

Puig Gabarró, Pau et al.

Working Paper

Measuring the socioeconomic impact of last-mile infrastructure development in Latin America and the Caribbean

IDB Working Paper Series, No. IDB-WP-1326

Provided in Cooperation with:

Inter-American Development Bank (IDB), Washington, DC

Suggested Citation: Puig Gabarró, Pau et al. (2022) : Measuring the socioeconomic impact of last-mile infrastructure development in Latin America and the Caribbean, IDB Working Paper Series, No. IDB-WP-1326, Inter-American Development Bank (IDB), Washington, DC, <https://doi.org/10.18235/0004326>

This Version is available at:

<https://hdl.handle.net/10419/290041>

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Measuring the Socioeconomic Impact of Last-Mile Infrastructure Development in Latin America and the Caribbean

Pau Puig Gabarró
Raúl Katz
Hernán Galperin
Fernando Callorda
Enrique Iglesias Rodríguez
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Marcos Robles
Ramiro Valencia

Inter-American Development Bank
Institutions for Development Sector

June 2022

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Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Measuring the socioeconomic impact of last-mile infrastructure development in Latin America and the Caribbean / Pau Puig Gabarró, Raúl Katz, Hernán Galperin, Fernando Callorda, Enrique Iglesias Rodríguez, Antonio García Zaballos, Marcos Robles, Ramiro Valencia.

p. cm. — (IDB Working Paper Series ; 1326)

Includes bibliographic references.

1. Infrastructure (Economics)-Latin America. 2. Infrastructure (Economics)-Caribbean Area. 3. Information technology-Social aspects-Latin América-Econometric models. 4. Information technology-Social aspects-Caribbean Area-Econometric models. 5. Information technology-Economic aspects-Latin America. 6. Information technology-Economic aspects-Caribbean Area. 7. Digital communications-Economic aspects-Latin America. 8. Digital communications-Economic aspects-Caribbean Area. I. Puig Gabarró, Pau. II. Katz, Raúl. III. Galperin, Hernán. IV. Callorda, Fernando. V. Iglesias Rodríguez, Enrique. VI. García Zaballos, Antonio. VII. Robles, Marcos. VIII. Valencia, Ramiro. IX. Inter-American Development Bank. Connectivity, Markets and Finance Division. X. Series.
IDB-WP-1326

<http://www.iadb.org>

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Fernando Callorda, Enrique Iglesias Rodríguez, Antonio
García Zaballos, Marcos Robles, and Ramiro Valencia

Abstract

The objective of this study is to estimate the socioeconomic impact of the deployment of last-mile digital infrastructure in Latin America and the Caribbean. To measure the impact of the economic and social aspects of this type of infrastructure, the analysis differentiates according to the geographic context (urban and rural), gender, and educational level, and details the effects and channels that link the deployment of last-mile infrastructure with socioeconomic benefits. The results of this study show that broadband improves job creation, the passage to formality, and salaries for the entire population. The findings indicate that the difference between the higher-skilled and lower-skilled segments of the population is considered in terms of the level of impact. The results also reveal that broadband deployment can generate an increase in inequality between genders, between the urban and the rural population, and between individuals with more years of formal education and individuals with fewer years of formal education if it is not accompanied by public policies that allow access equal use of this technology. This evidence confirms findings in previous studies that highlight the complementarity between broadband and skill levels in estimating benefits. For this reason, the contribution of public policies should be considered as a compensatory mechanism to counteract unintended effects. The set of results constitutes a rich base of empirical information that could help the governments of the region to make policy decisions, taking into account the importance of extending last-mile deployment to the rural context.

JEL codes: G18, G28, L96, L86, L42

Keywords: digital infrastructure, connectivity, inclusion, digital economy

Authors

Pau Puig Gabarró

He holds an MBA in international business management from the Universidad Internacional Menéndez Pelayo and a master's degree in Telecommunications from the Universidad Pompeu Fabra. He is a Telecommunications Specialist at the Inter-American Development Bank (IDB), where he provides support to governments in Latin America and the Caribbean for the reform of public policies in digital technologies and the planning and execution of investments in telecommunications infrastructure. Previously, he held similar positions at the World Bank.

Raúl Katz

He holds a PhD in political science and business administration, a master of science in communications technology and policy from the Massachusetts Institute of Technology (MIT), a master's degree and a bachelor's degree in communication sciences from the University of Paris, and a master's degree in political science from the University of Paris-Sorbonne. He spent 20 years at Booz Allen & Hamilton as the lead partner of the Americas Telecommunications Practice and a member of the firm's management team. He is president of Telecom Advisory Services, LLC, and director of Business Strategy Research at the Columbia Institute for Tele-Information, Columbia Business School, as well as a visiting professor in the Telecommunications Management Program at the Universidad de San Andrés.

Hernán Galperin

He holds a PhD and master's degree in communications from Stanford University and a bachelor's degree in sociology and economics from the University of Buenos Aires. He has been a professor in the Department of Social Sciences and director of the Master's Program in Information Technologies and Telecommunications at the Universidad de San Andrés. He is currently Associate Professor and Associate Dean of the Annenberg School of Communications at the University of Southern California and Director of the Annenberg Research Network on International Communication.

Fernando Callorda

He holds a master's degree and a bachelor's degree in economics from Universidad de San Andrés. He is a project manager at Telecom Advisory Services, LLC; researcher at the National Network of Public Universities of Argentina; and professor of Political Economy at the National University of La Matanza (UNLAM). Before joining Telecom Advisory Services, LLC, he worked as an analyst for the Argentine Congress and as an auditor at Deloitte.

Enrique Iglesias Rodríguez

He holds a master's degree in banking and financial markets from Universidad Carlos III and a master's degree in telecommunications from Universidad Autónoma de Madrid. He is a telecommunications specialist in the Connectivity, Markets, and Finance Division of the IDB, where he has supported governments in Latin America and the Caribbean in the development of broadband and digital economy agendas through technical assistance and lending operations. Previously, he worked as a strategy and operations consultant in Madrid, where he provided services to leading telecommunications companies in Latin America and the Caribbean and Europe.

Antonio García Zaballos

He holds a doctorate in economics from Universidad Carlos III. He is a professor of Finance Applied to Telecommunications at the Instituto de Empresa, and of Economic Regulation at American University and Johns Hopkins University. He is the author of several publications on economic and regulatory aspects applied to the telecommunications sector and is a leading specialist in telecommunications for the Management of Institutions for Development of the IDB, as well as coordinator of the IDB's broadband platform. He has extensive experience in the telecommunications sector, where he has carried out his professional activity in different positions of responsibility. At Deloitte Spain, he led the regulatory practice for Latin America and the Caribbean. Prior to that, he served as chief economist of the Cabinet of Economic Studies of Regulation at Telefónica de España and deputy director of Economic Analysis and Markets at the Spanish telecommunications regulator.

Throughout his professional career he has advised regulators, telecommunications operators, and governments in countries such as Argentina, China, the Czech Republic, the Dominican Republic, Ecuador, Paraguay, Poland, and Saudi Arabia. He is a member of various technical expert committees, including the World Economic Forum (WEF), within the Internet for All initiative, and the United Nations Broadband Commission.

Marcos Robles

He holds a master's degree in economics from the Centro de Investigación y Docencia Económicas de México. He is a research economist in the Social Sector at the IDB. Previously, he worked in the IDB's Poverty and Inequality Unit and the Research Department. He has provided technical support to Bank projects related to poverty, inequality, and targeting of social programs for Ecuador, the Dominican Republic, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, and Peru. Prior to joining the IDB, he was an advisor to the National Institute of Planning and the National Institute of Statistics, and Manager of Quantitative Methods at Maximize Consulting in Peru. He has been technical coordinator of the Program for the Improvement of Surveys and the Measurement of Living Conditions in Latin America and the Caribbean (MECOVI) of the IDB, the World Bank and the Economic Commission for Latin America and the Caribbean (ECLAC) and of the Budget and Social Expenditure Project of the United Nations Development Programme (UNDP) and the United Nations Children's Fund (UNICEF) in Paraguay. He has also been a professor of Econometrics and Quantitative Methods at several universities in Mexico and Peru. His research focuses on issues related to poverty, inequality, and social assistance.

Ramiro Valencia

He holds a master's degree in economics from the Latin American Faculty of Social Sciences (FLACSO), Ecuador, and is an electronics and telecommunications engineer from the National Polytechnic School of Ecuador. He currently works as a consultant at Telecom Advisory Services, LLC. Before that, he worked for nine years at the Ministry of Telecommunications and the Telecommunications Regulation and Control Agency of Ecuador, where he held the position of Director of Studies, Statistical and Market Analysis.

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Executive Summary

The objective of this study is to estimate the socioeconomic impact of last-mile digital infrastructure deployment in Latin America and the Caribbean.

For this task, the study considered five analytical modules:



A regional analysis, based on a consolidated panel of data from 16 countries for the purpose of building correlations between last-mile deployment and socioeconomic impact, and



Four econometric studies for the same number of countries (Brazil, Ecuador, El Salvador, and Jamaica) (Puig Gabarró et al., 2022a, 2022b, 2022c, 2022d) where the deployment of last-mile infrastructure is analyzed in a quasi-random manner to examine a causal link between the infrastructure and certain socioeconomic indicators. The four countries were selected based on the availability of data, and because each presents a different socioeconomic and technological profile (see Table R1).

Table R1. Socioeconomic and Technological Profiles of the Countries Studied

Country	Brazil		Ecuador		El Salvador		Jamaica		Sources
	2007	2018	2011	2019	2008	2019	2014	2018	
GDP per capita (current US\$)	\$12.550	\$15.020	\$9.858	\$11.851	\$6.063	\$9.147	\$8.545	\$9.969	IMF (2019)
Unemployment rate	8.33%	12.33%	3.46%	3.81%	5.88%	3.96%	13.74%	9.10%	ILO (2021)
FB adoption (% households)	13.49%	51.05%	21.24%	59.61%	7.81%	31.17%	18.94%	34.89%	ITU (2022)
FB speed (Mbps)	1.11	28.53	2.55	22.96	1.30	12.41	6.90	21.60	Ookla (2022)

Source: Authors' elaboration.

Note: Monetary figures expressed in U.S. dollars.

FB: Fixed broadband.

This document reviews the academic research conducted on the deployment of last-mile digital infrastructure and the results of the regional analysis. It also compares these results to those in each country.

The Problem to Be Studied

In the last 15 years, broadband deployment and adoption in Latin America and the Caribbean have evolved at an accelerated pace. On an aggregate basis, fixed broadband penetration per household grew from a weighted average of 24.87 percent in 2010 to 56.47 percent in 2020 (ITU, 2022), although, as expected, there is significant variation between countries in the region. This same trend can be detected in the case of mobile broadband, where the weighted penetration of unique subscribers¹ for the region increased in the same period from 19.78 percent to 56.82 percent (GSMA, 2021). In this context of increasing adoption, as in all regions worldwide, fixed and mobile broadband penetration varies significantly between urban and rural areas. At an aggregate level, the Economic Commission for Latin America and the Caribbean (ECLAC) estimates that in Latin America and the Caribbean, fixed broadband adoption is 67 percent in urban areas and 23 percent in rural areas (ECLAC, 2020). One of the main variables explaining this difference is the supply gap, that is, the limited service coverage outside urban areas.

In this dichotomous framework, Latin American and Caribbean governments must make public policy decisions to extend last-mile deployment to rural areas. If the evidence generated at the aggregate level regarding the socioeconomic impact of broadband is applicable to rural areas, last-mile digital infrastructure is a lever that can help remedy the urban-rural divide, which has been exacerbated by the conditions generated by the COVID-19 pandemic. Recent research has also linked the deployment of broadband infrastructure to greater economic resilience (Garcia Zaballos et al., 2020; Katz and Jung, 2021; Katz, Jung, and Callorda, 2020).

The points comprising the analytical focus of this study consist, then, of delving into the measurement of the economic and social impact of this type of infrastructure, differentiating the analysis by geographic context (urban and rural), gender, and educational level, and by detailing the effects and transmission channels that link the deployment of last-mile infrastructure with some socioeconomic benefits. Understanding these links will help governments in the region make public policy decisions, taking into account the importance of extending last-mile deployment to the rural context.

¹ The "unique subscribers" indicator is different from the total number of connections, as it considers only those individuals who subscribe to the service.

Background of the Research Literature

To date, comparative studies of the impact of last-mile digital infrastructure in urban and rural environments, based on ordinary least squares econometric modeling methodology, have already identified seven distinct effects:

- Urban areas tend to benefit more than rural areas, since the sectors with the highest transaction intensity and use of information are concentrated there.
- From a temporal standpoint, these benefits of urban areas, such as impacts on employment and wages, occur faster in cities than in rural communities, although once they reach the latter, they become long-lasting and sustainable.
- Rural communities on the periphery of urban areas have greater benefits in terms of employment, wages and entrepreneurship, compared to more isolated ones, as broadband deployment facilitates the relocation of certain industrial sectors from the metropolitan center to the periphery.
- Urban and suburban areas with a higher concentration of skilled workers receive more benefits from broadband deployment, mainly due to the increased productivity of more technologically advanced firms.
- Broadband deployment in rural areas is associated with GDP growth (albeit at a lower rate than in urban areas) and a loss of the least productive jobs in the short term, since the positive impact on productivity results in a capital-labor substitution that is not offset by the innovative and entrepreneurial effect observed in cities.

- The level of human capital determines the variance in the impact of broadband. The complementarity between the level of worker training and broadband determines that with the deployment of broadband, wages and employment increase among the most skilled workers and decrease among the least skilled, which increases inequality. The impact of broadband manifests itself in the increase in productivity and performance of those companies that benefit from the deployment of this technology.
- Access to the internet would contribute to reducing the labor participation gap for women, because access to the service could change women's job search strategy. Such behavior is more frequent among young women, women with low educational attainment, and single women, and assumes greater access to information as a means to explain higher labor participation.

Likewise, studies comparing the impact of last-mile digital infrastructure in urban and rural areas, based on propensity score matching and difference-in-differences methodologies, have found different effects depending on the universe considered:

- Rural areas tend to benefit more from the availability of broadband, given the greater presence of public establishments such as kiosks, telecenters, educational centers, or others that promote access to information. This provides more benefits to the population, such as the ability to promote services and products that they can offer in the market.
- The impact of broadband availability on employment of skilled labor is higher in most rural areas than urban areas. In general, the impact on employment in rural and isolated locations is significant; in addition, there are representative benefits in all areas in income levels, unemployment rate, and number of establishments.

- Although broadband deployment generally leads to a positive variation in the income of the entire rural population, the use of the service or equipment promotes a greater increase in all the variables studied.
-
- The differentiation of a lower impact in non-metropolitan or rural areas with high broadband availability, compared to the same types of areas with low service availability, could be explained by the fact that in counties with high coverage, households without service are not waiting for broadband access, while in counties with low coverage, the increase in availability causes an increase in income, since there is a population that is waiting for broadband access to be able to generate economic benefits.

Study Hypothesis

The evidence generated by previous research has made it possible to formalize 11 working hypotheses to be evaluated in the context of Latin America and the Caribbean. These can be grouped into five categories.

Aggregate economic impact



H1: Fixed broadband deployment generates a positive impact on total household and labor income.



H2: Broadband deployment is associated with an increase in the employed population and an increase in labor formality.

Comparative urban-rural impact

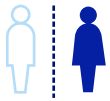


H3: Urban areas tend to benefit more than rural areas in economic terms (increase in income, total and labor income) as a consequence of broadband deployment, since they have the most transaction-intensive and information-intensive industrial sectors (e.g., financial services or professional activities).

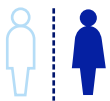


H4: Urban areas tend to benefit more than rural areas in terms of employment generation and labor formality, since they have the industrial sectors with the highest intensity of transactions and use of information.

Comparative impact by gender



H5: Internet use contributes to the reduction of the income gap between men and women, since access to the service allows women to obtain better-paying jobs.



H6: The use of the internet contributes to the reduction of the gender employment gap, since access to the service can especially help women to access better-paying jobs.

Comparative impact by educational level



H7: The economic impact of broadband access is higher for the more educated population, since they have a higher level of digital literacy.



H8: The economic impact in rural areas varies according to the level of human capital and digital skills: the higher the level of education, the higher the impact on employment.

Temporal impact



H9: The impact on total and labor income may grow over time due to an increase in the experience of using the service.



H10: The economic benefit in labor terms generates an increase, in the short term, in labor formality and, in the long term, in the generation of new jobs.



H11: The lower benefit in rural areas in relation to urban areas is also short term: the impact on income in rural areas appears in the medium and long term compared to the economy as a whole. The causality may be crossed by a temporal factor, in which the deployment of last-mile infrastructure does not generate benefits simultaneously or in the short term; rather, they only appear in the medium or long term.

Methodology of Analysis

The objective of the regional analysis has been to apply the difference-in-differences methodology to a consolidated base of sub-sovereign unit (parishes, municipalities, and regions) in Latin American and Caribbean countries. This allows us to compare the economic effect (increased income, job creation, and increased labor formality) resulting from the treatment that certain sub-sovereign units receive (i.e., when they move to fixed broadband access), compared to those that do not change their status (those that do not benefit from the deployment of last-mile fixed broadband).

To evaluate the impact of last-mile infrastructure deployment on income, a difference-in-differences model is specified using Equation 1. This is a simple regression, which determines the effect on income generated by residing in an area where there is the possibility of accessing broadband service at home.

$$\ln(Y_{it}) = \beta_0 + \beta_1 \text{Treatment}_{it} + \beta_2 \cdot \text{Year}_t + \beta_3 \text{Area}_i + \beta_4 \cdot X_{it} + \mu_{it} \quad \textcircled{1}$$

Where:

Y_{it} : Income.

Treatment $_{it}$: This is the variable that distinguishes the groups.

- 1: Areas with broadband in the home, defined as areas where at least 10 percent of the households in the survey adopt the service.
- 0: Areas with no broadband in the home, defined as areas where less than 10 percent of the households in the survey adopt the service.

$Year_t$: Corresponds to a fixed effect for each year between 2008 and 2019.

$Area_i$: Corresponds to a fixed effect for each geographic area (subnational unit) included in the regression.

X_{it} This is a matrix of other independent variables used as controls in the specifications, such as urban and rural area, gender, and years of education.

μ_{it} : It is the error term.

Different econometric models are applied to the dependent variable, considering both total income (which also includes non-labor income, such as rents or remittances) and exclusively labor income.

Different specifications of the econometric model corresponding to Equation 1 are made for the independent variables for each analysis. First, the direct relationship between the treatment and income is analyzed. Subsequently, understanding that both years of education and area of residence are factors that affect income, an additional control for these factors is included. Finally, a third model is added with an additional control for gender. In all specifications we include controls for year fixed effect (a binary variable for each year included in the regression) and geographic area (a binary variable for each sub-sovereign unit included in the regression).

To assess the impact of last-mile infrastructure deployment on employment metrics (percentages of employed population, inactive population, unemployed population, and ratio of formal to informal workers),² a difference-in-differences model is specified, according to the following equation:

$$\text{Percentage of population by group}_{it} = \beta_0 + \beta_1 \text{Treatment}_{it} + \beta_2 \cdot \text{Year}_t + \beta_3 \text{Area}_i + \beta_4 \cdot X_{it} + \mu_{it} \quad \textcircled{2}$$

² The percentage of formal employees is calculated by dividing the number of formal jobs by the total number of jobs (formal plus informal).

This is a simple regression, which determines the effect on the percentages of each group, generated from residing in an area where there is the possibility of accessing broadband service at home.

Where:

Percentage of population by group $_{it}$: Percentage of employed, inactive, and unemployed population, and ratio of formal to informal workers.

Treatment $_{it}$: This is the variable that distinguishes the two groups.

- 1: Areas with broadband in the home, defined as areas where at least 10 percent of the households in the survey adopt the service.
 - 0: Areas with no broadband in the home, defined as areas where less than 10 percent of households adopt the service.
-

Year $_t$: Corresponds to a fixed effect for each year between 2008 and 2019.

Area $_i$: Corresponds to a fixed effect for each geographic area (subnational unit) included in the regression.

X $_{it}$: A matrix of other independent variables used as controls in some specifications.

μ_{it} : It is the error term.

