV.7
COSTA RICA: IMPACT OF BROADBAND ON GROWTH
IN REAL HOUSEHOLD INCOME

Growth in household income	Coefficient	Standard error	Z	p>|z|	Confidence interval 95%	
Household income (-1)	-0.000337	0.000033	10.08	0.0000	-0.0004	-0.0003
Broadband penetration	2.960308	0.970254	3.05	0.0020	1.0586	4.8620
No education	-4.603882	0,889184	-5.18	0.0000	-6.3437	-2.8611
< 3 persons	1.923927	0,446712	4.31	0.0000	1.0484	2.7995
Manufacturing	2.526376	1.017825	2.48	0.0130	0.5315	4.5213
Agriculture	0.708006	0.195230	3.63	0.0000	0.3254	1.0907
Hotels and restaurants	2.665666	0.302174	8.82	0.0000	2.0734	3.2579
Exports (-1)	0.010438	0.001638	6.37	0.0000	0.0072	0.0136
Constant	-98.568610	31.663730	-3.11	0.0020	-160.6284	-36.5088

Number of observations	24
Number of groups	6
R^2 within groups	0.8029
R^2 between groups	0.8119
R^2 total	0.7971

Source: R. Katz, "Impacto económico de la Estrategia Nacional de Banda Ancha", Gobierno de Costa Rica, Rectoría de Telecomunicaciones, Estrategia Nacional de Banda Ancha, San José, 2011.

According to the model results, a one-percentage-point increase in regional broadband penetration raises average household income by 2.96%; the rise in household income is larger if the head of household is employed in manufacturing or in the tourism sector (hotels and restaurants). Achieving broadband penetration of 10% would increase real average monthly household income in Costa Rica by the equivalent of US$ 48. Thus, if broadband penetration reached 16%, average household income would increase by US$ 141. In turn, these increases in household income would contribute to GDP growth by boosting consumption.

For Colombia, the specified model aimed to study the impact of growth in broadband connections on the growth of real household income in 2006-2010. Following the literature, controls were included for population growth, human capital, share of output accounted for by the mining sector and initial level of wealth (as measured by the percentage of households with unmet basic needs (UBNs) in 2005).

Table IV.8
COLOMBIA: IMPACT OF BROADBAND PENETRATION GROWTH ON REAL HOUSEHOLD INCOME GROWTH

	Percentage increase in real household income, controlled for human capital[a]		
	Total	Low penetration	High penetration
Growth in broadband connections (percentage)	0.0034083	0.0035966	0.0025196
	(0.0011585)	(0.0013686)	(0.0011616)
Population growth (percentage)	-2.533624	-5.520381	1.702465
	(1.245529)	(1.361513)	(1.19664)
Years of education	1.462938	0.4542847	0.1371095
	(0.7531259)	(1.273384)	(0.7649286)
Mining sector output (percentage)	7.816958	9.122359	8.837977
	(4.226792)	(4.701466)	(8.11938)
Households with UBNs 2005 (percentage)	19.7768	31.17167	-34.74956
	(9.51923)	(10.61504)	(28.60452)
Adjusted R^2	0.1885	0.2986	0.1435
Prob > F	0.0101	0.0006	0.0672
Number of observations	132	64	68

Source: R. Katz and F. Callorda, *Medición de Impacto del Plan Vive Digital en Colombia y de la Masificación de Internet en la Estrategia de Gobierno en Línea*, Bogota, Centro de Investigación de la Telecomunicaciones (CINTEL), 2011.
Note: the symbols ***, ** and * indicate significance at a level of 1%, 10% and 15%, respectively.
[a] Dependent variable: growth in real household income between 2006 and 2010. Independent variables: growth in broadband connections, population growth, years of education, mining sector output and households with unmet basic needs in 2005.

The main finding is that if the number of connections increases by 10% in a year, real household income would rise by 0.034% (see table IV.8). Growth in broadband penetration consistently explains increases in real household income in the three models (national level, departments with low penetration and departments with high penetration). The effect appears to be greater in departments with low penetration, although, except in Bogota, no department had more than 9% broadband penetration in 2010 (in other words, all departments had low penetration by international standards). Thus, it can be concluded that none of Colombia's departments had reached a sufficient level of penetration in 2010 to see returns to scale of the type that exist in OECD countries.[7]

[7] In keeping with the human capital theory, a larger number of years of education results in greater growth in household income. Moreover, In accordance with the Solow growth model, there is a trend towards income convergence, as indicated by the coefficient "households with UBNs in 2005".

B. Digitization and development

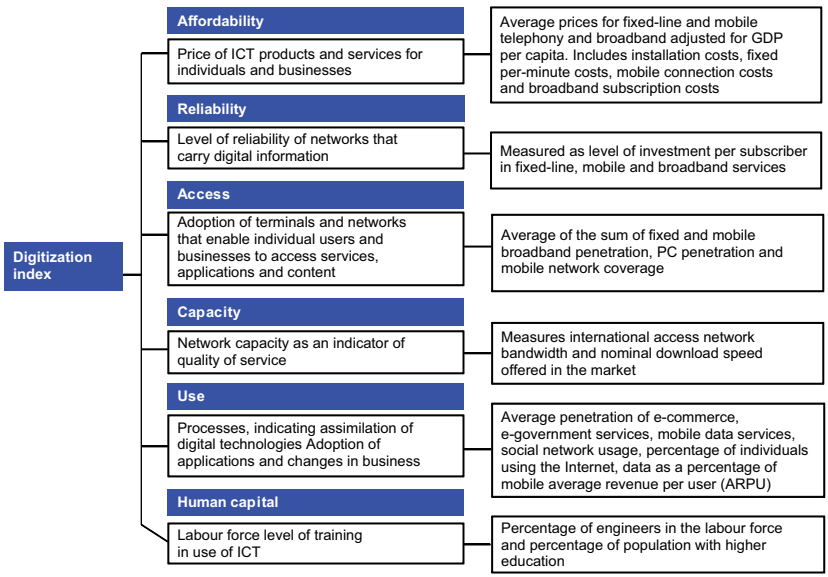
Beyond the impact of broadband access, it is important to study the combined impact of all services and applications enabled by broadband. The concept of digitization —defined as the ability to use digital technologies to generate, process and share information— was developed for that purpose (Katz and Koutroumpis, 2012b). This indicator measures not only the penetration of the technology, but also the use of applications and the consumption of content at three levels: (i) individuals, businesses and government; (ii) goods and services production processes; and (iii) provision of public services.

In order for digitization to reach its full potential, it must meet the following conditions with respect to infrastructure: affordability (prices), technological accessibility (network coverage) and technological reliability (capacity and access speed). A composite index based on the 23 indicators listed in diagram IV.3 was created in order to measure a country's level of development in terms of digitization.

The digitization index is composed not only of infrastructure indicators but also includes information regarding the adoption of applications and services transmitted by broadband —for example, use of e-commerce, mobile broadband, social networks, and e-government services. Calculations of the digitization index for a sample of 184 countries in 2011 indicated that countries pass through four stages of development (see figure IV.2).

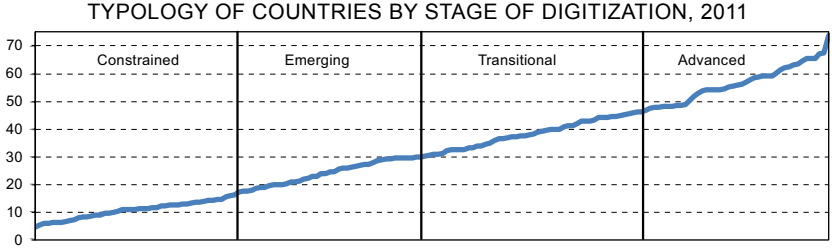
Generally speaking, industrialized countries score above 50 on the digitization index. Countries in transition to advanced digitization have scores ranging from 35 to 50; this group includes countries in the Middle East, Eastern Europe and South-East Asia and some Latin American countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, Panama and Uruguay). The majority of Latin American countries and some African and Asian countries have scores between 20 and 35, while the least developed countries score under 20.

Diagram IV.3
COMPONENTS OF THE DIGITIZATION INDEX



Source: R. Katz, P. Koutroumpis and F. Callorda, "The Latin American path towards digitization", *Info*, vol. 15, N°3, 2013, pp. 6-24.