For the independent variables used in each analysis, different specifications of the econometric models are made. The first model evaluates the direct relationship between treatment and the percentage of the population, by labor group. The second, under the assumption that expected income can affect labor participation decisions, includes a control for total income; and, in a third model, another control for labor income is added. All specifications include controls for year fixed effect (a binary variable for each year included in the regression) and geographic area (a binary variable for each sub-sovereign unit included in the regression).

The regional analysis was carried out based on data on broadband adoption generated by national household surveys in Latin American and Caribbean countries, included in the IDB's harmonized database. Based on the information available in the database, 16 countries were included in the analysis (Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Panama, Paraguay, Peru, and Uruguay) between 2008 and 2019. The lack of availability of panel data at the household/individual level was solved by means of pseudo-panels with sub-sovereign units.³ The next step was to calculate, for each year and sub-sovereign unit, the average (weighted by the weight of each individual observation) of the indicators of interest (internet ownership, total income, labor income, years of education, gender, urban population, and rural population). Thus, we ended up with 2,159 observations for the analysis for the years 2008 to 2019 (see Table 12).

³ This was the methodology applied in the case of Ecuador to solve the lack of panel data and to be able to perform the long-term analysis.

Analysis of Results

The results of the regional analysis, in terms of the hypotheses to be considered, allow the following conclusions to be drawn:

CONCLUSIONS

Aggregate Economic Impact



C1: The hypothesis that fixed broadband generates a positive impact on total income and labor income is confirmed. As a consequence of the deployment of the service, there is a positive and significant impact on total and labor income of 6.92 percent (US\$26.46 according to purchasing power parity [PPP])⁴ and 7.43 percent (US\$22.38), respectively.



C2: The hypothesis that broadband generates incentives to join the labor force is confirmed. As a consequence of the deployment of the service, the percentage of inactive population decreases 0.80 percentage points, which generates a positive effect on the employed population of 0.84 percentage points. In addition, the hypothesis that broadband produces a positive effect on higher quality jobs, which is reflected in an increase in labor formality, is confirmed. In particular, it is observed that, on average, labor formality increases 0.66 percentage points, which implies an increase of 1.84 percent.

⁴ For the purposes of this study, all figures will be presented in U.S. dollars at purchasing power parity.

Comparative urban-rural impact



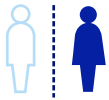
C3: The hypothesis that, as a consequence of broadband deployment, urban areas tend to benefit more than rural areas in total and labor income is confirmed. In particular, we find that, in general, broadband provision in urban centers has a positive impact on total and labor (monthly) income of 4.33 percent (US\$19.46) and 4.96 percent (US\$17.63), respectively, while in rural areas the impact is not significant, except under certain conditions (see H8).



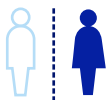
C4: The hypothesis that urban areas tend to benefit more than rural areas in terms of employment (employment generation and labor formality) as a consequence of broadband deployment is confirmed to the extent that the industrial sectors with the highest volume of transactions and information are concentrated there. Indeed, in urban centers there is a migration from the inactive population (0.43 percentage points) to the employed population (0.44 percentage points). This effect does not appear in rural areas.⁵ Labor formality in urban areas increased by 1.55 percentage points, while in rural areas the impact is significant but lower, at 0.97 percentage points. Considering temporality, in rural areas there is no impact of migration of the inactive population to the employed population, maintaining the effect on the improvement of labor formality.

⁵ In urban areas (Table 33), the employment rate is 54.58 percent and the inactivity rate is 41.30 percent. In rural areas, the distribution is similar (see Table 35): 53.81 percent and 44.31 percent, respectively. Unemployment is higher in urban than in rural areas, with levels of 4.12 percent and 1.88 percent, respectively (Tables 34 and 36). However, in neither case is a statistically significant impact found.

Comparative gender impact



C5: The hypothesis that internet access contributes to reducing the income gap between men and women is not confirmed. In particular, the impact in percentage terms on labor income is quite similar between men and women (7.55 percent for men vs. 6.92 percent for women). This results in an increase in men's labor income of US\$23.68 and in women's labor income of US\$20.01 (16 percent lower). This result shows that, with the introduction of broadband, the labor income gap by gender widens. Once again, this inequality requires the implementation of public policies aimed at remedying this progressive inequality. On the other hand, if we analyze the subgroup of the population with fewer than eight years of formal education, we observe that the introduction of broadband generates an equalizing effect on income between men and women. For this subgroup, the gap between men and women is reduced by 9 percent and 2 percent for total income and labor income, respectively.



C6: The hypothesis that internet use contributes to reducing the labor gap between men and women is not confirmed. Although the results show that for men there is a migration from the inactive to the employed population, the same is not true for women, among whom this migration is not significant. In terms of labor formality, for men there is an increase of 1.27 percentage points, while for women there is no statistically significant effect. This result shows that the deployment of broadband can generate an increase in gender inequality, if it is not accompanied by public policies that allow equal use of this technology.

Comparative impact by educational level



C7: The hypothesis that the economic impact of broadband is greater for the more educated population is confirmed, given that this group has a higher level of digital literacy. This can be seen when looking at the role played by formal education in the income of populations with higher levels (more than 11 years) and lower levels (fewer than eight years). In the group with more years of formal education, broadband deployment has a positive impact on labor income of 10.56 percent (US\$52.97), compared to only 5.55 percent (US\$11.89) for the group with less formal education.



C8: The hypothesis that the economic impact of broadband in rural areas depends on access to equipment and digital skills for internet use is confirmed. The impact on the income of the population residing in rural areas is positive and significant for those with more than 11 years of formal education (it is more likely that this group uses the service and equipment is available). In particular, for this group there is a positive impact on total and labor income of 10.50 percent (US\$39.59) and 11.51 percent (US\$35.46), respectively. According to these results, it is possible to conclude that educational level, by acting as a determinant of a greater benefit resulting from broadband, leads *ceteris paribus* to an accentuation of social inequality.⁶ This highlights the importance of implementing public policies to compensate for this disadvantage.⁷

⁶ An extension of the effect popularly known as the "Matthew effect," according to which the level of education ends up generating a widening of the social gap. See Rigney (2010).

⁷ This phenomenon of increasing inequality as a result of the diffusion of digital technologies has recently been referred to in a study by ECLAC (2021), which raises the possibility that frontier technologies, such as artificial intelligence, robotics, or gene editing, may widen or create new inequalities.

Temporary impact



C9: The hypothesis that, for users as a whole, the economic impact (measured in total and labor income) increases over time due to greater experience in using the service is confirmed. In the case of total income, the positive impact is 2.99 percent, with an additional 5.43 percent for early adopters and 4.05 percent for laggard adopters. This implies an increase in income for early adopters of US\$32.28, US\$27.00 for laggard adopters, and US\$11.46 for late adopters. In relation to labor income, the positive impact of broadband introduction is 3.95 percent, with an additional 4.76 percent for early adopters and 3.71 percent for laggard adopters. This translates into an increase in earnings for early adopters, laggard adopters, and late adopters of US\$26.31, US\$23.12, and US\$11.93, respectively.



C10: The hypothesis that the economic benefit in labor terms produces increases in labor formality in the short term and in the generation of new jobs in the long term is confirmed. Specifically, we find that, in the short term, labor formality increases by 3.62 percent while there is no significant change in the level of employment. On the other hand, in the long term, the level of labor formality grows by only 0.91 percent, due to the fact that what mainly increases is the employed population, by 2.67 percent. It is possible that, in the long term, the new jobs generated (quantified by the increase in the employed population) are informal, which implies a lower increase in labor formality.



C11: The hypothesis that the lower benefit for rural areas in relation to urban areas also manifests itself temporally is confirmed. The increase in the income of the population in rural areas occurs more slowly than in the economy as a whole, although it is long-lasting and sustainable in the long term. In particular, we find that, in the short term, the introduction of broadband does not have a significant effect on rural incomes; however, after at least six years of service provision, there is a positive impact on total and labor income of 6.13 percent (US\$15.53) and 6.79 percent (US\$13.37), respectively.

Comparison of Regional Results with Country Analyses

As mentioned above, the regional analysis was complemented by similar analytical modules for Brazil, Ecuador, El Salvador, and Jamaica. Although the availability and types of data in each country prevented the application of a consistent methodology, the national analyses have largely confirmed the results of the regional module (see Table R2).

Table R2. Comparison of the Results of the Study, by Analytical Module

Category	Hypothesis	Regional	Brazil	Ecuador	El Salvador	Jamaica
Aggregate economic impact	H1: Positive aggregate impact on total and labor income.	<ul style="list-style-type: none"> Positive impact on labor and total income for the average population. 	<ul style="list-style-type: none"> Positive economic impact (measured through GDP per capita) for the average population. 	<ul style="list-style-type: none"> Positive impact on labor income for the average population. 	<ul style="list-style-type: none"> Positive impact on labor and total income for the average population. 	<ul style="list-style-type: none"> Positive economic impact (measured in per capita expenditure) for the average population.
	H2: Aggregate increase in the employed population and labor formality.	<ul style="list-style-type: none"> Broadband generates incentives to join the labor force and an increase in formality. 	<ul style="list-style-type: none"> Broadband generates incentives to increase the employed population. 	<ul style="list-style-type: none"> Broadband generates incentives to increase the appropriate level of employment. 	<ul style="list-style-type: none"> Broadband generates incentives to increase formality. 	<ul style="list-style-type: none"> Increased broadband adoption creates incentives for an increase in the employed population.
Comparative urban-rural impact	H3: Urban areas tend to benefit more than rural areas in terms of income.	<ul style="list-style-type: none"> Impact on total and labor income only in urban areas for the average population. 	<ul style="list-style-type: none"> More populated municipalities receive higher benefits. 	<ul style="list-style-type: none"> Greater impact on urban (vs. rural) labor income in the short and long term. 	<ul style="list-style-type: none"> Impact on total and labor income in urban areas only. 	<ul style="list-style-type: none"> The hypothesis could not be verified because the sample is too small to differentiate between urban and rural.

Table R2. Comparison of the Results of the Study, by Analytical Module (continued)

Category	Hypothesis	Regional	Brazil	Ecuador	El Salvador	Jamaica
	H4: Urban areas tend to benefit more than rural areas in terms of employment and labor formality.	<ul style="list-style-type: none"> Greater impact on the employed population and labor formality in urban areas. 	<ul style="list-style-type: none"> The more populated municipalities receive higher benefits in terms of employment generation. 	<ul style="list-style-type: none"> Greater impact on labor participation in urban areas. 	<ul style="list-style-type: none"> Greater impact on the working population in urban areas. 	<ul style="list-style-type: none"> The hypothesis could not be verified because the sample is too small to differentiate between urban and rural.
Comparative impact by gender	H5: Internet use contributes to reducing the gender income gap.	<ul style="list-style-type: none"> Impact on total income and labor income greater in men than in women. 	<ul style="list-style-type: none"> The hypothesis could not be verified because the data did not differentiate by gender. 	<ul style="list-style-type: none"> Impact on men's labor income, but not significant for women in the short and long term. 	<ul style="list-style-type: none"> Higher impact on total and labor income for women than for men. 	<ul style="list-style-type: none"> Higher impact on per capita spending for men.
	H6: Internet use contributes to reducing the gender employment gap.	<ul style="list-style-type: none"> Greater impact on the employed population and labor formality in men than in women. 	<ul style="list-style-type: none"> The hypothesis could not be verified because the data did not differentiate by gender. 	<ul style="list-style-type: none"> More suitable employment and labor participation in men than in women. 	<ul style="list-style-type: none"> Greater impact on the employed population in women than in men. 	<ul style="list-style-type: none"> As the impact is higher in per capita spending for men, the same is assumed for employment.
Comparative impact by educational level	H7: The impact on income and employment is higher for the more educated population.	<ul style="list-style-type: none"> Higher impact on total and labor income for more educated groups. 	<ul style="list-style-type: none"> The hypothesis could not be verified because the data do not differentiate by educational level. 	<ul style="list-style-type: none"> Higher impact on population with higher education (vs. middle and elementary education). 	<ul style="list-style-type: none"> Greater impact on total and labor income in groups with higher education. 	<ul style="list-style-type: none"> Higher impact on per capita spending for more educated groups.

Table R2. Comparison of the Results of the Study, by Analytical Module (continued)

Category	Hypothesis	Regional	Brazil	Ecuador	El Salvador	Jamaica
		<ul style="list-style-type: none"> Greater impact on the employed population and labor formality in the more educated population. 			<ul style="list-style-type: none"> Greater impact of labor formality on the more educated population. 	
	H8: The economic impact of broadband in rural areas varies according to educational level and digital skills.	<ul style="list-style-type: none"> The impact on income in rural areas is positive and significant for the population with more than 11 years of formal education. 	<ul style="list-style-type: none"> The hypothesis could not be verified because the data do not differentiate between urban and rural areas at the educational level. 	<ul style="list-style-type: none"> Results suggest a greater impact among those with higher education. 	<ul style="list-style-type: none"> The hypothesis could not be verified because the data do not differentiate between urban and rural areas at the educational level. 	<ul style="list-style-type: none"> The hypothesis could not be verified because the sample is too small to differentiate between urban and rural areas.
Temporary impact	H9: The impact on total income and labor income grows over time.	<ul style="list-style-type: none"> Higher impact on total and labor income, employed population, and labor formality for early adopters. 	<ul style="list-style-type: none"> Superior impact on GDP per capita for early adopters. 	<ul style="list-style-type: none"> Impact on labor income grows over time, although not monotonically. 	<ul style="list-style-type: none"> Major impact on total income and labor income for early adopters. 	<ul style="list-style-type: none"> The hypothesis could not be verified since the sample is limited in time.
	H10: The impact on employment and labor formality grows over time.	<ul style="list-style-type: none"> Increase in labor formality in the short term and new jobs in the long term. 	<ul style="list-style-type: none"> Higher impact on GDP per capita for early adopters, which is assumed to be accompanied by better or more employment. 	<ul style="list-style-type: none"> Increased labor income over time, which is assumed to be accompanied by a combination of increased employment and formality. 	<ul style="list-style-type: none"> Increase in labor formality in the long term. 	<ul style="list-style-type: none"> The hypothesis could not be verified since the sample is limited in time.

Table R2. Comparison of the Results of the Study, by Analytical Module (continued)

Category	Hypothesis	Regional	Brazil	Ecuador	El Salvador	Jamaica
	H11: The impact on income in rural areas appears in the medium/long term.	<ul style="list-style-type: none"> The increase in income of the rural population is slower than in the economy as a whole, but it is durable and sustainable in the long term. 	<ul style="list-style-type: none"> The hypothesis could not be verified because the data do not differentiate between urban and rural areas. 	<ul style="list-style-type: none"> The long-term analysis does not generate significant results on the income impact of rural areas. 	<ul style="list-style-type: none"> The hypothesis could not be verified since a small rural sample is available to evaluate the effect of time. 	<ul style="list-style-type: none"> The hypothesis could not be verified since the sample is limited in time.

■ Confirmation of hypotheses
 ■ Non-confirmation of hypotheses
 ■ Impossible to verify hypotheses due to lack of data

Source: Authors' elaboration.

In terms of consistency, the following conclusions can be drawn from the results of the analytical modules:

CONCLUSIONS



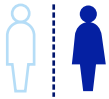
C1: Last-mile infrastructure generates a positive impact on total household income and labor income.



C2: The increase in the employed population and, especially, in labor formality is associated with the implementation of this infrastructure.



C3: Urban areas tend to benefit more from last-mile infrastructure deployment than rural areas.



C4: The positive impact generated by the implementation of broadband is greater among men than among women, and among the more educated population, which may accentuate the inequality between these groups.



C5: The impact of broadband deployment grows over time.

Furthermore, and beyond the directional consistency of the analyses, the degree of impact per country is related to the level of fixed broadband adoption and the quality of connections in the period under analysis:



The greatest impact occurs in Ecuador and Brazil (4.6 percent), which are the countries with the highest level of fixed broadband adoption and the highest quality of service (measured by fixed broadband speed), indicating the existence of a return to scale already pointed out in the literature (Koutroumpis, 2009; Katz, Avila, and Meille, 2010; Katz and Jung, 2021).



The impact is lower in El Salvador (2.9 percent), where adoption only reached 31.17 percent by the end of the analysis period and (broadband) speed is less than half that of Brazil (29 Mbps vs. 12 Mbps).



In El Salvador and Ecuador, countries with low levels of unemployment during the period analyzed, there was a significant impact on the increase in labor formality (El Salvador) and adequate employment (Ecuador).⁸

⁸ The Jamaican study was not taken into account for the comparison, as it required a different analysis methodology (*impact of increased adoption* rather than *service introduction*, since both fixed and mobile technologies were considered for the analysis).

Public Policy Implications

The body of evidence is presented as a rich empirical basis for the formulation of last-mile digital infrastructure deployment strategies and the reduction of demand gaps in Latin America and the Caribbean. In particular, these results show that broadband deployment can generate an increase in inequality at three levels (between genders, between urban and rural populations, and between individuals with more and less formal education) if it is not accompanied by public policies that allow access to equal use of such technology. This evidence is consistent with the results of previous studies that highlight the complementarity between broadband and the levels of training and skills in the estimation of benefits. The results of this study show that broadband improves job creation, the transition to formality, and the wage level for the entire population; likewise, the difference between the more-skilled population and the less-skilled population is posed in terms of level of impact. This is why the contribution of public policies should be considered as a compensatory mechanism to counteract unexpected effects.

In view of the above, four public policy axes should be considered to complement connectivity infrastructure deployment programs:



The results highlight the **need to carry out digital literacy actions in rural areas** to support the use of broadband in the productive fabric. Digital literacy programs should focus not only on communicating available services, but also on developing reliability in use and explaining the benefits of digital connectivity and the conditions necessary to ensure privacy and security. Programs can be organized into three areas of intervention:

- Incorporation of digital literacy content in formal education programs, both for students and teachers.
- Deployment of programs aimed at specific segments of the population, including the elderly, the unemployed, people with disabilities, and others.
- Implementation of generic programs to support the population in all community centers (libraries, cultural centers, clinics, etc.).



The lower impact on rural areas, a topic widely covered in the literature surveyed, requires recognition that **conventional rural development programs aimed at the creation of new ventures** represent an adequate complement to the development of digital infrastructure with universal reach.



The results of the study suggest a greater impact on those who actually use the internet. In other words, the results suggest a spillover effect towards the entire population of the sub-sovereign unit, which may, however, imply an increase in income inequality between users and non-users. Therefore, there is a need to **implement public policies to encourage the adoption of broadband service** to close the demand gap in the localities that receive connectivity. This may be reflected in the growing gender inequality and differences in terms of educational level.



With respect to the growing gender inequality, the greater short-term impact on men's employment (due to the network building effect), and the lack of impact on women's labor participation in the long term indicate the need to **act on online employment opportunities in sectors with higher labor participation among women**, such as services, health, and education.

Introduction

The objective of this study is to estimate the socioeconomic impact of last-mile digital infrastructure deployment in Latin America and the Caribbean.

For this task, the study considered five analytical modules:



A regional analysis, based on a consolidated panel of data from 16 countries for the purpose of constructing correlations between last-mile deployment and socioeconomic impact, and



Four econometric studies for the same number of countries (Brazil, Ecuador, El Salvador, and Jamaica) (Puig Gabarró et al., 2022a, 2022b, 2022c, 2022d) in which the deployment of last-mile infrastructure is analyzed in a quasi-random manner to examine a causal link between the infrastructure and certain socioeconomic indicators. The selection of these four countries was determined by the availability of data and because of their different socioeconomic and technological profiles (see Table 1).

Table 1. Socioeconomic and Technological Profile of the Countries Studied

Country	Brazil		Ecuador		El Salvador		Jamaica		Source
	2007	2018	2011	2019	2008	2019	2014	2018	
GDP per capita (current US\$)	\$12.550	\$15.020	\$9.858	\$11.851	\$6.063	\$9.147	\$8.545	\$9.969	IMF (2019)
Unemployment rate	8.33%	12.33%	3.46%	3.81%	5.88%	3.96%	13.74%	9.10%	ILO (2021)
FB adoption (% households)	13.49%	51.05%	21.24%	59.61%	7.81%	31.17%	18.94%	34.89%	ITU (2022)
FB speed (Mbps)	1.11	28.53	2.55	22.96	1.30	12.41	6.90	21.60	Ookla (2022)

Source: Authors' elaboration.