Figure IV.2
TYPOLOGY OF COUNTRIES BY STAGE OF DIGITIZATION, 2011

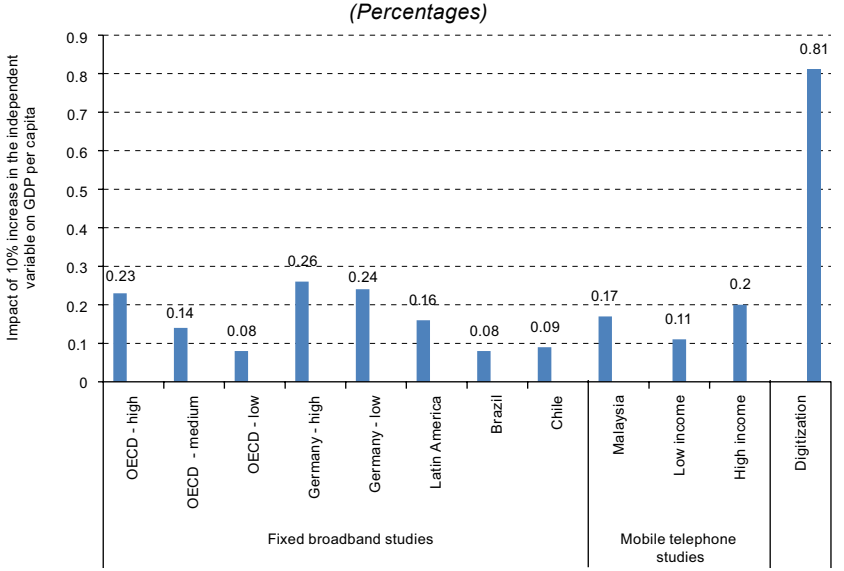


Region	Constrained	Emerging	Transitional	Advanced
Sub-Saharan Africa	35	6	1	0
South-East Asia	8	6	0	0
East Asia and the Pacific	5	7	4	6
CIS and Russian Fed.	3	3	3	2
Middle East and Northern Africa	4	9	7	2
Latin America and the Caribbean	3	14	13	0
Eastern Europe	0	3	13	4
North America	0	0	1	2
Western Europe	0	0	3	17

Source: R. Katz, P. Koutroumpis and F. Callorda, "The Latin American path towards digitization", *Info*, vol. 15, N°3, 2013, pp. 6-24.

Analysis of the six sub-indices in the digitization index reveals that the biggest difference between advanced and emerging countries is not necessarily in technological infrastructure but rather in network use and capacity and in availability of the local human capital necessary to develop applications and content. Although there are large differences between developed and emerging countries in access to fixed broadband (one of the components of the index), the recent deployment of mobile broadband has done much to narrow the gaps. For all countries, then, the sub-index for use of technology never reaches the same level of development as the access sub-index, although the numerical distance between the infrastructure and use of technology sub-indices is less in advanced countries than in developing ones. Overcoming the lag in the adoption of applications and content, especially in countries at a medium stage of development, is the greatest technological challenge. In other words, the focus of a technology strategy should be more on applications and services than on infrastructure development. Models of the economic impact of digitization show that it has greater effect than broadband or mobile telephony by themselves (see figure IV.3).

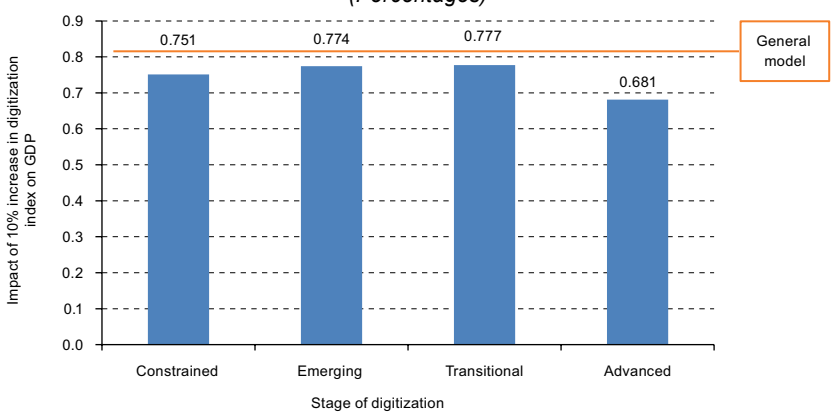
Figure IV.3
DIGITIZATION AND ECONOMIC GROWTH
(Percentages)



Source: R. Katz and P. Koutroumpis, "Measuring Socio-Economic Digitization: A Paradigm Shift", 2012, unpublished.