Note: Monetary figures expressed in U.S. dollars.

FB: Fixed broadband.

This document reviews the academic research conducted on the subject and the results of the regional analysis. Section 1 explains the need to study the deployment of last-mile digital infrastructure for the development of countries in the region. Section 2 presents the evidence from the academic literature on the differentiated socioeconomic impact of broadband. Its objective is to explore the research that differentiates the impact on income and employment according to variables such as geographic area, population with access to technological devices, educational level, and gender. Sections 4 and 5 present the methodology, data, results and discussion of the results of the regional analysis in relation to income and employment, respectively. Finally, Section 6 examines the implications of these results for public policy and presents four axes to complement last-mile broadband infrastructure deployment programs.

1. The Nature of the Problem to Be Studied

The economic impact of last-mile digital infrastructure deployment (in most cases referred to as "broadband") has been studied in the aggregate at the national level in numerous research studies over the last three decades.

Analyses have evolved from a purely correlational methodology toward the development of structural models aimed at demonstrating the economic value of fixed or mobile broadband adoption (Crandall, Lehr, and Litan, 2007; Czernich et al., 2009; Koutroumpis, 2009; Ferrés, 2010; Katz and Koutroumpis, 2012a, 2012b; Atif, Endres, and Macdonald, 2012; Gallego and Gutiérrez, 2013; Katz and Callorda, 2020; Katz and Jung, 2021). In most of these studies, the methodology used was based on the analysis of independent variables at the national level (e.g., fixed or mobile broadband penetration) and dependent variables, such as gross domestic product (GDP) per capita and job creation. The overall conclusion was, with few exceptions, that broadband leads to a number of positive externalities, including economic growth, job creation, and increases in per capita income, productivity, and entrepreneurship development.

In parallel, broadband deployment and adoption over the last 15 years in Latin America and the Caribbean has rapidly evolved. In the aggregate, fixed broadband penetration per household has grown from a weighted average of 24.87 percent in 2010 to 56.47 percent in 2020, although, as expected, adoption by country shows certain asymmetries (see Table 2).

Table 2. Latin America and the Caribbean: Fixed Broadband Household Penetration (percentage), 2020

Country	Percentage
Argentina	78.61
Barbados	98.58
Bolivia	34.67
Brazil	57.96
Chile	74.63
Colombia	55.26
Costa Rica	67.10
Dominican Republic	33.93
Ecuador	53.20
El Salvador	42.75
Guatemala	19.17
Honduras	24.95
Jamaica	45.72
Mexico	71.98
Panama	56.20
Paraguay	26.12
Peru	44.44
Trinidad and Tobago	84.88
Uruguay	76.72
Venezuela	42.73

Sources: Regulators' reports; extrapolation of ITU estimates.

As shown in Table 2, despite the progress recorded at the aggregate level, the continent still shows marked differences between advanced countries (Argentina, Barbados, Chile, Costa Rica, Mexico, Trinidad and Tobago, and Uruguay), countries in transition (Brazil, Colombia, Ecuador, El Salvador, Jamaica, Panama, Peru, and Venezuela), and somewhat more backward countries (Bolivia, Dominican Republic, Guatemala, Honduras, and Paraguay).

The same trend can be detected in the case of mobile broadband, where the weighted penetration of unique subscribers⁹ for the region between 2010 and 2020 has increased from 19.78 percent to 56.82 percent, respectively (see Table 3).

Table 3. Latin America and the Caribbean: Mobile Broadband Penetration (unique subscribers as a percentage of the population), 2020

Country	Percentage
Argentina	68.60
Barbados	56.27
Bolivia	44.83
Brazil	61.60
Chile	67.99
Colombia	51.50
Costa Rica	62.12
Dominican Republic	57.62
Ecuador	48.71
El Salvador	46.44
Guatemala	41.26
Honduras	38.97
Jamaica	48.20
Mexico	59.42
Panama	65.37

⁹ The "unique subscribers" indicator is different from the total number of connections, as it includes only those individuals who have a subscription to the service.

Table 3. Latin America and the Caribbean: Mobile Broadband Penetration (unique subscribers as a percentage of the population), 2020 (continued)

Country	Percentage
Paraguay	43.15
Peru	53.21
Trinidad and Tobago	55.80
Uruguay	65.37
Venezuela	52.25

Source: GSMA (2021).

In this context of growing adoption, as is the case worldwide, fixed and mobile broadband penetration varies significantly between urban and rural areas. At an aggregate level, ECLAC estimates that, in the region, fixed broadband adoption is 67 percent in urban areas and 23 percent in rural areas (ECLAC, 2020). One of the main variables that explains this difference is the gap in the supply of services —that is, the limited coverage outside large urban centers.

In the case of fixed broadband, despite the deployment of fiber optic backbones in many countries, the construction of last-mile access in rural and isolated regions has not been boosted, and the wholesale networks built by governments have not always contributed significantly to the growth of rural coverage. For example, the Dorsal Network, deployed over 13,200 km in Peru, has a utilization rate of only 3.2 percent after four years of operation. While initially the wholesale price of Peru's Dorsal Network helped to lower interurban transport costs, over time the lack of commercial flexibility of the network resulted in high wholesale transport prices, a phenomenon that has not helped to create an incentive for telecommunications operators to develop more last-mile infrastructure. Similar situations have been observed in the wholesale networks of Argentina, Colombia, and Mexico. In other words, the fact that a backbone network has points of presence in rural municipalities does not imply that the population can access broadband beyond the access provided at public access points, such as internet kiosks.

In the case of mobile broadband, the situation is more encouraging. 4G coverage in Latin America and the Caribbean has reached a national weighted average of 90.46 percent (GSMA, 2021) since the first deployment in 2010. As in the previous case, coverage also shows certain differences between countries, although the asymmetries are not as marked as with fixed broadband (see Table 4).

Table 4. Latin America and the Caribbean: 4G Coverage (percentage of population with access to 4G networks), 2020

Country	Percentage
Argentina	98.00
Barbados	95.00
Bolivia	80.00
Brazil	95.00
Chile	88.00
Colombia	88.00
Costa Rica	90.00
Dominican Republic	90.00
Ecuador	88.00
El Salvador	89.50
Guatemala	88.00
Honduras	88.00
Jamaica	90.00
Mexico	85.00
Panama	90.00
Paraguay	88.00
Peru	88.00
Trinidad and Tobago	90.00
Uruguay	88.00
Venezuela	88.00

Source: GSMA (2021).

Generally, most of the population not covered by 4G technology is located in rural areas due to high deployment costs in relation to low population density and low income per subscriber. Indeed, when differentiating between urban and rural population, the coverage variance is significant: according to the International Telecommunication Union (ITU), 4G coverage in Latin America and the Caribbean is 98 percent for the former and 54 percent for the latter (ITU, 2021).

In this dichotomous framework, Latin American and Caribbean governments must make public policy decisions to extend last-mile deployment to the rural world. If the evidence generated at the aggregate level regarding the socioeconomic impact of broadband is applicable to rural areas, last-mile digital infrastructure constitutes a lever that can help remedy the urban-rural duality, a problem that has been accentuated in the context of the conditions generated by the COVID-19 pandemic. Recent research has also linked the deployment of broadband infrastructure to greater economic resilience (Katz, Jung, and Callorda, 2020).

The points that constitute the analytical focus of this study consist, then, of delving into the measurement of the economic and social impact of this type of infrastructure, differentiating the analysis by geographic context (urban and rural), gender, and educational level, and detailing the effects and transmission channels that link the deployment of last-mile infrastructure with some socioeconomic benefits. This understanding will help governments in the region to make public policy decisions taking into account the importance of extending last-mile deployment to the rural context.

2. Evidence Generated by Academic Research

Academic research on the differential urban-rural impact of broadband began with the analysis of ordinary least squares econometric models based on economic data (GDP, employment, wages) at the level of sub-sovereign administrative units. And since this type of data was already being collected in more advanced economies, the first research results were generated in the developed world.

Subsequently, the increasing availability of national household surveys made it possible to perform *propensity score matching* models, in addition to *difference-in-differences* models, and to use panel data for urban and rural households. The following sections present the evidence generated by studies using each of these two methodologies. While the first type of approach (ordinary least squares econometric models) began to provide some understanding of the differential impact by region, the second (propensity score matching/difference-in-differences) allowed us to advance on the chains of causality and delve into the differential impact of other dimensions such as gender, ethnicity, educational level, households with digital devices, and type of broadband access.

2.1. Research Based on Ordinary Least Squares Econometric Modeling

Early studies of broadband impact differentiated by geography indicated the existence of a direct relationship between economic contribution and proximity to urban areas: the closer the rural administrative unit (e.g., county or district) was to a metropolitan center, the greater the economic impact. The reasons for this phenomenon included supply-side factors (the commercial attractiveness of service deployment, for example, favored competition among operators and, consequently, lower prices) and demand-side factors (e.g. urban and peripheral centers have a high concentration of sectors with high transaction costs, —i.e., sectors that are natural beneficiaries of broadband access).

These observations were made based on econometric models generated by Gillett et al. (2006) and Kolko (2010). In the first study, the authors estimated the effect of broadband on indicators such as employment and wages from a panel data of U.S. communities. For the period between 1998 and 2002, this research found that urban areas where broadband access had been deployed since 1999 experienced faster growth in employment and number of businesses than rural areas. However, although this result represented a first indication of the importance of the urban-rural difference, it is possible that these traits were affected by a reverse causality effect.

Kolko (2010) also analyzed the relationship between broadband and economic development through information on broadband in the United States between 1999 and 2006, using the topographic conditions of localities as an instrument to examine the expansion of this service. In this case, the author studied how the change in the number of broadband service providers in urban communities affected employment growth.

Although these two pioneering studies demonstrated the existence of a differentiated effect between urban and rural contexts, they did not provide a comparison of effects. The first quantitative study with an urban-rural comparison was conducted by Forman, Goldfarb, and Greenstein (2010) for a sample of 163 U.S. counties and a five-year period (between 1995 and 2000). The paper analyzed the relationship between broadband investment and wage growth at the county level. The authors found that internet access (which was already pre-served) explained wage growth in 6 percent of the counties, while only a few of the remaining 94 percent experienced wage growth, despite the investment in last-mile access. In other words, the income impact appeared with a time lag, and urban areas that had previously received last-mile access were the first beneficiaries of the economic impact.

On the other hand, Kandilov and Renkow (2010) conducted the first impact study focused on the rural world. To do so, they analyzed the effect of the U.S. Department of Agriculture's loan program¹⁰ for the construction of broadband networks in rural communities. The authors determined that, among rural counties that received loans for last-mile access deployment, those closer to urban centers generated greater economic benefits. In particular, positive impacts on employment, wages, and venture deployment were identified (see Table 5).

¹⁰ The authors mention that between 2005 and 2008, the U.S. Department of Agriculture provided loans to 148 rural communities located 30 miles from urban centers with a population of more than 200,000.

Table 5. Average Economic Impact of a Department of Agriculture Loan For Last-Mile Broadband Deployment (percent)

Type of county	Employment	Salaries	Undertakings
All counties (excluding rural areas)	5.0	4.5	6.8
Urban counties	7.2	5.5	5.3
Rural counties near urban centers	2.5	- 1.6	0.8

Source: Adapted from Kandilov and Renkow (2010).

Note: The results for isolated rural counties presented non-significant results.

As can be seen, the economic impact in metropolitan counties was higher than in rural counties near urban centers, while the latter had an impact on job creation (coefficient of 2.5 percent) and, minimally, on business development (0.8 percent). According to the authors, the impact on employment is due to the fact that broadband deployment favors the relocation of logistics infrastructure (e.g., distribution centers) to easily accessible areas located on the periphery of urban areas. Burton and Hicks (2005) reached a similar conclusion in a study analyzing the relocation of companies to areas with broadband coverage in the Appalachian Mountains. Shideler, Badasyan, and Taylor (2007), who investigated the same phenomenon in the state of Kentucky, United States, found a similar result. A series of comparative geographic impact studies found that administrative units located on the periphery of metropolitan centers benefited economically from the deployment of last-mile digital infrastructure, although the impacts were lower than in urban centers.

In the case of rural areas isolated from urban centers, two studies conducted in Canada (Selouani and Hamam, 2007; Strategic Networks Group, 2003) detected three different (and, in some cases, contradictory) effects resulting from broadband deployment:

- Relocation of companies from urban centers to rural areas in certain industries (logistics transportation, health, financial services), combined with the decline of jobs in other sectors (e.g., retail trade).

- Productivity gains in certain industries (transportation, lodging, entertainment), leading to job destruction due to the substitution effect between factors of production.
- Improved provision of health, education, social inclusion, and entertainment, with a consequent increase in consumer surplus.

In an econometric study comparing the economic impact by region, Katz, Avila, and Meille (2010) analyzed the impacts of broadband on median household income and job creation in rural counties in the state of Kentucky. The study estimated that a 1 percent growth in broadband coverage would result in a 0.0704 percent increase in median income in rural counties adjacent to urban centers, and 0.0800 percent in that of isolated rural counties, compared to the 0.0968 percent found for median income in urban centers. This means that the observed impact on the median wage was higher for metropolitan counties than for isolated rural counties, while outlying rural counties occupied an intermediate position. On the other hand, a 1 percent increase in broadband penetration in rural counties peripheral to urban centers and isolated rural counties was associated with a reduction in the unemployment rate of 0.1953 percent,¹¹ while the results for urban centers were not significant (see Table 6).

Table 6. Kentucky: Impact of a 1 Percent Increase in Broadband Availability on Average Wage and Unemployment

Type of county	Average salary	Unemployment
Metropolitan	0.0968***	0.0301
Rural peripheral to urban center	0.0704***	-0.1953***
Rural isolated	0,0800***	

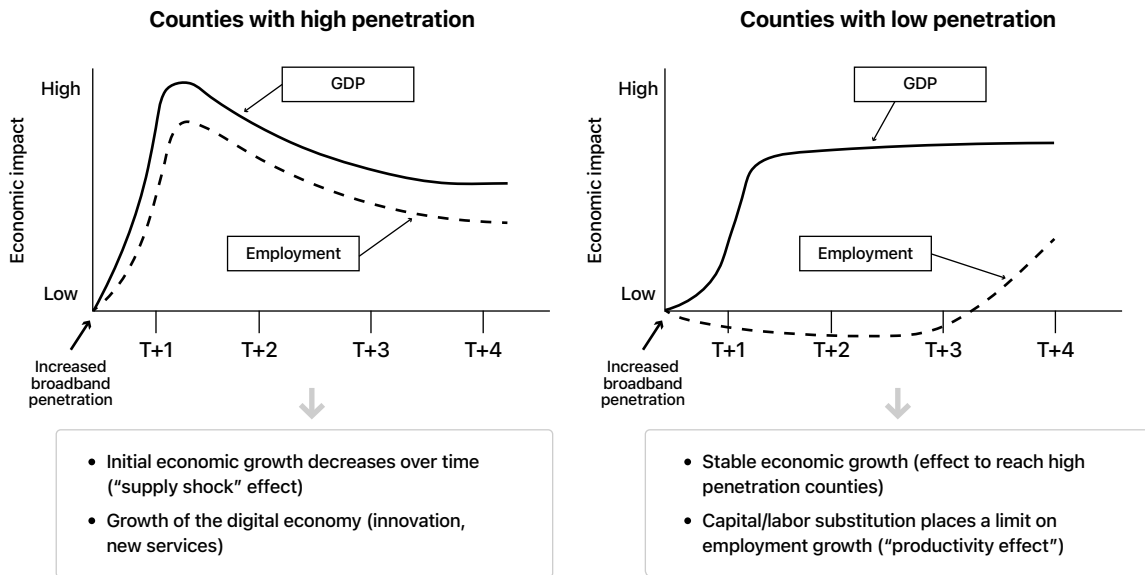
Source: Katz, Avila, and Meille (2010).
 Statistical significance: ***p<0.01.

¹¹ The results, differentiated by type of rural county, do not generate statistically significant coefficients.

In the same vein, Mack and Faggian (2013) developed a series of spatial econometric models to examine the impact of broadband deployment on productivity in selected U.S. counties. The authors found that the variance in the impact of broadband was determined by the level of human capital, which determined that productivity gains occurred in territories with high levels of human capital and/or high-skilled workers, concentrated in urban and suburban environments, which increases levels of inequality. Akerman, Gaarder, and Mogstad (2015) deepened these findings and analyzed the complementarity between the skill level of workers and broadband access. In particular, they found that wages and employment level increase with broadband deployment among higher-skilled workers and decrease with lower-skilled workers, thereby increasing inequality. The channel of broadband's impact is through the increase in productivity and performance of those firms that benefit from the deployment of the technology. In other words, broadband adoption, according to these authors, generates a change in the use of production factors by firms, increasing the marginal productivity of the highest-skilled workers. The effect of broadband on productivity was also confirmed by Cambini, Grinza, and Sabatino (2021) in a study conducted in Italy on the deployment of fiber optics at the municipal level.

Another confirmation of the heterogeneity of complex effects by region can be seen in a study conducted in Germany by Katz, Avila, and Meille (2010), which differentiates between counties with high and low broadband penetration, which corresponds to the work focused on urban and rural areas. When analyzing the temporal impact in these two geographic areas, it was observed that in urban areas where more last-mile infrastructure was deployed, there was an immediate increase in GDP and employment rate, offsetting the increase in productivity (and consequent job destruction) with the innovation effect and the growth of entrepreneurship. On the other hand, the increase in broadband penetration in rural areas had a smaller initial impact on the GDP growth rate, which increased after the technology managed to penetrate the productive fabric. On the other hand, it was also found that the impact on job creation in rural areas did not show up in the initial years of penetration, since the positive impact of broadband on productivity entailed a capital/labor substitution with no compensatory creation of new enterprises. These effects observed in the different regions can be seen conceptually in Figure 1.

Figure 1. Germany: Differential Impact of Broadband by Region



Source: Katz, Avila, and Meille (2010).

The CINTEL study (Katz and Callorda, 2011) conducted in Colombia between 2006 and 2010 on the impact of the Vive Digital Plan and internet massification confirms different effects for departments with low and high broadband penetration. Thus, it was observed that for every 10 percent increase in broadband penetration, real income per household varies between 0.035 percent for departments with low penetration and 0.025 percent for departments with high penetration. Similarly, the authors point out that there is an impact on the employment rate of 0.003 percent for every 10 percent increase in broadband penetration, which in turn is made up of 0.0029 percent for areas with low penetration and 0.0065 percent for those with high penetration, although the latter are not statistically significant.

Atasoy (2013) analyzed the impact of broadband on the U.S. labor market between 1999 and 2007. To do so, he used Federal Communications Commission (FCC) deployment data in conjunction with demographic and labor market information from the Bureau of Labor Statistics census for 3,116 counties. The study was based on a county fixed effects model and found that access to service was associated with a positive impact on the percentage of the population employed of 1.8 percentage points (see Table 7).

Table 7. Impact of Broadband Availability in 3,116 U.S. Counties

Type of county	Employment	Number of establishments	Unemployment
All counties	0.0181***	0.0048	-0.0476***
Large metropolitan counties	0.0123*	-	-
Metropolitan counties	0.0152*	-	-
Small metropolitan counties	0.0172*	-	-
Metropolitan micro counties	0.0175*	-	-
Rural counties	0.0224***	-	-

Source: Atasoy (2013).

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Similarly, the aforementioned study indicates that unemployment in the counties is reduced by approximately 4.7 percent and the number of establishments is increased by 0.48 percent, although statistical significance was not verified. In addition, the availability of broadband in rural or isolated counties reported an impact on the employed population of 2.2 percentage points, which exceeds the impact found in metropolitan counties, although the author does not state the reasons for a higher rate of increase in employment in rural areas.

Beyond the comparative analyses by geographic area, the study by Viollaz and Winkler (2020) using an ordinary least squares and instrumental variables model, conducted in Jordan between 2010 and 2016, analyzed the impact of broadband by gender. The authors identified a positive effect on female labor force participation from internet adoption, but found no effect on male labor force participation. The study shows that for every percentage point increase in internet access, female labor force participation increases by 0.7 percent.