A 10% rise in the digitization index results in a 0.81% increase in GDP per capita. This result is highly significant as it suggests that the economic impact of ICT is the result of cumulative adoption of all technologies, as well as of the assimilation of content and applications. Achieving high broadband penetration is just a telecommunications policy objective; maximizing its economic impact requires a combination of policies in the areas of telecommunications, information technology, and content and applications. In addition, disaggregating the economic impact model in order to measure the contribution of digitization by stage of digitization again reveals the existence of returns to scale (see figure IV.4).

Figure IV.4
RETURNS TO SCALE FROM DIGITIZATION
(Percentages)



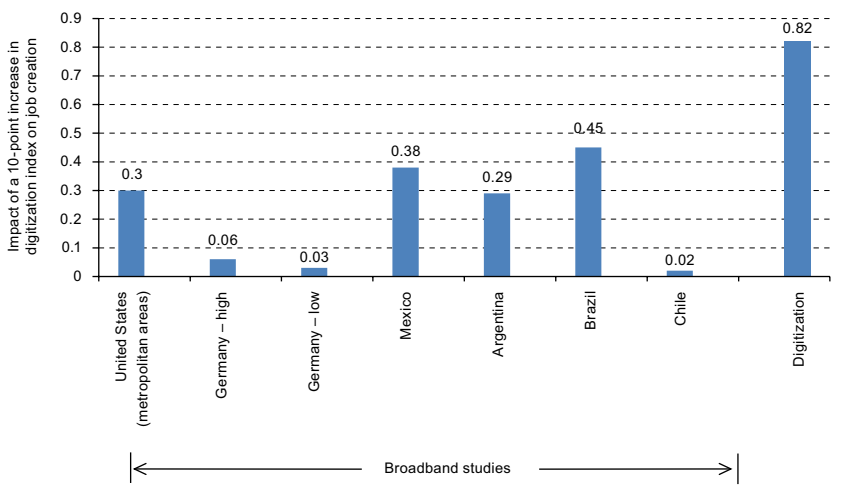
Source: R. Katz and P. Koutroumpis, "Measuring Socio-Economic Digitization: A Paradigm Shift", 2012, unpublished.

While, as shown above, the overall model indicates that a 10% increase in digitization results in a 0.81% increase in GDP per capita, for advanced-stage countries the figure is 0.681% and for countries with lower levels of digitization it is between 0.751% and 0.777%. The results presented in figure IV.4 confirm the hypothesis of increasing returns, but they could also indicate that diminishing returns begin to emerge at an advanced stage of digitization. The impact is less pronounced among advanced-stage countries than among countries in the transitional and emerging stages. The latter two stages are closely linked and are in a different position in relation to countries at a constrained stage. Obviously, there is considerable heterogeneity within these categories,

which could affect the results. However, from an aggregate perspective it is clear that there are increasing returns to scale in the process and that the benefits began to be seen at a digitization level of 30, with a saturation effect appearing at around 65.

Digitization also has a greater impact on job creation than broadband alone (see figure IV.5). A 10% increase in the digitization index results in an increase of 0.82% in employment. This effect can, once again, be attributed to two trends. First, the deployment and assimilation of ICT contributes more to job growth in technology-intensive sectors (software development, business process outsourcing, manufacturing of equipment and parts). Second, the assimilation of ICT has a spillover effect on other sectors of the economy, especially commerce, financial services and health services.