In summary, comparative studies of the impact of last-mile digital infrastructure in urban and rural environments, based on the methodology of ordinary least squares econometric models, have identified six differentiated effects:

- Urban areas tend to benefit more than rural areas, since they concentrate the sectors with the highest transaction intensity and use of information.
- From a temporal dimension, these benefits of urban areas, such as employment and wage impacts, occur faster in cities than in rural communities.
- Rural communities on the periphery of urban areas benefit more in terms of employment, wages, and entrepreneurship compared to more isolated ones, as broadband deployment facilitates the relocation of certain industrial sectors from the metropolitan center to the periphery.
- Urban and suburban areas with a higher concentration of skilled workers receive more benefits from broadband deployment, mainly due to the increased productivity of more technologically advanced firms.
- Broadband deployment in rural areas is associated with GDP growth (albeit at a lower rate than in urban areas) and a loss of the least productive jobs in the short term, since the positive impact on productivity results in a capital/labor substitution that is not offset by the innovation and entrepreneurship effect observed in cities.
- The variance in the impact of broadband is determined by the level of human capital. The complementarity between the skill level of workers and broadband determines that, with the deployment of broadband, wages and employment levels increase among the most skilled workers and decrease among the least skilled, a phenomenon that increases inequality. The broadband impact channel is manifested in the increase in productivity and performance of those companies that benefit from the deployment of this technology.

- Access to the internet would contribute to reducing the labor participation gap for women, since access to the service could change women's job search strategy. Such behavior is more frequent among young women, women with low educational levels, and single women, and assumes greater access to information as a means to explain greater labor participation.

2.2. Studies Based on Difference-in-Differences Models

Advances in statistical methods and the gradual availability of statistical series and panels made it possible to advance in the analysis of the differentiated urban-rural impact of last-mile digital infrastructure. In addition, due to the availability of household surveys, studies could be extended beyond the environment of advanced economies.

For example, Whitacre, Gallardo, and Strover (2014a) evaluated the impact of broadband on economic growth in rural communities in the United States between 2001 and 2010, in a study of 3,073 counties. The statistical series of supply and adoption of the service were compared with economic variables (e.g., median household income), and the latter were analyzed using the propensity score matching technique between treated group (associated with various broadband thresholds) and control group. The results showed a positive impact on income, especially in rural areas. It is interesting to note that the supply of the service, as opposed to adoption, shows a lower impact (see Table 8).

Table 8. Impact of Broadband in Non-Metropolitan U.S. Counties

Non-metropolitan (rural) counties	Income	Employment	Unemployment	Number of establishments
Counties with high broadband availability (>85%)	-0.054**	-	-0.0476***	-
Counties with low broadband availability (<50%)	0.017*	-	-	-
Counties with high broadband adoption (>60%)	0.013*	-	-0.096***	-
Counties with low broadband adoption (<40%)	-	-0.034*	-	-0.028***
Counties with low average speed (<3Mbps)	0.010*	-	-	-

Source: Whitacre, Gallardo, and Strover (2014a).
 Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Table 8 indicates that increasing broadband availability (i.e., coverage) in rural counties with high coverage has a negative impact on income. Alternatively, increasing availability in counties with low coverage leads to a positive impact (see the first two rows of the table). The authors speculate that this difference could be due to the fact that, in counties with high coverage, unserved households are not waiting for broadband access. Conversely, in counties with low coverage, the increase in availability leads to an increase in income because there is a population that is waiting to access broadband to generate economic benefits. The impact on adoption confirms that the higher the penetration, the greater the increase in income and number of jobs.

Along the same lines, in a working paper by the Peruvian Ministry of Transport and Communications, Aguilar et al. (2020) estimate the impact of internet services on household welfare in the country for the period 2017-2019. To do so, the authors use a quasi-experimental difference-in-differences method, in combination with the propensity score matching technique, on the national household survey panels.

The change in income due to fixed internet access at home reported, on average, values of S/ 298.5 per month per year, of which S/ 275.8 corresponded to urban areas and S/ 390.9 to rural areas, while the impact of internet use at the rural level amounted to S/ 212.1 per month per year. The analysis would indicate a greater impact size in the rural sector, provided that internet access through establishments other than the home is included in the analysis, such as digital kiosks, booths, and educational or work centers, whose presence is greater in rural areas than in urban areas. However, it should also be noted that the authors indicate that "although rural incomes are slightly higher, the percentage of access is still quite low."

The study by Katz and Callorda (2013) estimated the economic impact of broadband deployment in Ecuador. The authors built a model based on microdata from the National Survey of Employment, Unemployment and Underemployment, and study the impact of broadband service deployment on the income of individuals at the cantonal level between 2009 and 2011, based on a difference-in-differences analysis.

The regression model evaluates the impact on the treatment group, which is located in cantons where households started to have broadband, versus a control group, where households never had broadband in the period of analysis. The result is that the deployment of broadband service increases average individual labor income by 3.67 percent per year. The study generated other results of differentiated annual impact on labor income, depending on the use of computer devices and internet access. For example, if the individual uses a computer, the percentage increase in income is higher (3.92 percent). The authors also indicate that there is an annual impact on labor income for the male subsample of 3.40 percent. Among the potential channels of impact on income, the study mentions the following:

- Household members can improve their job search by accessing job boards that provide an efficient means of matching supply and demand (*matching platforms*).
- Last-mile infrastructure allows household members to improve their ability to highlight and signal their capabilities (*resume promotion effect*).

- Broadband access allows household members to access training platforms, which can increase their income through better-paid work.
-
- Broadband generates a positive effect on worker productivity. Then, following the classical labor economics literature, wages in competitive markets are equal to marginal productivity and, therefore, the higher the labor productivity, the better the average wages.
-
- The introduction of broadband also helps reduce job search times and enables the underemployed to obtain full-time employment or jobs with better conditions. This situation reduces periods of unemployment and generates an increase in the migration of underemployed workers to full-time jobs, which, in turn, is a source of higher labor income.

Finally, Bahia et al. (2020) study the impact of mobile broadband coverage on household consumption and poverty reduction in Nigeria. The study crosses information from the general household survey with mobile broadband deployment data from Nigerian mobile operators between 2010 and 2016. The paper uses household and time fixed effects, concluding that mobile broadband coverage had a positive impact on households, both on their consumption levels (increase of about 6 percent) and poverty (4.3 percent reduction of households below the poverty line). The analysis also makes a geographical differentiation, where the impact of coverage on food consumption in rural areas is 7.7 percent, while in urban areas the result is not significant. Similarly, the presence of mobile broadband promotes a 5.2 percent reduction in poverty among rural households.

To summarize, comparative studies of the impact of last-mile digital infrastructure on urban and rural areas, based on propensity score matching and difference-in-differences methodologies, have found different effects according to the universe considered:

- Rural areas tend to benefit more from the availability of broadband, since there are more establishments, such as kiosks, telecenters, educational centers, and others that promote access to information, which would bring greater benefits to the population due to the possibility they have to promote the services and products they can offer in the market.
- The impact of broadband availability on skilled labor employment is higher in most rural areas compared to urban areas. In general, rural and isolated localities show a significant impact on employment; in addition, all areas show a representative benefit in income levels, unemployment rate, and number of establishments. That is, consistent with research analysis based on ordinary least squares econometric models (especially Akerman, Gaarder, and Mogstad, 2015), the population in rural areas that benefits the most from broadband deployment is the most skilled.
- While broadband deployment in general leads to a positive variation in the income of the entire rural population, the use of the service or equipment promotes a greater increase in all the variables studied.
- The differentiation of a lower impact in non-metropolitan or rural areas with high broadband availability, compared to the same types of areas with low service availability, could be explained by the fact that in counties with high coverage, households without service are not waiting for broadband access, while in counties with low coverage, the increase in availability does cause an increase in income, since there is a population that is waiting for broadband access in order to be able to generate economic benefits.

In conclusion, the following study, focused on the Latin American context, aims to verify the existence of heterogeneity of effects with the deployment of last-mile broadband access, both geographically (urban-rural), and in terms of training and gender.

3. Hypotheses to Be Considered in the Regional Analysis

As can be deduced from the analysis of the research literature presented in the previous section, the study of the differential impact between urban and rural, through both the ordinary least squares method with fixed effects and the propensity score matching and difference-in-differences methodologies, has begun to generate important evidence regarding income effects, job creation, and increased entrepreneurship. The evidence has also begun to identify other dimensions of impact, such as temporality, that is, the time required for the economic impact of infrastructure deployment to materialize in the rural world. The results of the preceding study have made it possible to formalize 11 working hypotheses that should be evaluated in the context of Latin America and the Caribbean. These hypotheses can be grouped into five categories for two types of impact analysis: income and employment (see Table 9).

Table 9. Impact Analysis Hypothesis for Income and Employment

Type of impact	Revenues	Employment
Aggregate economic impact	<ul style="list-style-type: none"> H1: Fixed broadband deployment generates a positive impact on total household and labor income. 	<ul style="list-style-type: none"> H2: Broadband deployment is associated with an increase in the employed population and an increase in labor formality.
Comparative urban-rural impact	<ul style="list-style-type: none"> H3: Urban areas tend to benefit more than rural areas in economic terms (increase in income, total and labor income) as a consequence of broadband deployment, since they have the most transaction-intensive and information-intensive industrial sectors (e.g., financial services or professional activities). 	<ul style="list-style-type: none"> H4: Urban areas tend to benefit more than rural areas in terms of employment generation and labor formality, since they have the industrial sectors with the highest intensity of transactions and use of information.
Comparative impact by gender	<ul style="list-style-type: none"> H5: Internet use contributes to the reduction of the income gap between men and women, since access to the service allows women to obtain better-paying jobs. 	<ul style="list-style-type: none"> H6: The use of the internet contributes to the reduction of the gender employment gap, since access to the service can help women in particular to access better-paying jobs.

Table 9. Impact Analysis Hypothesis for Income and Employment (continued)

Type of impact	Revenues	Employment
Comparative impact by educational level	<ul style="list-style-type: none"> • H7: The economic impact of broadband access is higher for the more educated population, since they have a higher level of digital literacy. • H8: The economic impact in rural areas varies according to the level of human capital and digital skills: the higher the level of education, the higher the impact on income. 	<ul style="list-style-type: none"> • H8: The economic impact in rural areas varies according to the level of human capital and digital skills: the higher the level of education, the higher the impact on employment.
Temporary impact	<ul style="list-style-type: none"> • H9: The impact on total and labor income may grow over time due to an increase in the experience of using the service. • H11: The lower benefit in rural areas in relation to urban areas is also short term: the impact on income in rural areas appears in the medium and long term compared to the economy as a whole. 	<ul style="list-style-type: none"> • H10: The economic benefit in labor terms generates an increase, in the short term, in labor formality and, in the long term, in the generation of new jobs.

4. Regional Revenue Impact Analysis

The objective of the regional analysis is to apply the difference-in-differences methodology to a consolidated base of sub-sovereign units (parishes, municipalities, and regions) of Latin American and Caribbean countries.

The analysis is based on the IDB's harmonized database and focuses on the differential impact of broadband on income (both total and labor income), dependent variables that can be harmonized across countries.

4.1. Methodology

To evaluate the impact of last-mile infrastructure deployment on income at the regional level, a difference-in-differences model is specified, according to Equation 1. This is a simple regression, which determines the effect on income generated by residing in an area where there is the possibility of accessing a broadband service offer at home.

$$\ln(Y_{it}) = \beta_0 + \beta_1 \text{Treatment}_{it} + \beta_2 \cdot \text{Year}_t + \beta_3 \text{Area}_i + \beta_4 \cdot X_{it} + \mu_{it} \quad \textcircled{1}$$

Where:

Y_{it} : Income.

Treatment $_{it}$: This is the variable that distinguishes the groups.

- 1: Areas with broadband in the home, defined as areas where at least 10 percent of the households in the survey adopt the service.

0: Areas with no broadband in the home, defined as areas where less than 10 percent of the households in the survey adopt the service.

Year_t: Corresponds to a fixed effect for each year between 2008 and 2019.

Area_i: Corresponds to a fixed effect for each geographic area included in the regression.

X_{it}: This is a matrix of other independent variables used as controls in the specifications, such as urban and rural area, gender and years of education.

μ_{it}: It is the error term.

Different econometric models are applied to the dependent variable, considering both total income (which also includes non-labor income, such as rents or remittances) and exclusively labor income.

Different specifications of the econometric models are made on the independent variables for each analysis. First, the direct relationship between treatment and income is evaluated. Subsequently, understanding that both years of education and area of residence are factors that affect income, an additional control for these factors is included. Finally, a third model is added with an additional control for gender. In all specifications we include controls for year fixed effect (a binary variable for each year included in the regression) and geographic area (a binary variable for each sub-sovereign unit included in the regression).

4.2. Data Used

The regional analysis was based on data on broadband adoption generated by national household surveys of Latin American and Caribbean countries included in the IDB's harmonized database. Broadband was considered at the sub-sovereign level to estimate its impact on income levels, and the calculation was based on the "internet_ch" indicator of the IDB database. If at least 10 percent of households in the sub-sovereign unit have adopted broadband service at home, it is assumed that the service is available.¹²

¹² Each survey asks whether or not the household has an internet connection.

The surveys available for each country between 2008 and 2019 were considered, including the last available survey of each year that contains information at the sub-sovereign level and on the analytical module of information and communication technologies (ICT). The analysis is at the sub-sovereign level, considered in the "region_c" indicator of the harmonized base. Thus, information was initially examined for 16 countries and 263 sub-sovereign units in the region (see Table A1 in Annex 1). Based on the information available in the harmonized database for the period 2008-19, information from the following 16 countries was included in the analysis: Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Panama, Paraguay, Peru, and Uruguay. Also, for various reasons, it was not possible to include information from Argentina, Bahamas, Belize, Guyana, Haiti, Nicaragua, Suriname, Trinidad and Tobago, and Venezuela (see Table 10).

Table 10. Countries and Years Considered in the Regional Analysis, 2008-19

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Argentina	No information in the harmonized base on internet use											
Bahamas	Microdata only up to 2014, which does not allow deployment to be measured											
Barbados	No information in the harmonized base on internet use											
Belize	Latest microdata available for 2008											
Bolivia	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brazil	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Chile	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	No
Colombia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Costa Rica	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Dominican Republic	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
Ecuador	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
El Salvador	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Guatemala	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Guyana	Small base –only three years (2017, 2018, and 2019)– which does not allow deployment to be measured											

Table 10. Countries and Years Considered in the Regional Analysis, 2008-19 (continued)

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Haiti	Information for a single year											
Honduras	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jamaica	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	No
Mexico	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Nicaragua	Microdata only up to 2012, which does not allow deployment to be measured											
Panama	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Paraguay	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Peru	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Suriname	Information for a single year											
Trinidad and Tobago	No regional disaggregation of data											
Uruguay	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Venezuela	Problems in estimating revenues in a comparable way with other countries											

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

For the years, countries, and sub-sovereign units for which information is available, only microdata responding on household internet ownership and income are retained. For the observations that meet the prerequisites, income data between countries are made compatible based on the income indicators of the harmonized base, and the purchasing power parity (PPP) exchange rate indicated by the IDB. To obtain effects in terms of percentage of income, the natural logarithm of income in PPP dollars is estimated. Thus, a total of 15,097 million observations are retained at the regional level (see Table 11).

Table 11. Number of Observations by Country and Year Considered in the Regional Analysis (in thousands)

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Bolivia	0	16	0	34	32	36	37	37	39	38	38	40	345
Brazil	391	399	0	358	362	362	362	356	460	458	0	444	3.950
Chile	0	247	0	200	0	218	0	267	0	216	0	0	1.149
Colombia	209	208	206	207	202	198	197	198	196	194	191	190	2.395
Costa Rica	46	47	41	41	39	39	38	37	37	35	70	0	471
Dominican Republic	0	0	0	0	0	0	0	0	0	20	20	21	62
Ecuador	79	79	83	70	74	81	117	113	114	110	0	0	919
El Salvador	68	83	85	85	86	82	80	88	76	75	75	74	959
Guatemala	0	0	18	18	18	18	17	24	24	23	22	22	204
Honduras	0	98	4	5	29	29	5	24	24	21	23	22	284
Jamaica	5	0	0	0	0	0	6	5	6	13	16	0	50
Mexico	178	0	163	0	43	0	74	0	258	0	269	0	984
Panama	0	0	0	48	0	44	43	42	41	43	41	43	345
Paraguay	3	3	4	5	7	21	20	31	38	35	19	18	205
Peru	92	93	91	103	102	121	120	122	134	128	136	125	1.366
Uruguay	60	133	132	131	120	128	132	121	119	118	109	108	1.410
TOTAL	1.129	1.405	827	1.304	1.113	1.376	1.247	1.465	1.565	1.529	1.029	1.106	15.097

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Note: As the values are expressed in thousands, there are differences between the sums of the rows/columns and the totals due to rounding.

The unavailability of panel data at the household and individual level prevented us from running difference-in-differences regressions at that level of disaggregation. This problem was solved by generating pseudo-panels through the sub-sovereign units.¹³ Thus, the next step was to calculate, for each year and sub-sovereign unit, the average (weighted by the weight of each individual observation)¹⁴ of the indicators of interest (internet ownership, total income, labor income, years of education, gender, urban population, and rural population). Thus, we ended up with 2,159 observations for the analysis for the years 2008 to 2019 (see Table 12).

Table 12. Sub-Sovereign Units by Country and Year Considered in the Regional Analysis

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Bolivia	0	5	0	9	9	9	9	9	9	9	9	9	86
Brazil	27	27	0	27	27	27	27	27	27	27	0	27	270
Chile	0	15	0	15	0	15	0	15	0	16	0	0	76
Colombia	25	25	25	24	24	24	24	24	24	24	24	24	291
Costa Rica	7	7	6	6	6	6	6	6	6	6	6	0	68
Dominican Republic	0	0	0	0	0	0	0	0	0	8	5	6	19
Ecuador	16	18	18	18	18	18	18	18	18	18	0	0	178
El Salvador	14	14	14	14	14	14	14	14	14	14	14	14	168
Guatemala	0	0	3	3	3	3	3	3	3	3	3	3	30
Honduras	0	16	2	2	13	12	2	9	9	11	12	10	98
Jamaica	1	0	0	0	0	0	1	1	1	1	1	0	6
Mexico	32	0	32	0	32	0	32	0	32	0	32	0	192
Panama	0	0	0	10	0	11	11	11	11	11	11	11	87
Paraguay	0	1	3	3	4	7	7	7	7	7	8	8	62

¹³ This was the methodology applied in the case of Ecuador to solve the lack of panel data in the long-term analysis.

¹⁴ For indicators such as internet ownership, urban population, rural population, or gender, the only available option is to use the average as a measure to quantify the percentage of the population that meets each condition in each sub-sovereign area, since these are originally binary variables. For other indicators, such as total income, labor income, or years of education, there is the alternative of using the median as the reference indicator. The average was used for consistency in the treatment of all indicators. In any case, applying logarithms to the variables reduces the sensitivity of the estimates to extreme or atypical observations.

Table 12. Sub-Sovereign Units by Country and Year Considered in the Regional Analysis (continued)

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Peru	25	25	25	25	25	25	25	25	25	25	25	25	300
Uruguay	19	19	19	19	19	19	19	19	19	19	19	19	228
TOTAL	166	172	147	175	194	190	198	188	205	199	169	156	2,159

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Finally, for each econometric regression, observations generated by less than 750 surveys were excluded to preserve statistical reliability at the sub-sovereign level. This situation implies the non-use of only 15 observations out of a total of 2,159 in most of the regressions.¹⁵ This restriction plays an important role in the study of the sample for rural areas, where, if such an exclusion is not made, very important changes in the adoption of the internet are observed due to the temporal variability in the number of observations of the sub-sovereign units with rural population.

4.3. Results

The first econometric model estimates the impact of broadband on revenues based on all available observations in the region. In the first case, where only the fixed effect per year and per sub-sovereign unit is included as a control, we find that the introduction of the service generates a positive and significant impact on total income of 6.92 percent (US\$26.46, according to PPP)¹⁶ and 7.41 percent (US\$22.32) on labor income. Considering the controls by area (positive and significant effect for urban areas) and years of education (positive and significant effect with more years of formal education), there is a positive and significant impact on total and labor income of 6.83 percent (US\$26.11) and 7.32 percent (US\$22.04), respectively. The following are some of the channels that make it possible to generate this effect:

¹⁵ The inclusion of these 15 observations does not significantly affect the results of the overall model.

¹⁶ For the purposes of this study, all figures will be presented in dollars at purchasing power parity.

- Household members can improve their job search by accessing job boards that provide an efficient means of matching supply and demand.

- Last-mile infrastructure allows household members to improve their ability to highlight and signal their capabilities (*resume promotion effect*).

- Broadband access allows household members to access training platforms, which can increase income by getting a better-paying job.

- Broadband generates a positive effect on worker productivity. In competitive markets, wages are equal to marginal productivity and, therefore, the higher the labor productivity, the better the average wages.

- The introduction of broadband helps reduce job search times and allows the underemployed to seek full-time employment in this way. This situation reduces periods of unemployment and generates an increase in the migration of underemployed workers to full-time jobs, which, in turn, generates higher labor income.

The following is a control for gender, which is not significant, with a positive and significant impact on total and labor income of 6.92 percent (US\$26.46) and 7.43 percent (US\$22.38), respectively (Table 13).

Table 13. Impact of Broadband in the Home on Total and Labor Income of the General Population

General model	Ln total revenues			Ln labor income		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.0692259 ***	0.0683115 ***	0.0692314 ***	0.0741532 ***	0.0731912 ***	0.0743324 ***
	(0.0135630)	(0.0117090)	(0.0116884)	(0.0151337)	(0.0130618)	(0.0130529)
Zone	-	0.2313491 ***	0.2427173 ***	-	0.2558870 ***	0.2699903 ***
	-	(0.0760247)	(0.0778672)	-	(0.0842351)	(0.0857824)
Gender	-	-	-0.4959753	-	-	-0.6153026
	-	-	(0.4076116)	-	-	(0.4271907)
Years of education	-	0.0860749 ***	0.0869612 ***	-	0.0877849 ***	0.0888845 ***
	-	(0.0097619)	(0.0096396)	-	0.0115171	(0.0113974)
Remarks	2.145	2.145	2.145	2.145	2.145	2.145
Groups	236	236	236	236	236	236
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.1380	0.6290	0.6323	0.1316	0.6430	0.6488
Average income	\$382.22	\$382.22	\$382.22	\$301.06	\$301.06	\$301.06
Impact on income	\$26.46	\$26.11	\$26.46	\$22.32	\$22.04	\$22.38

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Subsequently, we estimate the impact of the provision of broadband in the home on income, considering only the available observations for men in the region. When only the fixed effect by year and sub-sovereign unit is included as a control, we find that the introduction of the service generates a positive and significant impact on total and labor income of 6.97 percent (US\$27.09) and 7.66 percent (US\$24.04), respectively. And if we consider controls for area (positive and significant effect for urban areas) and years of education (positive and significant effect with more years of formal education), we find a positive and significant impact on total and labor income for men of 6.86 percent (US\$26.68) and 7.55 percent (US\$23.68), respectively (see Table 14).

Table 14. Impact of Broadband in the Home on Men's Incomes

Men	Ln total revenues		Ln labor income	
	(1)	(2)	(1)	(2)
Offer	0.0696679***	0.0686097***	0.0766183***	0.0754907***
	(0.0135370)	(0.0116355)	(0.0145228)	(0.0125084)
Zone	-	0.2548879***	-	0.2834128***
	-	(0.0759164)	-	(0.0837913)
Years of education	-	0.0845612***	-	0.0839045***
	-	(0.0098025)	-	(0.0113009)
Remarks	2.145	2.145	2.145	2.145
Groups	236	236	236	236
Effect per year	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes
R ²	0.1394	0.5804	0.1364	0.5991
Average income	\$388.83	\$388.83	\$313.73	\$313.73
Impact on income	\$27.09	\$26.68	\$24.04	\$23.68

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Subsequently, we estimate the impact of the provision of broadband in the home on income, considering only the observations of women available in the region. When only the fixed effect by year and sub-sovereign unit is included as a control, we find that the introduction of the service generates a positive and significant impact on total and labor income of 6.86 percent (US\$25.79) and 7.02 percent (US\$20.30), respectively. Then, when considering controls for area (positive and significant effect for urban areas) and years of education (positive and significant effect with more years of formal education), there is a positive and significant impact on women’s total and labor income of 6.77 percent (US\$25.43) and 6.93 percent (US\$20.01), respectively (see Table 15).

Table 15. Impact of Broadband in the Home on Women’s Income

Women	Ln total revenues		Ln labor income	
	(1)	(2)	(1)	(2)
Offer	0.0686119***	0.0676683***	0.0702520***	0.0692562***
	(0.0140419)	(0.0123922)	(0.0159095)	(0.0139503)
Zone	-	0.2360093***	-	0.2514879***
	-	(0.0763537)	-	(0.0842806)
Years of education	-	0.0846811***	-	0.0893621***
	-	(0.0093192)	-	(0.0112144)
Remarks	2.145	2.145	2.145	2.145
Groups	236	236	236	236
Effect per year	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes
R ²	0.1369	0.6576	0.1253	0.6626
Average income	\$375.86	\$375.86	\$288.94	\$288.94
Impact on income	\$25.79	\$25.43	\$20.30	\$20.01

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

When comparing the results for the subgroups of men and women, we find that the impact measured in dollars is 5 percent lower for women in terms of total income (US\$26.68 vs. US\$25.43) and 16 percent lower in terms of labor income (US\$23.68 vs. US\$20.01). In view of these results, the possibility of a reduction in this gender gap was studied for some population subgroup. To this end, the impact of broadband in the home on income was estimated, considering only the observations available for men with fewer than eight years of formal education.

The analysis indicates that when only the fixed effect by year and sub-sovereign unit is included as a control, we find that the introduction of the service generates a positive and significant impact on men's total and labor income of 6.82 percent (US\$19.75) and 7.47 percent (US\$16.80), respectively. Now, if we consider controls for area (positive and significant effect for urban areas) and years of education (positive and significant effect with more years of formal education), we find a positive and significant impact on the total income of men with fewer than eight years of formal education of 6.05 percent (US\$17.53), and 6.61 percent (US\$14.86) on labor income (see Table 16).

Table 16. Impact of Broadband at Home on the Income of Men with Fewer Than Eight Years of Formal Education

Men with fewer than eight years of formal education	Ln total revenues		Ln labor income	
	(1)	(2)	(1)	(2)
Offer	0.0681984*** (0.0139309)	0.0605406*** (0.0121982)	0.0746555*** (0.0147703)	0.0660551*** (0.0135686)
Zone	-	0.3704800*** (0.0947947)	-	0.4121347*** (0.1068533)
Years of education	-	0.1088422*** (0.0247682)	-	0.0594756** (0.0294200)
Remarks	2.145	2.145	2.145	2.145
Groups	236	236	236	236
Effect per year	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes
R ²	0.1693	0.5431	0.1518	0.4923
Average income	\$289.52	\$289.52	\$225.03	\$225.03
Impact on income	\$19.75	\$17.53	\$16.80	\$14.86

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

After repeating this exercise for women with fewer than eight years of formal education, we find that the introduction of the service generates a positive and significant impact on total and labor income of 7.44 percent (US\$21.31) and 8.18 percent (US\$17.11), respectively. Likewise, when controls for area (positive and significant effect for urban areas) and years of education (positive and significant effect with more years of formal education) are considered, a positive and significant impact on the total income of women with fewer than eight years of formal education of 6.64 percent (US\$19.03) and 7.25 percent (US\$15.14) on labor income is obtained (see Table 17).

Table 17. Impact of Broadband in the Home on the Income of Women with Fewer Than Eight Years of Formal Education

Women with fewer than eight years of formal education	Ln total revenues		Ln labor income	
	(1)	(2)	(1)	(2)
Offer	0.0744094***	0.0664418***	0.0818452***	0.0724611***
	(0.0151606)	(0.0122102)	(0.0165062)	(0.0141241)
Zone	-	0.3400318***	-	0.4355596***
	-	(0.0994367)	-	(0.1170145)
Years of education	-	0.1292859***	-	0.0807845**
	-	(0.0236386)	-	(0.0318135)
Remarks	2.145	2.145	2.145	2.145
Groups	236	236	236	236
Effect per year	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes
R ²	0.1788	0,5597	0.1753	0.4910
Average income	\$286.39	\$286.39	\$209.00	\$209.00
Impact on income	\$21.31	\$19.03	\$17.11	\$15.14

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

This result shows that, for the subgroup of the population with fewer than eight years of formal education, the introduction of broadband generates an equalizing effect on income between genders. In particular, the gap between men and women is reduced by 9 percent and 2 percent for total and labor income, respectively.

Next, we estimate the impact of the provision of broadband in the home on income, considering only observations located in urban areas. When only the fixed effect by year and sub-sovereign unit is included as a control, we find that the introduction of the service generates a positive and significant impact on total urban and labor income of 4.48 percent (US\$20.14) and 5.11 percent (US\$18.17), respectively, while controlling for years of education (positive and significant effect with more years of formal education), there is a positive and significant impact on total urban and labor income of 4.33 percent (US\$19.46) and 4.96 percent (US\$17.63), respectively. Finally, we also include a control for gender, which is not significant, obtaining a positive and significant impact on total urban income of 4.37 percent (US\$19.65) and 5.02 percent (US\$17.86) on urban labor income (Table 18).

Table 18. Impact of Broadband in the Home on the Income of the Urban Population

Urban area	Ln total revenues			Ln labor income		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.0447773 **	0.0432594 ***	0.0436807 ***	0.0511078 ***	0.0495959 ***	0.0502252 ***
	(0.0180574)	(0.0153851)	(0.0153957)	(0.0194440)	(0.0164542)	(0.0164390)
Gender	-	-	-0.2735266	-	-	-0.4085771
	-	-	(0.3737293)	-	-	(0.4014275)
Years of education	-	0.0875995 ***	0.0879234 ***	-	0.0872511 ***	0.0877349 ***
	-	(0.0088769)	(0.0088007)	-	(0.0104371)	(0.0103510)
Remarks	1.956	1.956	1.956	1.956	1.956	1.956
Groups						
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.1233	0.3723	0.3738	0.1160	0.4043	0.4082
Average income	\$449.87	\$449.87	\$449.87	\$355.56	\$355.56	\$355.56
Impact on income	\$20.14	\$19.46	\$19.65	\$18.17	\$17.63	\$17.86

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Subsequently, we estimate the impact of the provision of broadband in the home on income considering only the observations located in rural areas. When only the fixed effects by year and sub-sovereign units are included as a control, we find that the introduction of the service generates a positive and significant impact on total rural and labor income of 4.30 percent (US\$10.89) and 3.89 percent (US\$7.65), respectively. When controlling for years of education (positive and significant effect with more years of formal education), the impact of the introduction of broadband in the home on income is not significant. This situation remains unchanged when gender is included as an additional control (see Table 19).

Table 19. Impact of Broadband in the Home on the Income of the Rural Population

Rural area	Ln total revenues			Ln labor income		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.0430118 **	0.0060941	0.0054341	0.0388724 *	-0.0001735	-0.0012043
	(0.0169528)	(0.0162217)	(0.0160634)	(0.0221019)	(0.0202968)	(0.0201297)
Gender	-	-	-0.2044684	-	-	-0.3193269
	-	-	(0.3762170)	-	-	(0.4708086)
Years of education	-	0.1145365 ***	0.1149299 ***	-	0.1211393 ***	0.1217537 ***
	-	(0.0198642)	(0.0199272)	-	(0.0259407)	(0.0261056)
Remarks	1.624	1.624	1.624	1.624	1.624	1.624
Groups	210	210	210	210	210	210
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.1522	0.5035	0.5081	0.1122	0.5168	0.5254
Average income	\$253.17	\$253.17	\$253.17	\$196.86	\$196.86	\$196.86
Impact on income	\$10.89	\$0.00	\$0.00	\$7.65	\$0.00	\$0.00

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

In this context, we examined the possibility that the impact in rural areas, under certain conditions, could be positive or, on the contrary, remain nil. To this end, we first analyzed the subgroup of individuals who lived in rural areas and had more than 11 years of formal education.

When the fixed effects by year and sub-sovereign unit are included as a control, we find that the introduction of broadband in rural areas generates a positive and significant impact on the total and labor income of the population with more than 11 years of formal education of 10.27 percent (US\$38.71) and 11.16 percent (US\$34.40), respectively. On the other hand, when controlling for years of education, the impact is maintained, with values of 11.20 percent (US\$42.24) and 12.18 percent (US\$37.53) for total and labor income, respectively. Finally, adding a control for gender (which, in this case, is positive and significant), the impact on total and labor income of the population in rural areas with more than 11 years of formal education amounts to 10.50 percent (US\$39.59) and 11.51 percent (US\$35.46), respectively (see Table 20). This result shows that, in rural areas, the introduction of broadband has a positive impact for the subgroup of the population with an advanced level of formal education.

Table 20. Impact of Broadband in the Home on the Income of the Rural Population with More Than 11 Years of Formal Education

Rural area and formal education >11 years	Ln total revenues			Ln labor income		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.1026634 ***	0.1120382 ***	0.1050161 ***	0.1116080 ***	0.1217553 ***	0.1150603 ***
	(0.0266890)	(0.0265756)	(0.0267040)	(0.0277155)	(0.0274820)	(0.0277605)
Gender	-	-	0.6971112 ***	-	-	0.6646431 ***
	-	-	(0.2128154)	-	-	(0.2346901)
Years of education	-	-0.0610647 ***	-0.0556190 ***	-	-0.0660965 ***	-0.0609044 ***
	-	(0.0128553)	(0.0113514)	-	(0.0147021)	(0.0130407)
Remarks	1.624	1.624	1.624	1.624	1.624	1.624
Groups	210	210	210	210	210	210
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.2354	0.1492	0.2134	0.2358	0.1549	0.2023
Average income	\$377.03	\$377.03	\$377.03	\$308.21	\$308.21	\$308.21
Impact on income	\$38.71	\$42.24	\$39.59	\$34.40	\$37.53	\$35.46

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Another factor analyzed to determine whether in rural areas, in certain contexts, the introduction of broadband has a positive effect, is temporality. In particular, in the following econometric model, a control was added to the treatment variable when the treatment occurred "early" (between 2008 and 2013).

If the fixed effect is controlled exclusively by year and sub-sovereign unit, we find that, in general, the introduction of broadband service has no impact on income. However, when the introduction of broadband occurred between 2008 and 2013, this situation has a positive and significant impact on total and labor income of 4.75 percent (US\$12.02) and 5.32 percent (US\$10.48), respectively. Then, when considering the control for years of education (positive and significant effect with higher number of years of formal education), we find that the overall effect of broadband is still not significant, although it had a positive and significant impact on the population that adopted the service between 2008 and 2013; for this subgroup, the effect on total and labor income was 6.13 percent (US\$15.53) and 6.79 percent (US\$13.37), respectively. Finally, we also include a control for gender that is not significant; the impact remains significant only for early adopters ([early adopters] who went online between 2008 and 2013), which had an effect on total and labor income of 6.20 percent (US\$15.69) and 6.88 percent (US\$13.55), respectively (see Table 21).

Table 21. Impact of Broadband in the Home on the Income of the Rural Population, with Time Effect

Rural area and time effect	Ln total revenues			Ln labor income		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.0284039 (0.0200298)	-0.0138592 (0.0188131)	-0.0148846 (0.0186498)	0.0224925 (0.0252178)	-0.0222663 (0.0228749)	-0.0237783 (0.0227134)
Offer 2008-2013	0.0474584 ** (0.0204507)	0.0613316 *** (0.0191544)	0.0619684 *** (0.0190853)	0.0532153 ** (0.0228879)	0.0679077 *** (0.0212414)	0.0688467 *** (0.0211699)
Gender	- (0.3727859)	- (0.3727859)	-0.2534766 (0.3727859)	- (0.3727859)	- (0.3727859)	-0.3737749 (0.4679536)
Years of education	- (0.0255781)	0.1178724 *** (0.0194828)	0.1183948 *** (0.0195359)	- (0.0255781)	0.1248329 *** (0.0255781)	0.1256031 *** (0.0257469)
Remarks	1.624	1.624	1.624	1.624	1.624	1.624
Groups	210	210	210	210	210	210
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.1598	0.5158	0.5216	0.1215	0.5315	0.5418
Average income	\$253.17	\$253.17	\$253.17	\$196.86	\$196.86	\$196.86
Impact on income of early adopters	\$12.02	\$15.53	\$15.69	\$10.48	\$13.37	\$13.55
Impact on income of late adopters	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

These last two results generate sufficient evidence to affirm that the impact in rural areas is positive and significant in certain cases: (i) when the population has advanced education (more than 11 years of formal education), and (ii) when the service has been available for a prolonged period (more than six years).

Next, we estimate the impact of home broadband on income based on observations of individuals with fewer than eight years of formal education.

In the first case, where only the fixed effect by year and sub-sovereign unit is included as a control, we find that the introduction of the service generates a positive and significant impact on total and labor income of 4.54 percent (US\$12.93) and 5.69 percent (US\$12.19), respectively. The controls for zone and years of education have a positive and significant impact on total and labor income of 4.70 percent (US\$13.37) and 5.63 percent (US\$12.05), respectively. Finally, we also include a control for gender, which is not significant, resulting in a positive and significant impact on total and labor income of 4.77 percent (US\$13.57) and 5.55 percent (US\$11.89), respectively (see Table 22).

Table 22. Impact of Broadband in the Home on the Income of Population with Fewer Than Eight Years of Formal Education

Fewer than eight years of formal education	Ln total revenues			Ln labor income		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.0454221 ***	0.0469864 ***	0.0476736 ***	0.0569403 ***	0.0562852 ***	0.0555306 ***
	(0.0115645)	(0.0114102)	(0.0114047)	(0.0131150)	(0.0131476)	(0.0131012)
Zone	-	0.0727517	0.0689343	-	0.1109037	0.1150955
	-	(0.0934542)	(0.0938560)	-	(0.1085597)	(0.1096035)
Gender	-	-	0.2099384	-	-	-0.2305347
	-	-	(0.2960068)	-	-	(0.3388226)
Years of education	-	0.0765690 ***	0.0772429 ***	-	0.0265546	0.0258147
	-	(0.0271505)	(0.0273978)	-	(0.0365013)	(0.0363368)
Remarks	2.026	2.026	2.026	2.026	2.026	2.026
Groups	231	231	231	231	231	231
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.1573	0.3457	0.3409	0.1421	0.2894	0.2903
Average income	\$284.65	\$284.65	\$284.65	\$214.06	\$214.06	\$214.06
Impact on income	\$12.93	\$13.37	\$13.57	\$12.19	\$12.05	\$11.89

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Next, we estimate the impact of the provision of broadband in the home on income considering only the observations for individuals with eight to 11 years of formal education. When only the fixed effect by year and sub-sovereign unit is included as a control, we find that the introduction of the service generates a positive and significant impact on total and labor income of 4.25 percent (US\$15.91) and 5.51 percent (US\$16.66), respectively. Now, when we consider controls for area and years of education (which has a positive and significant effect), we obtain a positive and significant impact on total and labor income, respectively, of 3.97 percent (US\$14.87) and 5.18 percent (US\$15.68). Finally, we also include a control for gender, which is not significant, which shows a positive and significant impact on total and labor income of 4.13 percent (US\$15.47) and 5.40 percent (US\$16.33), respectively (see Table 23).

Table 23. Impact of Broadband in the Home on the Income of the Population with 8–11 Years of Formal Education

Eight to 11 years of formal education	Ln total revenues			Ln labor income		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.0424615 ***	0.0396858 ***	0.04129890 ***	0.0550738 ***	0.0518406 ***	0.0540035 ***
	(0.0146144)	(0.0143223)	(0.0143562)	(0.0160241)	(0.0155893)	(0.0156677)
Zone	-	0.0399957	0.0431417	-	0.0240657	0.0282842
	-	(0.1206303)	(0.1210785)	-	(0.1251106)	(0.1254755)
Gender	-	-	-0.1757119	-	-	-0.2356054
	-	-	(0.1973933)	-	-	(0.2113955)
Years of education	-	0.1309928 ***	0.1315349 ***	-	0.1509293 ***	0.1516562 ***
	-	(0.0434015)	(0.0432028)	-	(0.0528640)	(0.0527357)
Remarks	1.430	1.430	1.430	1.430	1.430	1.430
Groups	182	182	182	182	182	182
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0672	0.0249	0.0240	0.0810	0.0185	0.0185
Average income	\$374.64	\$374.64	\$374.64	\$302.43	\$302.43	\$302.43
Impact on income	\$15.91	\$14.87	\$15.47	\$16.66	\$15.68	\$16.33

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Subsequently, we estimate the impact of broadband in the home on income, considering only the observations of individuals with more than 11 years of formal education. In the first case, where only the fixed effect by year and sub-sovereign unit is included as a control, we find that the introduction of the service generates a positive and significant impact on total and labor income of 14.31 percent (US\$88.45) and 14.45 percent (US\$72.46), respectively. Likewise, when controls for area (which has a positive and significant effect) and years of education are considered, there is a positive and significant impact on total and labor income of 10.41 percent (US\$64.38) and 10.59 percent (US\$53.11), respectively. Finally, we also control for gender, finding a positive and significant impact on total income of 10.39 percent (US\$64.23) and 10.56 percent (US\$52.97) on labor income (see Table 24).