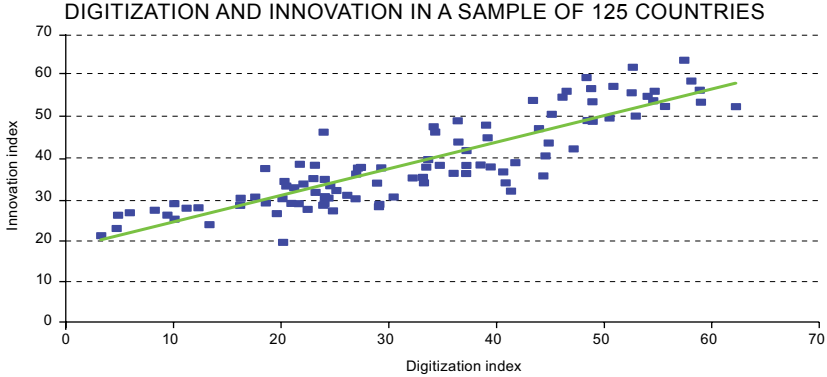
Figure IV.5
DIGITIZATION AND EMPLOYMENT



Source: R. Katz and P. Koutroumpis, "Measuring Socio-Economic Digitization: A Paradigm Shift", 2012, unpublished.

Lastly, a country's level of digitization is closely correlated with the innovation capacity of its economy (see figure IV.6), although, as in the models presented above, it is not possible to confirm a causality relationship. The impact of digitization on innovation capacity would appear to be attributable to the capacity of the digitization environment to facilitate the creation of new products and services that add value.

Figure IV.6
DIGITIZATION AND INNOVATION IN A SAMPLE OF 125 COUNTRIES



Source: R. Katz and P. Koutroumpis, "Measuring Socio-Economic Digitization: A Paradigm Shift", 2012, unpublished.

Based on the correlation coefficient, a 10% increase in digitization would result in a 6.4% increase in innovation. This boost to innovation comes from the introduction of ICT-facilitated services and applications (including new ones like telemedicine, Internet searching, e-commerce, distance education and social networks) and new forms of commerce and financial intermediation. These estimates show that the economic impact of digitization is significant (see table IV.9).

Table IV.9
LATIN AMERICA: ESTIMATED ECONOMIC IMPACT OF DIGITIZATION

Country	Indicators (2011)			Change as a result of 10% increase in digitization index[a]		
	Digitization index	GDP per capita[b] (dollars)	Innovation index	Digitization index	GDP per capita[b] (dollars)	Innovation index
Argentina	41.32	10 881	34.40	45.45	10 969	36.60
Brazil	36.61	12 594	36.60	40.27	12 696	38.94
Chile	45.33	13 738	42.70	49.86	13 849	45.43
Colombia	38.33	7 121	35.50	42.16	7 179	37.77
Costa Rica	37.33	8 644	36.30	41.06	8 714	38.62
Ecuador	32.75	4 504	28.50	36.03	4 540	30.32
El Salvador	29.56	3 602	29.50	32.52	3 631	31.39
Mexico	37.05	9 980	32.90	40.76	10 061	35.01
Panama	44.29	8 740	30.90	48.72	8 811	32.88
Paraguay	28.68	3 594	31.60	31.55	3 623	33.62
Peru	32.20	5 860	34.10	35.42	5 907	36.28
Uruguay	42.78	14 294	35.10	47.06	14 410	37.35

Source: World Economic Forum, *Maximizing the Impact of Digitization*, Global Information Technology Report (GITR), Geneva, 2012; R. Katz and P. Koutroumpis, "Measuring Socio-Economic Digitization: A Paradigm Shift", 2012, unpublished.
[a] An ICT development policy results in a 10% increase in the digitization index.
[b] Constant United States dollars.

In conclusion, digitization has a positive economic impact. Every 10% rise in the digitization index increases GDP by 0.81% and decreases the unemployment rate by 0.82%. In this process, there are increasing returns to scale, the benefits of which are seen mainly after the index reaches a threshold of 30 points; a saturation point is reached at around 50 points. This suggests that countries should accelerate the development of digitization, in particular for usage, applications and content, in order to maximize its impact on economic growth.

C. Policy implications

There is abundant empirical evidence of the economic impact of broadband and its positive externalities in innovation, productivity and business restructuring. Studies are beginning to show that these effects vary with the environment in which broadband is deployed (more or less developed regions). This highlights the need for prospective impact studies in order to target plans and investment, as well as to coordinate broadband deployment with regional economic development programmes in less developed areas. From an impact research standpoint, more work is needed on threshold and saturation levels in order to identify quantitative targets for digitization programmes. This is because the broadband demand gap is the main obstacle standing in the way of increasing the digitization index in Latin America (see table IV.10).