Table 24. Impact of Broadband in the Home on the Income of Population with More Than 11 Years of Formal Education

More than 11 years of formal education	Ln total revenues			Ln labor income		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.1430865 ***	0.1041392 ***	0.1038993 ***	0.1444644 ***	0.1058834 ***	0.1056131 ***
	(0.0244684)	(0.0245824)	(0.0243411)	(0.0262717)	(0.0264131)	(0.0261019)
Zone	-	1.154522 ***	1.118926 ***	-	1.126660 ***	1.086559 ***
	-	(0.1590141)	(0.1541068)	-	(0.1679727)	(0.1624411)
Gender	-	-	0.5624732 *	-	-	0.6336575 **
	-	-	(0.2921113)	-	-	(0.2917237)
Years of education	-	-0.0671357 ***	-0.0623281 ***	-	-0.0671707 ***	-0.0617547 ***
	-	(0.0140683)	(0.0124095)	-	(0.0147717)	(0.0130560)
Remarks	1.451	1.451	1.451	1.451	1.451	1.451
Groups	197	197	197	197	197	197
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0822	0.3008	0.3431	0.0800	0.2996	0.3448
Average income	\$618.18	\$618.18	\$618.18	\$501.57	\$501.57	\$501.57
Impact on income	\$88.45	\$64.38	\$64.23	\$72.46	\$53.11	\$52.97

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Thus, the analysis by educational level allows us to conclude that the impact of the introduction of broadband increases with years of formal education. This is consistent with the research of Mack and Faggian (2013), which established that the variance in the impact of broadband was conditioned by the level of human capital, which determines that the increase in productivity occurs in places with high levels of human capital and/or workers. Similarly, Akerman, Gaarder, and Mogstad (2015) analyze the complementarity between worker skill level and broadband access. In particular, this study found that, with broadband deployment, wages and employment increase for higher-skilled workers and decrease for less-skilled workers, thus increasing inequality. The impact channel of broadband is the increase in productivity and performance of those companies that benefit from the deployment of this technology.

Finally, we examine the possibility that for the complete sample there is a differential effect based on the timing of the introduction of the service. For this purpose, the original model is given two controls: the first one, which takes into account the cases in which the internet service (treatment) was introduced between 2008 and 2011, and the second one, which takes into account the cases in which the internet service (treatment) was introduced between 2012 and 2015.

When only the fixed effect by year and sub-sovereign unit is included as a control, we find that the introduction of the service generates a positive and significant impact on total and labor income of 5.43 percent (US\$20.77) and 6.25 percent (US\$18.81), respectively. In this first scenario, no additional effect is found in the temporality controls. Then, in the second model, we add a control for urban area (with a positive and significant effect) and years of education (also with a positive and significant effect), finding that, in general, the introduction of the service generates a positive effect on total and labor income of 4.24 percent and 5.04 percent, respectively. It is worth noting that this effect is not the total of total income, since for early adopters (between 2008 and 2011) we obtain an additional effect of 3.23 percent on total income and, for late adopters (between 2012 and 2015), one of 3.07 percent. Thus, the impact on total income for early adopters, laggard adopters, and late adopters is US\$28.56, US\$27.94, and US\$16.91, respectively. In relation to labor income, with a statistical significance level of 10 percent,¹⁷ the temporal effects are not significant, with an impact of US\$15.19 for all periods.

¹⁷ At a statistical significance level of 15 percent, the time effects are significant for both early adopters and late adopters.

Finally, controlling for gender in total income also yields an overall effect of 4.19 percent, to which must be added an additional effect of 3.44 percent for early adopters and 3.22 percent for late adopters. This implies that the final impact is US\$29.14, US\$28.30, and US\$16.00 for early adopters, laggard adopters, and late adopters, respectively. On the other hand, in relation to labor income we obtain an overall effect of 4.98 percent and, in addition, an additional effect for early adopters of 3.04 percent. The additional effect for laggard adopters is 2.96 percent, but it is not significant at the 10 percent significance level.¹⁸ This implies that the impact is US\$24.17 for early adopters and US\$15 for the other two groups (see Table 25).

¹⁸ The coefficient has a statistical significance of 10.1 percent.

Table 25. Impact of Broadband in the Home on the Income of the General Population, with Time Effect (full sample)

Time effects (full sample)	Ln total revenues			Ln labor income		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.0543419 ***	0.0423660 ***	0.0418548 ***	0.0624945 ***	0.0504470 ***	0.0498276 ***
	(0.0160903)	(0.0148879)	(0.0148815)	(0.0176595)	(0.0165093)	(0.0164994)
Offer 2008-2011	0.0218166	0.0323432 **	0.0343896 **	0.0175524	0.0279634	0.0304426 *
	(0.0176273)	(0.0163262)	(0.0163548)	(0.0193465)	(0.0181043)	(0.0181329)
Offer 2012-2015	0.0105796	0.0307452 *	0.0321969 **	0.0072855	0.0277919	0.0295507
	(0.0175084)	(0.0162150)	(0.0162247)	(0.0192160)	(0.0179810)	(0.0179886)
Zone	-	0.2248742 ***	0.2368282 ***	-	0.2503650 ***	0.2648475 ***
	-	(0.0550016)	(0.0553580)	-	(0.0609917)	(0.0613765)
Gender	-	-	-0.5407628 *	-	-	-0.6551388 **
	-	-	(0.2967548)	-	-	(0.3290180)
Years of education	-	0.0870746 ***	0.0880933 ***	-	0.0886761 ***	0.0899102 ***
	-	(0.0055800)	(0.0056045)	-	(0.0061877)	(0.0062139)
Remarks	2.145	2.145	2.145	2.145	2.145	2.145
Groups	236	236	236	236	236	236
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.1358	0.6299	0.6337	0.1296	0.6443	0.6506
Average income	\$382.22	\$382.22	\$382.22	\$301.06	\$301.06	\$301.06
Impact on income of early adopters	\$20.77	\$28.56	\$29.14	\$18.81	\$15.19	\$24.17
Impact on income of laggard adopters	\$20.77	\$27.94	\$28.30	\$18.81	\$15.19	\$15.00
Impact on income of late adopters	\$20.77	\$16.19	\$16.00	\$18.81	\$15.19	\$15.00

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

As an alternative model to the previous one, the same exercise is also performed, but excluding, in Honduras, the years 2009, 2010, and 2014, which have a different number of sub-sovereign regions than the rest of the sample (see Table 12) and may bias the results when temporality is considered.

In the first case (control: fixed effect per year and sub-sovereign unit), we find that the introduction of the service generates a positive and significant impact on total revenues of 3.72 percent, plus an additional 3.77 percent for early adopters. This situation implies an increase in total income of US\$28.71 for early adopters and US\$14.25 for the rest of the groups. In relation to labor income, in this first model a positive and significant impact of 4.68 percent is obtained, although there is no additional effect due to seasonality, which implies an increase in income of US\$14.12, regardless of the year of adoption of the service. When controls for urban area and years of education are added to the regression model, we find that the introduction of broadband generates a positive impact on total revenues of 3.01 percent, with an additional 5.30 percent for early adopters and 3.96 percent for laggard adopters. This indicates an increase in total income of US\$31.85, US\$26.72, and US\$11.55 for early adopters, laggard adopters, and late adopters, respectively. With respect to labor income, the overall effect of broadband introduction is 3.98 percent, with an additional 4.58 percent for early adopters and 3.58 percent for late adopters. The effect yields an increase in labor income for early adopters, laggard adopters, and late adopters of US\$25.85, US\$22.83, and US\$12.02, respectively. Finally, when controlling for gender, similar results are obtained. In the case of total income, a positive impact of 2.99 percent is verified, with an additional 5.43 percent for early adopters and 4.05 percent for late adopters. This implies an increase in income of US\$32.28, US\$27.00, and US\$11.46 for early adopters, laggard adopters, and late adopters, respectively. The positive impact of broadband introduction on labor income was 3.95 percent, with an additional 4.76 percent for early adopters and 3.71 percent for late adopters. This generates an increase in income for early adopters, laggard adopters, and late adopters of US\$26.31, US\$23.12, and US\$11.93, respectively (see Table 26).

Table 26. Impact of Broadband in the Home on the Income of the General Population, with Time Effect (partial sample)

Time effects (partial sample)	Ln total revenues			Ln labor income		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.0371858 **	0.0301416 **	0.0299114 **	0.0467753 ***	0.0398342 **	0.0395276 **
	(0.0156539)	(0.0146794)	(0.0146781)	(0.0173167)	(0.0164097)	(0.0164054)
Offer 2008-2011	0.0377356 **	0.0529579 ***	0.0543169 ***	0.0307060	0.0458356 **	0.0476458 ***
	(0.0172750)	(0.0162463)	(0.0162792)	(0.0191099)	(0.0181614)	(0.0181949)
Offer 2012-2015	0.0230383	0.0395866 **	0.0405459 **	0.0191592	0.0358098 **	0.0370875 **
	(0.0169390)	(0.0159050)	(0.0159206)	(0.0187382)	(0.0177799)	(0.0177940)
Zone	-	0.2270582 ***	0.2352116 ***	-	0.2483657 ***	0.2592253 ***
	-	(0.0539818)	(0.0543566)	-	(0.0603450)	(0.0607530)
Gender	-	-	-0.3711877	-	-	-0.4943959
	-	-	(0.2933949)	-	-	(0.3279204)
Years of education	-	0.0861893 ***	0.0871937 ***	-	0.0869816 ***	0.0883194 ***
	-	(0.0061013)	(0.0061517)	-	(0.0068204)	(0.0068756)
Remarks	2.123	2.123	2.123	2.123	2.123	2.123
Groups	233	233	233	233	233	233
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.1182	0.6186	0.6221	0.1124	0.6329	0.6389
Average income	\$383.27	\$383.27	\$383.27	\$301.77	\$301.77	\$301.77
Impact on income of early adopters	\$28.71	\$31.85	\$32.28	\$14.12	\$25.85	\$26.31
Impact on income of laggard adopters	\$14.25	\$26.72	\$27.00	\$14.12	\$22.83	\$23.12
Impact on income of late adopters	\$14.25	\$11.55	\$11.46	\$14.12	\$12.02	\$11.93

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Note: Monetary figures expressed in U.S. dollars.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

The latter models show that to achieve a greater impact from introducing of broadband, some time must elapse after its implementation, which could be related to the fact that, in order to obtain more significant effects, a greater percentage of the population must use the service.

4.4. Discussion of the Results

The results of the analysis of the impact on income, in terms of the hypotheses proposed, lead to the following conclusions:

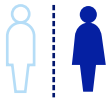
CONCLUSIONS



C1: The hypothesis that fixed broadband generates a positive impact on total and labor income is confirmed. As a consequence of the deployment of the service, we find a positive and significant impact on total and labor income of 6.92 percent (US\$26.46) and 7.43 percent (US\$22.38), respectively.



C3: The hypothesis that, as a consequence of broadband deployment, urban areas tend to benefit more than rural areas in total and labor income is confirmed. In particular, we find that, in general terms, broadband provision in urban centers has a positive impact on total and labor (monthly) income of 4.33 percent (US\$19.46) and 4.96 percent (US\$17.63), respectively, while in rural areas the impact is not significant, except under certain conditions (see H8).



C5: The hypothesis that internet access contributes to reducing the income gap between men and women is not confirmed. In particular, the impact in percentage terms on labor income is quite similar between men and women (7.55 percent for men vs. 6.92 percent for women). This results in an increase in men's labor income of US\$23.68 and in women's labor income of US\$20.01 (16 percent lower). This result shows that, with the introduction of broadband, the labor income gap by gender widens. Once again, this underscores the need for public policies aimed at remedying this progressive inequality. On the other hand, if we analyze the subgroup of the population with fewer than eight years of formal education, we observe that the introduction of broadband has an equalizing effect on income between men and women. For this subgroup, the gap between men and women is reduced by 9 percent and 2 percent for total income and labor income, respectively.



C7: The hypothesis that the economic impact of broadband is higher for the more educated population is confirmed, since this group has a higher level of digital literacy. This can be seen when looking at the role played by formal education in the income of populations with higher levels (more than 11 years) and lower levels (fewer than eight years). In the group with more years of formal education, broadband deployment has a positive impact on labor income of 10.56 percent (US\$52.97), compared to only 5.55 percent (US\$11.89) for the group with fewer than eight years of formal education.



C8: The hypothesis that the economic impact of broadband in rural areas depends on access to equipment and digital skills for internet use is confirmed. The impact on the income of the rural population is positive and significant for those with more than 11 years of formal education (in this group it is more likely that there is use of the service and availability of equipment). In particular, for this group there is a positive impact on total and labor income of 10.50 percent (US\$39.59) and 11.51 percent (US\$35.46), respectively. According to these results, we can conclude that educational level, by acting as a determinant of a greater benefit resulting from broadband, leads *ceteris paribus* to an accentuation of social inequality.¹⁹ This highlights the importance of implementing public policies to compensate for this disadvantage.²⁰



C9: The hypothesis that, for users as a whole, the economic impact (measured in total and labor income) increases over time due to greater experience in using the service is confirmed. In the case of total income, the positive impact is 2.99 percent, with an additional 5.43 percent for early adopters and 4.05 percent for laggard adopters. This implies an increase in income for early adopters of US\$32.28, US\$27.00 for laggard adopters, and US\$11.46 for late adopters. In relation to labor income, the positive impact of broadband introduction is 3.95 percent, with an additional 4.76 percent for early adopters and 3.71 percent for laggard adopters. This translates into an increase in earnings for early adopters, laggard adopters, and late adopters of, respectively, US\$26.31, US\$23.12, and US\$11.93.

¹⁹ An extension of the effect popularly known as the "Matthew effect," according to which the level of education ends up widening the social gap (see Rigney, 2010).

²⁰ This phenomenon of increasing inequality as a result of the diffusion of digital technologies has recently been referred to in a study by ECLAC (2021), which raises the possibility that frontier technologies, such as artificial intelligence, robotics, or gene editing, may widen or create new inequalities.



C11: The hypothesis that the lower benefit for rural areas in relation to urban areas also manifests itself temporally is confirmed: the increase in the income of the rural population occurs more slowly than in the economy as a whole, although it is long-lasting and sustainable in the long term. In particular, we find that, in the short term, the introduction of broadband does not have a significant effect on rural incomes; however, after a minimum of six years of using the service, there is a positive impact on total and labor incomes of 6.13 percent (US\$15.53) and 6.79 percent (US\$13.37), respectively.

5. Regional Analysis of Impact on Employment Indicators

Similar to the analysis of the impact of broadband on income levels, the objective of the regional study that covers employment indicators focuses on the differentiated impact of broadband on employment, considering indicators such as employed population, inactive population, unemployed population, and degree of labor formality.

5.1. Methodology

To assess the impact of last-mile infrastructure deployment on employment metrics (percentages of employed population, inactive and unemployed population, and ratio of formal to informal workers), we use a difference-in-differences model, according to the following equation:

$$\text{Percentage of population by group}_{it} = \beta_0 + \beta_1 \cdot \text{Treatment}_{it} + \beta_2 \cdot \text{Year}_t + \beta_3 \cdot \text{Area}_i + \beta_4 \cdot X_{it} + \mu_{it} \quad \textcircled{2}$$

This is a simple regression, which determines the effect on the percentages of each group generated from residing in an area where broadband service can be accessed at home, where:

Percentage of population by group_{it}: percentage of employed, inactive and unemployed population, and ratio of formal to informal workers.

Treatment_{it}: This is the variable that distinguishes the two groups.

- 1: Areas with broadband service in the home, defined as areas where at least 10 percent of the households in the survey adopt the service.
- 0: Areas with no broadband in the home, defined as areas where less than 10 percent of households adopt the service.

Year_{*t*}: Corresponds to a fixed effect for each year between 2008 and 2019.

Area_{*i*}: Corresponds to a fixed effect for each geographic area (subnational unit) included in the regression.

X_{*it*}: A matrix of other independent variables used as controls in some specifications.

μ_{*it*}: It is the error term.

For the independent variables used in each analysis, different specifications of the econometric models are made. The first model evaluates the direct relationship between treatment and the percentage of the population, by labor group. The second, under the assumption that expected income can affect labor participation decisions, includes a control for total income; and, in a third model, another control for labor income is added. All specifications include controls for year fixed effect (a binary variable for each year included in the regression) and geographic area (a binary variable for each sub-sovereign unit included in the regression).

5.2. Data Used

The regional analysis has been performed based on the broadband adoption data used in the preceding analysis of impact on income.

For the years, countries, and sub-sovereign units for which information was available, only the microdata responding on household internet ownership and labor indicators are retained. For the observations that meet the prerequisites, cross-country employment data are matched based on the harmonized base indicators. This resulted in a total of 12,430,747 observations at the regional level.²¹

²¹ The difference in the number of observations, in relation to the regional analysis on income, lies in the fact that, in this case, only the observations with information on employment status are kept.

As in the case of the previous analysis, the unavailability of panel data at the household and individual level did not allow us to run difference-in-differences regressions at that level of disaggregation, so pseudo-panels were generated through sub-sovereign units.²² Thus, the next step was to generate for each year and sub-sovereign unit the average (weighted by the weight of each individual observation) of the indicators of interest. Finally, for the performance of each econometric regression, observations generated by less than 750 surveys were excluded, as a way to ensure statistical reliability at the sub-sovereign level. This restriction plays an important role in the study of the sample for rural areas, where, if this exclusion is not made, temporal changes in internet adoption associated with temporal variability in the number of observations of sub-sovereign units with rural population are observed. Thus, the analysis ended up with a maximum of 2,119 observations for the period 2008-19.

5.3. Results

The first econometric model estimates the impact of broadband in the home on the levels of employed population, inactive population, unemployed population, and labor formality. Considering only those individuals over the age of 18, the population can be grouped into three categories: employed population (55.38 percent), inactive population (41.23 percent) and unemployed population (3.39 percent). Within the employed population, it is possible to distinguish between the formally and informally employed, which, in the period analyzed, yields an average of 35.59 percent of formally employed (out of the total employed population). The first analysis shows that, with the introduction of broadband, there is a significant increase in the employed population by 0.84 percentage points, which means an increase in employment of 1.51 percent (Model 3). This increase in the employed population comes entirely from a population that was previously inactive; specifically, it has been found that with the broadband offer the inactive population decreases by 0.80 percentage points (1.93 percent). Since all the increase in the level of activity is absorbed by a growth in employment levels, no significant changes in unemployment levels are observed. Finally, since the introduction of broadband, an increase in the labor formality rate of 0.66 percentage points is detected, which implies a 1.84 percent rise in formality levels (see Tables 27 and 28).

²² This was the methodology applied in the cases of Brazil, Ecuador, and El Salvador to solve the lack of panel data in the long-term analysis.

Table 27. Impact of Broadband in the Home on the Employed and the Inactive Population

General model	Employed population			Inactive population		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	1.0354750 ***	0.9792463 ***	0.8369154 ***	-0.9791757 ***	-0.9253868 ***	-0.7952386 ***
	(0.2481441)	(0.2438173)	(0.2405168)	(0.2310316)	(0.2267683)	(0.2240095)
Total income	-	0.0114776 ***	-	-	-0.0109795 ***	-
	-	(0.0013755)	-	-	(0.0012794)	-
Labor income	-	-	0.0180701 ***	-	-	-0.0167393 ***
	-	-	(0.0015719)	-	-	(0.0014640)
Remarks	2.119	2.119	2.119	2.119	2.119	2.119
Groups	232	232	232	232	232	232
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0029	0.0240	0.0239	0.0102	0.0525	0.0476
Percentage of population	55.38	55.38	55.38	41.23	41.23	41.23
Impact	1.04	0.98	0.84	-0.98	-0.93	-0.80
Incremental percentage	1.87	1.77	1.51	-2.37	-2.24	-1.93

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Table 28. Impact of Broadband in the Home on the Unemployed Population and Labor Formality

General model	Unemployed population			Labor formality		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	-0.0562992	-0.0538593	-0.0416766	0.8905924 ***	0.8103909 ***	0.6556249 **
	(0.0753451)	(0.0753664)	(0.0754138)	(0.2814423)	(0.2734755)	(0.2719035)
Total income	-	-0.0004980	-	-	0.0164102 ***	-
	-	(0.0004252)	-	-	(0.0015430)	-
Labor income	-	-	-0.0013307 ***	-	-	0.0213962 ***
	-	-	(0.0004929)	-	-	(0.0017771)
Remarks	2.119	2.119	2.119	2.119	2.119	2.119
Groups	232	232	232	231	231	231
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0090	0.0001	0.0046	0.0236	0.4850	0.4065
Percentage of population	3.39	3.39	3.39	35.59	35.59	35.59
Impact	0.00	0.00	0.00	0.89	0.81	0.66
Incremental percentage	0.00	0.00	0.00	2.50	2.28	1.84

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

The following econometric model estimates the impact of broadband in the home on the levels of employed population, inactive population, unemployed population, and labor formality, considering only the subgroup of men. Including in the analysis only men of legal age, it is possible to group them into three categories: employed population (67.11 percent), inactive population (29.48 percent), and unemployed population (3.40 percent). Within the employed population, it is possible to disaggregate between the formally employed and the informally employed, with an average of 36.14 percent being formally employed (out of the total number of employed) during the period analyzed. The first analysis shows that with the introduction of broadband, the level of employment among men increased significantly by 1.22 percentage points, which implies an increase of 1.83 percent in employment (Model 3). This growth comes entirely from a population that was previously inactive, so it is also observed that, with broadband offer, the inactive population decreases by 1.03 percentage points (3.49 percent). In this case, the increase in employment manages to absorb the totality of the reduction in inactivity levels. To this is added the fact that there is also a 0.20 percentage point decrease in the percentage of unemployed men (5.74 percent). In other words, there is a shift from an inactive to an active population, although not all of them find full-time employment. Finally, with the introduction of broadband, there is an increase in the rate of labor formality of 1.27 percentage points, which means an increase of 3.51 percent (see Tables 29 and 30).

Table 29. Impact of Broadband in the Home on the Employed and Inactive Population, Men

Men	Employed population			Inactive population		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	1.366934 ***	1.334404 ***	1.224940 ***	-1.143824 ***	-1.118443 ***	-1.029709 ***
	(0.2423258)	(0.2412687)	(0.2388397)	(0.2097196)	(0.2090054)	(0.2072065)
Total income	-	0.0057255 ***	-	-	-0.0044673 ***	-
	-	(0.0013048)	-	-	(0.0011303)	-
Labor income	-	-	0.0121703 ***	-	-	-0.0097808 ***
	-	-	(0.0014929)	-	-	(0.0012952)
Remarks	2.119	2.119	2.119	2.119	2.119	2.119
Groups	232	232	232	232	232	232
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0024	0.0069	0.0064	0.0087	0.0236	0.0206
Percentage of population	67.11	67.11	67.11	29.48	29.48	29.48
Impact	1.37	1.33	1.22	-1.14	-1.12	-1.03
Incremental percentage	2.04	1.99	1.83	-3.88	-3.79	-3.49

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Table 30. Impact of Broadband in the Home on the Unemployed Population and Labor Formality, Men

Men	Unemployed population			Labor formality		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	-0.2231096 ***	-0.2159610 **	-0.1952316 **	1.5115990 ***	1.4255020 ***	1.2676630 ***
	(0.0858070)	(0.0857021)	(0.0856048)	(0.2867954)	(0.2795668)	(0.2770312)
Total income	-	-0.0012582 **	-	-	0.0151856 ***	-
	-	(0.0004635)	-	-	(0.0015121)	-
Labor income	-	-	-0.0023894 ***	-	-	0.0209191 ***
	-	-	(0.0005351)	-	-	(0.0017317)
Remarks	2.119	2.119	2.119	2.119	2.119	2.119
Groups	232	232	232	231	231	231
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0002	0.0191	0.0209	0.0525	0.4963	0.4500
Percentage of population	3.40	3.40	3.40	36.14	36.14	36.14
Impact	-0.22	-0.22	-0.20	1.51	1.43	1.27
Incremental percentage	-6.56	-6.35	-5.74	4.18	3.94	3.51

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

The following econometric model estimates the impact of broadband in the home on the employed population, inactive population, unemployed population, and labor formality, considering only women. Older women can be grouped into three categories: employed population (44.27 percent), inactive population (52.33 percent),²³ and unemployed population (3.39 percent). In turn, if we take the subgroup of the employed population, it is possible to distinguish between the formally employed and the informally employed. The study finds that in the period analyzed the average number of formally employed (out of the total number of employees) was 35.02 percent. The first three analyses show that, with the introduction of broadband, there are no significant changes among women in the distribution between the employed, inactive, and unemployed population. Furthermore, the last econometric model shows no significant impact on women in terms of labor formality (see Tables 31 and 32).

²³ It is likely that the gender gap in the inactivity rate is due to the fact that it probably includes care and household tasks that are indispensable for the family, which makes the transition to broadband-facilitated jobs more difficult.

Table 31. Impact of Broadband in the Home on the Employed and Inactive Population, Women

Women	Employed population			Inactive population		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.6775855 **	0.6268281 **	0.4697075	-0.6663388 **	-0.6153361 **	-0.4611509
	(0.3075820)	(0.3002078)	(0.2972760)	(0.3052229)	(0.2977140)	(0.2951129)
Total income	-	0.0162344 ***	-	-	-0.0163129 ***	-
	-	(0.0016670)	-	-	(0.0016532)	-
Labor income	-	-	0.0226225 ***	-	-	-0.0223298 ***
	-	-	(0.0019100)	-	-	(0.0018961)
Remarks	2.119	2.119	2.119	2.119	2.119	2.119
Groups	232	232	232	232	232	232
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0052	0.0395	0.0386	0.0083	0.0680	0.0615
Percentage of population	44.27	44.27	44.27	52.33	52.33	52.33
Impact	0.68	0.63	0.00	-0.67	-0.62	-0.46
Incremental percentage	1.53	1.42	0.00	-1.27	-1.18	-0.88

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Table 32. Impact of Broadband in the Home on the Unemployed Population and Labor Formality, Women

Women	Unemployed population			Labor Formality		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	-0.0112473	-0.0114926	-0.0085571	0.1189304	0.0649404	-0.0732996
	(0.0837347)	(0.0837691)	(0.0838968)	(0.3337256)	(0.3259764)	(0.3258005)
Total income	-	0.0000785	-	-	0.0173262	-
	-	(0.0004652)	-	-	(0.0018103)	-
Labor income	-	-	-0.0002928	-	-	0.0209332
	-	-	(0.0005391)	-	-	(0.0020934)
Remarks	2.119	2.119	2.119	2.119	2.119	2.119
Groups	232	232	232	231	231	231
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0135	0.0176	0.0060	0.0041	0.4517	0.3343
Percentage of population	3.39	3.39	3.39	35.02	35.02	35.02
Impact	0.00	0.00	0.00	0.00	0.00	0.00
Incremental percentage	0.00	0.00	0.00	0.00	0.00	0.00

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

This result indicates that broadband deployment can increase gender inequality, particularly when it is not accompanied by the implementation of public policies that enable the equal use of this technology.

The following econometric model estimates the impact of broadband in the home on levels of employed population, inactive population, unemployed population, and labor formality, considering only the urban population. Older individuals residing in urban areas can be grouped into three categories: employed population (54.58 percent), inactive population (41.30 percent), and unemployed population (4.12 percent). In turn, the employed population can be divided into the formally employed and the informally employed. The study finds that in the period analyzed, the average number of formally employed (out of the total number of employees) was 42.64 percent. The first analysis shows that, with the introduction of broadband, there was a significant increase in the employed population in urban areas of 0.44 percentage points, which implies an increase in employment of 0.81 percent (model 3). This growth in the employed population comes entirely from a previously inactive population; in particular, the inactive population decreases 0.43 percentage points (1.04 percent) with the deployment of broadband. As the entire increase in the level of activity is absorbed by an increase in employment levels, we detect no significant changes in unemployment levels. Finally, the introduction of broadband increases the labor formality rate of 1.55 percentage points, equivalent to an increase of 3.63 percent (see Tables 33 and 34).

Table 33. Impact of Broadband in the Home on the Employed and Inactive Population, Urban Areas

Urban area	Employed population			Inactive population		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.5265463 **	0.5593915 **	0.4395030 *	-0.5119915 **	-0.5447596 **	-0.4293168 *
	(0.2538684)	(0.2471064)	(0.2423451)	(0.2353287)	(0.2280373)	(0.2240922)
Total income	-	0.0100356 ***	-	-	-0.0100121 ***	-
	-	(0.0010316)	-	-	(0.0009520)	-
Labor income	-	-	0.0154584 ***	-	-	-0.0146826 ***
	-	-	(0.0011991)	-	-	(0.0011088)
Remarks	1.915	1.915	1.915	1.915	1.915	1.915
Groups	221	221	221	221	221	221
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0112	0.0460	0.0355	0.0115	0.0530	0.0351
Percentage of population	54.58	54.58	54.58	41.30	41.30	41.30
Impact	0.53	0.56	0.44	-0.51	-0.54	-0.43
Incremental percentage	0.96	1.02	0.81	-1.24	-1.32	-1.04

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Table 34. Impact of Broadband in the Home on the Unemployed Population and Labor Formality, Urban Areas

Urban area	Unemployed population			Labor formality		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	-0.0145545	-0.0146317	-0.0101860	1.6570890 ***	1.7059960 ***	1.5474090 ***
	(0.1054309)	(0.1054720)	(0.1054339)	(0.3820763)	(0.3721048)	(0.3700618)
Total income	-	-0.0000236	-	-	0.0149388 ***	-
	-	(0.0004403)	-	-	(0.0015535)	-
Labor income	-	-	-0.0007758	-	-	0.0194754 ***
	-	-	(0.0005217)	-	-	(0.0018312)
Remarks	1.915	1.915	1.915	1.910	1.910	1.910
Groups	221	221	221	220	220	220
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0170	0.0167	0.0130	0.0277	0.3815	0.2989
Percentage of population	4.12	4.12	4.12	42.64	42.64	42.64
Impact	0.00	0.00	0.00	1.66	1.71	1.55
Incremental percentage	0.00	0.00	0.00	3.89	4.00	3.63

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

The following econometric model estimates the impact of broadband in the home on the levels of employed population, inactive population, unemployed population and labor formality, considering only the rural population. Older individuals residing in rural areas can be grouped into three categories: employed population (53.81 percent), inactive population (44.31 percent) and unemployed population (1.88 percent).²⁴ Within the employed population, a distinction can be made between the formally employed and the informally employed. In the period analyzed, the average number of formally employed (out of the total number of employees) was 20.06 percent. The results of the first three analyses show that the introduction of broadband does not generate significant changes in the distribution of rural residents between employed, inactive, and unemployed. On the other hand, the last model shows a growth in the labor formality rate of 0.97 percentage points, with an increase of 4.84 percent due to the introduction of broadband (see Tables 35 and 36).

²⁴ In urban areas (Table 33), the employment rate is 54.48 percent and the inactivity rate is 41.30 percent. In rural areas, the distribution is similar (see Table 35): 53.81 percent and 44.31 percent, respectively. Unemployment is higher in urban than in rural areas, with levels of 4.12 percent and 1.88 percent, respectively (Tables 34 and 36); however, in neither case is a statistically significant impact found.

Table 35. Impact of Broadband in the Home on the Employed and Inactive Population, Rural Areas

Rural area	Employed population			Inactive population		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.1671679	0.0231484	-0.0326258	-0.2711663	-0.1201370	-0.0639587
	(0.4490907)	(0.4461829)	(0.4460344)	(0.4443669)	(0.4407884)	(0.4406439)
Total income	-	0.0107675 ***	-	-	-0.0112916 ***	-
	-	(0.0033254)	-	-	(0.0032852)	-
Labor income	-	-	0.0141980 ***	-	-	-0.0147249 ***
	-	-	(0.0039283)	-	-	(0.0038809)
Remarks	497	497	497	497	497	497
Groups	77	77	77	77	77	77
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0057	0.0188	0,0207	0.0051	0.0241	0.0267
Percentage of population	53.81	53.81	53.81	44.31	44.31	44.31
Impact	0.00	0.00	0.00	0.00	0.00	0.00
Incremental percentage	0.00	0.00	0.00	0.00	0.00	0.00

Source: Authors' elaboration. based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Table 36. Impact of Broadband in the Home on the Unemployed Population and Labor Formality, Rural Zones

Rural area	Unemployed population			Labor formality		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.1039985	0.0969888	0.0965847	1.1414150 ***	1.0299370 ***	0.9717130 **
	(0.0830071)	(0.0834523)	(0.0837022)	(0.3964513)	(0.3950407)	(0.3942017)
Total income	-	0.0005241	-	-	0.0083399 ***	-
	-	(0.0006220)	-	-	(0.0029446)	-
Labor income	-	-	0.0005269	-	-	0.0120655 ***
	-	-	(0.0007372)	-	-	(0.0034722)
Remarks	497	497	497	495	495	495
Groups	77	77	77	76	76	76
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0207	0.0449	0.0425	0.0413	0.2553	0.2822
Percentage of population	1.88	1.88	1.88	20.06	20.06	20.06
Impact	0.00	0.00	0.00	1.14	1.03	0.97
Incremental percentage	0.00	0.00	0.00	5.69	5.14	4.84

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Note: Econometric models were used for rural areas, considering seasonality. There is no impact of migration from inactive to employed population, and the effect on the improvement of labor formality is maintained.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

This result demonstrates that broadband deployment can generate increases in inequality, especially when it is not supported by public digital literacy policies aimed at achieving its assimilation among different sectors of the population, such as people residing in rural areas.

The following econometric model estimates the impact of broadband in the home on the levels of employed population, inactive population, unemployed population and labor formality, considering only the population with fewer than 11 years of formal education. Among older individuals with fewer than 11 years of formal education, it is possible to distinguish three groups: employed population (49.33 percent), inactive population (48.10 percent), and unemployed population (2.57 percent). Likewise, as mentioned above, the employed population includes both the formally and informally employed; in the period analyzed, the average number of formally employed (out of the total number of employees) was 23.50 percent. The first three analyses show that the introduction of broadband does not generate significant changes for the population with fewer than 11 years of formal education in its distribution among the employed, the inactive, and the unemployed. In contrast, the last of the models suggests that with the introduction of broadband there is an increase in the labor formality rate of 0.47 percentage points, which implies an increase of 2.02 percent (see Tables 37 and 38).

Table 37. Impact of Broadband in the Home on the Employed and Inactive Population with Fewer Than 11 Years of Formal Education

Fewer than 11 years of formal education	Employed population			Inactive population		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	-0.0884591 (0.2760333)	-0.1197647 (0.2740498)	-0.2377975 (0.2711757)	0.1897896 (0.2631094)	0.2159765 (0.2616858)	0.3104526 (0.2599669)
Total income	-	0.0122088 *** (0.0023096)	-	-	-0.0102125 (0.0022054)	-
Labor income	-	-	0.0230463 *** (0.002686)	-	-	-0.0186210 (0.002575)
Remarks	2.040	2.040	2.040	2.040	2.040	2.040
Groups	232	232	232	232	232	232
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0063	0.0001	0.0005	0.0081	0.0033	0.0007
Percentage of population	49.33	49.33	49.33	48.10	48.10	48.10
Impact	0.00	0.00	0.00	0.00	0.00	0.00
Incremental percentage	0.00	0.00	0.00	0.00	0.00	0.00

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Table 38. Impact of Broadband in the Home on the Unemployed Population and Labor Formality, for Population with Fewer Than 11 Years of Formal Education

Fewer than 11 years of formal education	Unemployed population			Labor formality		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	-0.1013308	-0.0962120	-0.0726553	0.5660362 **	0.5339776 **	0.4735480 **
	(0.0710284)	(0.0708445)	(0.0704097)	(0.2350292)	(0.2325043)	(0.2331032)
Total income	-	-0.0019963 ***	-	-	0.0125456 ***	-
	-	(0.0005971)	-	-	(0.0019597)	-
Labor income	-	-	-0.0044253 ***	-	-	0.0142830 ***
	-	-	(0.0006974)	-	-	(0.0023091)
Remarks	2.040	2.040	2.040	2.035	2.035	2.035
Groups	232	232	232	231	231	231
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0023	0.0450	0.0298	0.0283	0.4357	0.2878
Percentage of population	2.57	2.57	2.57	23.50	23.50	23.50
Impact	0.00	0.00	0.00	0.57	0.53	0.47
Incremental percentage	0.00	0.00	0.00	2.41	2.27	2.02

Source: Authors' elaboration based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

The following econometric model estimates the impact of broadband in the home on the levels of employed population, inactive population, unemployed population, and labor formality considering only the population with more than 11 years of formal education. Among older individuals with more than 11 years of formal education, it is possible to distinguish three groups: employed population (67.01 percent), inactive population (27.96 percent), and unemployed population (5.04 percent). In addition, the employed population includes the formally employed and the informally employed; in the period analyzed, the average number of formally employed (out of the total number of employees) was 52.94 percent. The first analysis shows that the introduction of broadband significantly increased the employed population in urban areas by 0.69 percentage points, which implies an increase in employment of 1.03 percent (model 3). This growth comes entirely from a previously inactive population; in particular, with broadband, the inactive population decreases by 1.49 percentage points (5.35 percent). The incentives that the inactive population had to become active were of such magnitude that the labor market did not manage to employ all of the new population. Thus, these 0.80 percentage points of excluded population generated an increase in the unemployment rate. Finally, with respect to the labor formality rate, there was an increase of 1.01 percentage points, equivalent to an increase of 1.92 percent (see Tables 39 and 40).

Table 39. Impact of Broadband in the Home on the Employed and Inactive Population with More Than 11 Years of Formal Education

More than 11 years of formal education	Employed population			Inactive population		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.9029532 **	0.8179917 **	0.6931426 *	-1.6796880 ***	-1.6031800 ***	-1.4945750 ***
	(0.3865692)	(0.3742232)	(0.3690447)	(0.3642418)	(0.3536471)	(0.3498592)
Total income	-	0.0118776 ***	-	-	-0.0106958 ***	-
	-	(0.0010516)	-	-	(0.0009938)	-
Labor income	-	-	0.0160643 ***	-	-	-0.0141733 ***
	-	-	(0.0011752)	-	-	(0.0011141)
Remarks	2.119	2.119	2.119	2.119	2.119	2.119
Groups	232	232	232	232	232	232
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0206	0.0918	0.0989	0.0247	0,0862	0.0898
Percentage of population	67.01	67.01	67.01	27.96	27.96	27.96
Impact	0.90	0.82	0.69	-1.68	-1.,60	-1.49
Incremental percentage	1.35	1.22	1.03	-6.01	-5.73	-5.35

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Table 40. Impact of Broadband in the Home on the Unemployed Population and Labor Formality, for Population with More Than 11 Years of Formal Education

More than 11 years of formal education	Unemployed population			Labor formality		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.7767354 ***	0.7851886 ***	0.8014332 ***	1.1106810 **	1.0719690 **	1.0139490 **
	(0.1457779)	(0.1455223)	(0.1452969)	(0.4341643)	(0.4320894)	(0.4313228)
Total income	-	-0.0011818 ***	-	-	0.0054003 ***	-
	-	(0.0004089)	-	-	(0.0012143)	-
Labor income	-	-	-0.0018910 ***	-	-	0.0073995 ***
	-	-	(0.0004627)	-	-	(0.0013735)
Remarks	2.119	2.119	2.119	2.114	2.114	2.114
Groups	232	232	232	231	231	231
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0409	0.0299	0.0274	0.0206	0.3540	0.3448
Percentage of population	5.04	5.04	5.04	52.94	52.94	52.94
Impact	0.78	0.79	0.80	1.11	1.07	1.01
Incremental percentage	15.42	15.58	15.91	2.10	2.02	1.92

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

As is the case with gender and residence, broadband deployment can generate increases in inequality in relation to people's formal education, provided that it is not accompanied by public digital literacy policies aimed at facilitating its use among the different sectors of the population.