Table IV.10
LATIN AMERICA: BROADBAND SUPPLY AND DEMAND GAP, 2011
(Percentages)

Country	Fixed broadband		Mobile broadband	
	Supply gap (network coverage)	Demand gap[a]	Supply gap (network coverage)	Demand gap
Argentina	4	55	8	73
Bolivia (Plurinational State of)	60	37	71	26
Brazil	6	65	16	63
Chile	22	34	28	65
Colombia	19	54	4	87
Costa Rica	5	63	7	82
Ecuador	13	67	34	55
Mexico	38	15	23	63
Peru	41	43	37	54

Source: Katz and Galperín (2013).
[a] The difference between the percentage of population covered and the penetration rate.

As expected, the percentage of households that could obtain fixed broadband service but do not do so is significant. Excluding countries with low fixed-line telephony coverage (Peru and the Plurinational State of Bolivia), the demand gap ranges from 67% (Ecuador) to 15% (Mexico). The situation with respect to mobile broadband is similar: excluding countries with low mobile coverage (Plurinational State of Bolivia), the demand gap is significant, ranging from 87% (Colombia) to 54% (Peru). However, mobile broadband is still in the embryonic stages; dissemination projections indicate that the demand gap will narrow significantly in the coming years.

The demand gap is determined by generational, education and economic factors. Studies in industrialized and developing countries show that broadband adoption and Internet access are associated with younger generations. In the study of Costa Rica, over 80% of individuals accessing the Internet by means of a computer at home were between 15 and 24 years of age. The number drops substantially among age groups over 45 and is only 20% among persons aged over 55. Just as broadband adoption is associated with younger generations, greater household Internet and computer penetration are associated with higher levels of education. In the Costa Rican study, households with lower levels of education showed considerably lower adoption rates (less than 50% in terms of service use). In contrast, more than 70% of households headed by an individual with post-secondary education used computers and broadband. In keeping with the affordability argument put forward by Galperin and Ruzzier (2010), the third explanation for the demand gap is the economic factor.

In this context, public policies aimed at addressing the demand gap should be underpinned by four fundamental principles. First, to the extent that affordability is one of the main obstacles to broadband adoption, it is important to highlight the benefits of increased competition among private operators as a factor leading to lower prices. Second, beyond the benefits of competition, the State should play a key role in promoting programmes designed to encourage broadband adoption. Areas to be prioritized include education and training programmes, deployment of e-government services that enhance the appeal of broadband service and implementation of subsidy programmes for the purchase of equipment.

Third, one of the most important factors in stimulating broadband adoption is the development of applications that meet individual needs, in both the social and the economic realms. The role of the applications and equipment ecosystem in fostering demand is critical. Lastly, public policies aimed at promoting broadband adoption should be long-range ones, since some of their results will not materialize in the short term. Accordingly, such initiatives should stem from State policies that go beyond political and electoral cycles.

Bearing in mind these principles, four public policy areas for encouraging broadband adoption and increasing digitization can be identified. From an *economic perspective*, consideration should be given to eliminating sales tax on basic broadband service and on computers (especially import duties) and to offering subsidies to reduce monthly service fees for certain beneficiaries. It is also important to negotiate with broadband providers with a view to ensuring the availability of affordable broadband services.

In the area of *education*, ICT should figure more prominently in the curriculum. Secondary schools and specialized training institutions should be encouraged to offer short courses or university extension classes on ICT. Governments should promote digital literacy programmes targeting disadvantaged groups, older persons and persons with disabilities. They should also introduce initiatives to promote *broadband adoption by small and medium-sized enterprises* (SMEs). Measures to be considered include reducing taxes on the purchase of computer equipment and on broadband services, allowing accelerated depreciation of equipment and offering discounts or rewards to companies using ICT and broadband for their transactions with the government. Such economic incentives should be accompanied by training programmes for SME workers and advisory services to enable business owners to install and obtain maximum benefit from ICT.

Finally, with regard to *incentives for broadband adoption arising from direct government action*, it is important to develop content on portals providing information on cultural topics, preventive health care and public services. Mechanisms should also be put in place to promote e-government services such as electronic tax payment systems, e-procurement systems for use by suppliers of goods and services to the government and the development of platforms to facilitate telework.

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