The last of the econometric models estimates the impact of broadband in the home on levels of employed population, inactive population, unemployed population, and labor formality, considering the entire population over the age of 18 and including an additional control for seasonality. Older individuals can be grouped into three categories: employed population (55.38 percent), inactive population (41.23 percent), and unemployed population (3.39 percent). Within the employed population, a distinction can be made between the formally employed and the informally employed. In the period analyzed, the average number of formally employed (out of the total number of employees) was 35.59 percent. In particular, this model finds that, in the short term, labor formality increases by 3.62 percent, while the level of employment does not show a significant change. On the other hand, in the long term, the level of labor formality reports an increase of only 0.91 percent, due to a 2.66 percent increase in the employed population (see Tables 41 and 42). It is possible that, in the long term, the new jobs generated are informal (quantified in terms of the increase in the employed population), which explains the lower increase in labor formality.

Table 41. Impact of Broadband in the Home on the Employed and Inactive Population, with Time Effect

With time effect	Employed population			Inactive population		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	0.3044914 (0.3443026)	0.0061285 (0.3391940)	-0.1309505 (0.3341858)	-0.2742403 (0.3205007)	0.0112706 (0.3153748)	0.1295072 (0.3111747)
Offer 2008-2012	1.122808 *** (0.3674958)	1.489827 *** (0.3626368)	1.477409 *** (0.3557958)	-1.082797 *** (0.3420905)	-1.434006 *** (0.3371714)	-1.411588 *** (0.3312967)
Total income	-	0.0121294 *** (0.0013789)	-	-	-0.0116069 *** (0.0012821)	-
Labor income	-	-	0.0186184 *** (0.0015707)	-	-	-0.0172633 *** (0.0014625)
Remarks	2.119	2.119	2.119	2.119	2.119	2.119
Groups	232	232	232	232	232	232
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0050	0.0266	0.0260	0.0122	0.0553	0.0499
Percentage of population	55.38	55.38	55.38	41.23	41.23	41.23
Impact on early adopters	1.12	1.49	1.48	-1.08	-1.43	-1.41
Impact on late adopters	0.00	0.00	0.00	0.00	0.00	0.00
Incremental percentage of early adopters	2.03	2.69	2.67	-2.63	-3.48	-3.42
Incremental percentage of late adopters	0.00	0.00	0.00	0.00	0.00	0.00

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Table 42. Impact of Broadband in the Home on the Unemployed Population and Labor Formality, with Time Effect

With time effect	Unemployed population			Labor formality		
	(1)	(2)	(3)	(1)	(2)	(3)
Offer	-0.0302508 (0.1047986)	-0.0173989 (0.1053128)	0.0014435 (0.1052551)	1.7800030*** (0.3903615)	1.3861280*** (0.3816925)	1.2882040*** (0.3789559)
Offer 2008-2012	-0.0400110 (0.1118582)	-0.0558202 (0.1125913)	-0.0658212 (0.1120614)	-1.3661100*** (0.4166504)	-0.8814224** (0.4080667)	-0.9655796** (0.4034554)
Total income	-	-0.0005225 (0.0004281)	-	-	0.0160247*** (0.0015518)	-
Labor income	-	-	-0.0013552*** (0.0004947)	-	-	0.0210379*** (0.0017812)
Remarks	2.119	2.119	2.119	2.114	2.114	2.114
Groups	232	232	232	231	231	231
Effect per year	Yes	Yes	Yes	Yes	Yes	Yes
Fix effect for sub-sovereign unit	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.0095	0.0001	0.0045	0.0287	0.4831	0.4069
Percentage of population	3.39	3.39	3.39	35.59	35.59	35.59
Impact on early adopters	0.00	0.00	0.00	0.41	0.50	0.32
Impact on late adopters	0.00	0.00	0.00	1.78	1.39	1.29
Incremental percentage of early adopters	0.00	0.00	0.00	1.16	1.42	0.91
Incremental percentage of late adopters	0.00	0.00	0.00	5.00	3.89	3.62

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

Standard errors in parentheses.

Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

5.4. Discussion of the Results

With regard to the impact on employment, the results of the analysis, in terms of the hypotheses proposed, allow us to reach the following conclusions:

CONCLUSIONS

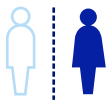


C2: The hypothesis that broadband generates incentives to join the labor force is confirmed. As a consequence of the deployment of the service, the inactive population decreases by 0.80 percentage points, which generates a positive effect on the employed population of 0.84 percentage points. In addition, the hypothesis that broadband has a positive effect on higher-quality jobs, reflected in an increase in labor formality, is confirmed. In particular, on average, labor formality increases by 0.66 percentage points, which implies an increase of 1.84 percent.



C4: The hypothesis that urban areas tend to benefit more than rural areas in terms of employment (employment generation and labor formality) as a consequence of broadband deployment is confirmed. Indeed, in urban centers there is a migration from inactive population (0.43 percentage points) to employed population (0.44 percentage points). This result, which is not recorded in rural areas, confirms the conclusion of Akerman, Gaarder, and Mogstad (2015) regarding the transmission channels of the broadband effect. To the extent that urban centers concentrate a greater number of technology beneficiary firms, in terms of their productivity and workers whose skill levels allow them to take greater advantage of such technology, it is to be expected that with broadband deployment urban areas will benefit more than rural areas.

In terms of labor formality, in urban centers, it increases by 1.55 percentage points, while in rural areas the impact is significant but lower, at 0.97 percentage points. Considering temporality, in rural areas there is no impact of migration of the inactive population to the employed population, maintaining the effect on the improvement of labor formality.



C6: In the income analysis, the hypothesis that internet use contributes to reducing the labor gap between men and women is not confirmed. Although the results show that for men there is a migration from the inactive to the employed population, the same is not true for women, among whom this migration is not significant. In terms of labor formality, for men there is an increase of 1.27 percentage points, while for women there is no statistically significant effect. This result shows that the deployment of broadband can generate an increase in gender inequality, if it is not accompanied by public policies that allow equal use of this technology.



C8: The hypothesis that the impact on employment is higher for the more educated population is confirmed. In the population with more than 11 years of formal education, a migration from inactive population (1.49 percentage points) to employed population (0.69 percentage points) is observed. This effect is not repeated in the population with fewer than 11 years of formal education. In terms of labor formality, for the population with more than 11 years of formal education there is an increase of 1.01 percentage points as a consequence of broadband deployment. For the population with fewer than 11 years of formal education, this impact is 0.47 percentage points.



C10: The hypothesis that the economic benefit in labor terms produces increases, in the short term, in labor formality and, in the long term, in the generation of new jobs, is confirmed. In particular, we find that, in the short term, labor formality increases by 3.62 percent, while there is no significant change in the level of employment. On the other hand, in the long term, the level of labor formality grows by only 0.91 percent, due to the fact that the employed population increases by 2.67 percent. It is possible that, in the long term, the new jobs generated (quantified by the increase in the employed population) are informal, which implies a lower increase in labor formality.

6. Public Policy Implications

The body of evidence provides a rich empirical basis for the formulation of last-mile digital infrastructure deployment strategies and the reduction of demand gaps in Latin America and the Caribbean.

In particular, these results show that broadband deployment can generate an increase in inequality at three levels (between genders, between urban and rural populations, and between more and less formally educated individuals), if not accompanied by public policies that allow access to an equal use of this technology. This evidence is consistent with the results of previous studies that highlight the complementarity between broadband and levels of training and skills in the estimation of benefits. The results of this study show that broadband improves job creation, the transition to formality, and wages for the entire population; likewise, the difference between the more-skilled and the less-skilled population is posed in terms of the level of impact. This is why public policies should be considered as a compensatory mechanism to counteract unintended effects.

In view of the above, four public policy axes should be considered to complement connectivity infrastructure deployment programs:



The results highlight the **need to carry out digital literacy actions in rural areas** to support the use of broadband in the productive fabric. Digital literacy programs should focus not only on communicating available services, but also on developing reliability in use and explaining the benefits of digital connectivity and the conditions necessary to ensure privacy and security. Programs can be organized into three areas of intervention:

- Incorporation of digital literacy content in formal education programs, including for both students and teachers. These programs are critical for capacity building in the early stages of development. Also, formal education provides an opportunity to reach large segments of the population. Considering that a portion of the most vulnerable population in the region does not reach an educational level higher than primary education, formal education could be the only mechanism for promoting digital literacy. Finally, children with digital skills acquired at school can become agents of change and educate adults at home. Implementing these programs in the region is not without difficulties. For example, in many countries the intervention focuses exclusively on the provision of electronic devices in schools, when in reality the *bottlenecks* are more related to the existence of broadband with sufficient capacity in the school, the provision of connectivity to the student at home, the development of curricula adapted to the demands of virtual education, and the professional training of teachers. All these elements are key to the development of formal education programs at the primary level. Similarly, programs at the secondary level and technical schools require the components of primary education, to which must be added specific infrastructure for learning at school (computer laboratories and special teaching devices) and vocational education programs aimed at ensuring an adequate transition to the labor market.

- Deployment of programs aimed at specific segments of the population, including the elderly, the unemployed, people with disabilities, and others. Research shows that these segments of the population represent, from a sociodemographic point of view, one of the central components of the digital divide. In addition, literacy programs must be tailored to the needs of each segment. For example, for the elderly population, priority should be given to digital uses to aid socialization, information, telemedicine, and entertainment. In the segment of unemployed people, emphasis should be placed on capacity building to enable them to reenter the labor market. Programs for people with disabilities should focus on building work skills and, in some cases, support for socialization. In short, these interventions should not be designed or implemented in a generic way. It is recommended that they should be implemented by public sector organizations, such as the ministries of labor, social development, and education, among others.
-
- Implementation of generic programs to support the population in all community centers (libraries, cultural centers, clinics, etc.). Community centers are a locus of knowledge transmission and digital literacy. Libraries should be transformed not only into access centers for written publications, but also into centers for digitization and support to the population, providing training courses and acting as technical support platforms.



The minor impact on rural areas, a topic widely covered in the literature surveyed, requires recognition that **conventional rural development programs aimed at the creation of new ventures** represent an adequate complement to the development of digital infrastructure with universal reach.



The results of the study suggest that there is a greater impact on those who actually use the internet service. In other words, the results suggest a spillover effect toward the entire population of the sub-sovereign unit, which, however, may increase income inequality between users and non-users. Therefore, there is a need to **implement public policies to encourage the adoption of broadband service** to close the demand gap in the localities that receive connectivity. This may be reflected in the growing gender inequality and differences in educational level.



With respect to the growing gender inequality, the greater short-term impact on men's employment (due to the network building effect), and the lack of impact on women's labor participation in the long term, indicate the need to **act on online employment opportunities in sectors with higher labor participation among women**, such as services, health, and education. These programs can include support modules for homemakers to increase social and economic inclusion. Among the best practices for the development of such programs (Katz and Berry, 2014), international experience recommends:

- Digital literacy and mentoring courses should be taught by women.

- Promote courses in places that women attend, such as clinics, markets, and schools.

- Organize curricula in such a way that they focus on the specific needs of the students and not on compliance with a rigid program.

- Consider partnerships of each program with civil society organizations involved in women's development and inclusion.

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Annex 1. Countries and Sub-Sovereign Units Considered in the Regional Analysis

Table A1. Countries and Sub-Sovereign Units Used to Measure the Socioeconomic Impact of Last-Mile Infrastructure Development in Latin America and the Caribbean

Country	Region	Country	Region
Bolivia	Chuquisaca	Brazil	Rio de Janeiro
Bolivia	La Paz	Brazil	São Paulo
Bolivia	Cochabamba	Brazil	Parana
Bolivia	Oruro	Brazil	Santa Catarina
Bolivia	Potosí	Brazil	Rio Grande do Sul
Bolivia	Tarija	Brazil	Mato Grosso do Sul
Bolivia	Santa Cruz	Brazil	Mato Grosso
Bolivia	Beni	Brazil	Goiás
Bolivia	Pando	Brazil	Distrito Federal
Brazil	Rondônia	Chile	Tarapacá
Brazil	Acre	Chile	Antofagasta
Brazil	Amazonas	Chile	Atacama
Brazil	Roraima	Chile	Coquimbo
Brazil	Pará	Chile	Valparaíso
Brazil	Amapá	Chile	Libertador General Bernardo O'Higgins
Brazil	Tocantins	Chile	Maule
Brazil	Maranhão	Chile	Bío Bío
Brazil	Piauí	Chile	La Araucanía
Brazil	Ceará	Chile	Los Lagos
Brazil	Rio Grande do Norte	Chile	Aysén del General Carlos Ibáñez del Campo
Brazil	Paraíba	Chile	Magallanes and Antarctica Chilena
Brazil	Pernambuco	Chile	Metropolitana de Santiago
Brazil	Alagoas	Chile	Los Ríos
Brazil	Sergipe	Chile	Arica y Parinacota
Brazil	Bahia	Chile	Not delimited
Brazil	Minas Gerais	Colombia	Antioquia
Brazil	Espírito Santo	Colombia	Atlántico

Table A1. Countries and Sub-Sovereign Units Used to Measure the Socioeconomic Impact of Last-Mile Infrastructure Development in Latin America and the Caribbean (continued)

Country	Region	Country	Region
Colombia	Bogotá, D.C.	Dominican Republic	Distrito Nacional
Colombia	Bolívar	Dominican Republic	Azua
Colombia	Boyaca	Dominican Republic	Bahoruco
Colombia	Caldas	Dominican Republic	Barahona
Colombia	Caquetá	Dominican Republic	Dajabón
Colombia	Cauca	Dominican Republic	Duarte
Colombia	César	Dominican Republic	Elías Piña
Colombia	Córdoba	Dominican Republic	El Seibo
Colombia	Cundinamarca	Dominican Republic	Espailat
Colombia	Chocó	Dominican Republic	Independencia
Colombia	Huila	Dominican Republic	La Altagracia
Colombia	La Guajira	Dominican Republic	La Romana
Colombia	Magdalena	Dominican Republic	La Vega
Colombia	Meta	Dominican Republic	María Trinidad Sánchez
Colombia	Nariño	Dominican Republic	Monte Cristi
Colombia	Norte de Santander	Dominican Republic	Pedernales
Colombia	Quindío	Dominican Republic	Peravia
Colombia	Risaralda	Dominican Republic	Puerto Plata
Colombia	Santander	Dominican Republic	Salcedo
Colombia	Sucre	Dominican Republic	Samana
Colombia	Tolima	Dominican Republic	San Cristóbal
Colombia	Valle	Dominican Republic	San Juan
Costa Rica	Central	Dominican Republic	San Pedro de Macorís
Costa Rica	Chorotega	Dominican Republic	Sanchez Ramirez
Costa Rica	Pacífico central	Dominican Republic	Santiago
Costa Rica	Brunca	Dominican Republic	Santiago Rodriguez
Costa Rica	Huetar Atlántica	Dominican Republic	Valverde
Costa Rica	Huetar Norte	Dominican Republic	Monseñor Nouel
Costa Rica	Limón	Dominican Republic	Monte Plata

Table A1. Countries and Sub-Sovereign Units Used to Measure the Socioeconomic Impact of Last-Mile Infrastructure Development in Latin America and the Caribbean (continued)

Country	Region	Country	Region
Dominican Republic	Hato Mayor	El Salvador	La Paz
Dominican Republic	San José de Ocoa	El Salvador	Cabañas
Dominican Republic	Santo Domingo	El Salvador	San Vicente
Ecuador	Azuay	El Salvador	Usulután
Ecuador	Bolívar	El Salvador	San Miguel
Ecuador	Cañar	El Salvador	Morazán
Ecuador	Carchi	El Salvador	La Unión
Ecuador	Cotopaxi	Guatemala	Región 1
Ecuador	Chimborazo	Guatemala	Región 2
Ecuador	El Oro	Guatemala	Región 3
Ecuador	Esmeraldas	Honduras	Atlántida
Ecuador	Guayas	Honduras	Colón
Ecuador	Imbabura	Honduras	Comayagua
Ecuador	Loja	Honduras	Copán
Ecuador	Los Ríos	Honduras	Cortés
Ecuador	Manabí	Honduras	Choluteca
Ecuador	Pichincha	Honduras	El Paraíso
Ecuador	Tungurahua	Honduras	Francisco Morazán
Ecuador	Santo Domingo de los Tsáchilas	Honduras	Intibucá
Ecuador	Santa Elena	Honduras	La Paz
Ecuador	Amazonía	Honduras	Lempira
Ecuador	Undemarcated areas	Honduras	Ocotepeque
El Salvador	Ahuachapán	Honduras	Olancho
El Salvador	Santa Ana	Honduras	Santa Barbara
El Salvador	Sonsonate	Honduras	Valle
El Salvador	Chalatenango	Honduras	Yoro
El Salvador	La Libertad	Jamaica	Jamaica
El Salvador	San Salvador	Mexico	Aguascalientes
El Salvador	Cuscatlán	Mexico	Baja California

Table A1. Countries and Sub-Sovereign Units Used to Measure the Socioeconomic Impact of Last-Mile Infrastructure Development in Latin America and the Caribbean (continued)

Country	Region	Country	Region
Mexico	Baja California Sur	Mexico	Zacatecas
Mexico	Campeche	Panama	Bocas del Toro
Mexico	Coahuila de Zaragoza	Panama	Cocle
Mexico	Colima	Panama	Colón
Mexico	Chiapas	Panama	Chiriqui
Mexico	Chihuahua	Panama	Darien
Mexico	Distrito Federal	Panama	Herrera
Mexico	Durango	Panama	Los Santos
Mexico	Guanajuato	Panama	Panamá
Mexico	Guerrero	Panama	Veraguas
Mexico	Hidalgo	Panama	Guna Yala
Mexico	Jalisco	Panama	Emberá
Mexico	México	Panama	Ngäbe-Buglé
Mexico	Michoacán de Ocampo	Paraguay	Asunción
Mexico	Morelos	Paraguay	San Pedro
Mexico	Nayarit	Paraguay	Caaguazú
Mexico	Nuevo León	Paraguay	Itapua
Mexico	Oaxaca	Paraguay	Alto Paraná
Mexico	Puebla	Paraguay	Central
Mexico	Querétaro	Paraguay	Resto
Mexico	Quintana Roo	Peru	Amazonas
Mexico	San Luis Potosí	Peru	Ancash
Mexico	Sinaloa	Peru	Apurimac
Mexico	Sonora	Peru	Arequipa
Mexico	Tabasco	Peru	Ayacucho
Mexico	Tamaulipas	Peru	Cajamarca
Mexico	Tlaxcala	Peru	Callao
Mexico	Veracruz de Ignacio de la Llave	Peru	Cusco
Mexico	Yucatán	Peru	Huancavelica

Table A1. Countries and Sub-Sovereign Units Used to Measure the Socioeconomic Impact of Last-Mile Infrastructure Development in Latin America and the Caribbean (continued)

Country	Region	Country	Region
Peru	Huanuco	Uruguay	Canelones
Peru	Ica	Uruguay	Cerro Largo
Peru	Junín	Uruguay	Colonia
Peru	La Libertad	Uruguay	Durazno
Peru	Lambayeque	Uruguay	Flores
Peru	Lima	Uruguay	Florida
Peru	Loreto	Uruguay	Lavalleja
Peru	Madre de Dios	Uruguay	Maldonado
Peru	Moquegua	Uruguay	Paysandú
Peru	Pasco	Uruguay	Río Negro
Peru	Piura	Uruguay	Rivera
Peru	Puno	Uruguay	Rocha
Peru	San Martín	Uruguay	Salto
Peru	Tacna	Uruguay	San José
Peru	Tumbes	Uruguay	Soriano
Peru	Ucayali	Uruguay	Tacuarembó
Uruguay	Montevideo	Uruguay	Treinta y Tres
Uruguay	Artigas		

Source: Authors' elaboration, based on IDB Harmonized Household Surveys.

