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Measuring the Socioeconomic Impact of Last-Mile Infrastructure in Jamaica

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Measuring the Socioeconomic Impact of Last-Mile Infrastructure Development in Jamaica

Pau Puig Gabarró, Raúl Katz, Hernán Galperin, Fernando Callorda, Enrique Iglesias Rodríguez, Antonio García Zaballos, Marcos Robles, and Ramiro Valencia

Jamaica

IDB

Abstract

This paper seeks to measure the economic and social impact (e.g., level of population spending and labor indicators) of the deployment of last-mile digital infrastructure in Jamaica. Having this information can help the Jamaican government make public policy decisions on the importance of extending last-mile deployment and creating incentives for household broadband adoption.

The results demonstrate the importance of accompanying the deployment of broadband with public policies that promote an equitable benefit from technology. In this regard, the need to carry out actions to promote digital literacy in the less-educated population, as well as specific actions to narrow the gender gap, is highlighted.

JEL codes: G18, G28, L96, L86, L42
Keywords: connectivity, digital economy, digital infrastructure, inclusion

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Contents

Executive Summary

In recent years, broadband adoption in Latin American and Caribbean countries has rapidly evolved. This has also occurred in Jamaica.

Fixed broadband penetration per household[1] in the country grew from 15 percent in 2010 to 47 percent in 2020.[2] However, Jamaica continues to lag behind the regional average for Latin America and the Caribbean, where in 2020, the household adoption rate was 56 percent.[3] The situation of Jamaican households improves when access that includes internet at home through any type of technology (e.g., through mobile as well as fixed broadband) is considered. In 2014, 30 percent of households in the country had some type of broadband access at home; by 2018, that percentage had risen to 73 percent.[4]

[1] Understood as the number of fixed broadband connections reported by the regulator divided by the number of households.

[2] Based on ITU World Telecommunication/ICT Indicators (WTI) Database 2021.

[3] Based on a survey of the number of fixed broadband subscribers, based on data published by telecommunications regulators in the region.

[4] Based on the authors' analysis of data from the Jamaica Living Conditions Survey, based on IDB Harmonized Household Surveys.

In this context of growing adoption, as in all areas of the world, broadband penetration varies significantly between urban and rural areas. The Jamaica Survey of Living Conditions, which surveys broadband adoption at home (considering all technologies), has data available for the period 2014–18 for three areas of the country, with Zone 1 being exclusively urban and Zones 2 and 3 exclusively rural. For the entire period analyzed, the level of adoption was higher in urban than in rural areas, although the adoption gap narrowed sharply between 2014 and 2018. One of the main variables explaining this difference is the supply gap, that is, limited service coverage.

In this dichotomous framework, 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 duality. This issue is even more urgent in the context of pandemic conditions, as recent research has linked broadband infrastructure deployment to a greater capacity for economic resilience.[5]

It is important to understand how a further increase in broadband adoption would affect the country's socioeconomic indicators (level of spending and labor indicators). This understanding will help the Jamaican government make public policy decisions about the importance of extending last-mile deployment and generating incentives for broadband adoption in the home. Thus, this study focuses on the differential impact of an increase in broadband adoption on per capita spending[6] and levels of employment, inactivity, and unemployment.[7]

[5] See García Zaballos et al. (2020), Katz and Jung (2021), and Katz, Jung, and Callorda (2020).

[6] The Jamaican data present information on per capita expenditure. This indicator, compared to income, has the advantage of being more stable over time (for example, if a household were to run out of income, it could maintain part of its spending through savings or loans). It is also an indicator with fewer extreme values (in high-income households, for example, only a fraction of the total is spent, with the rest going to savings) than income.

[7] The Jamaican database was examined to explore the possibility of also including impact analyses on certain social indicators, such as school enrollment, but the number of observations to estimate this indicator at the regional level was very low.

In the case of Jamaica, the evidence that has emerged from the research to date has made it possible to formalize a series of working hypotheses for evaluation:

HYPOTHESIS

H1: Growth in broadband access leads to an increase in average per capita expenditure.

H2: The increase in average per capita expenditure as a result of the increase in broadband access occurs only if the household has a computer.

H3: The economic impact (measured through average per capita expenditure) of growth in broadband access is greater for the more educated population, given their higher level of digital literacy.

H4: The economic impact (measured through average per capita expenditure) of growth in broadband access is greater for women, thus reducing the gender gap.

H5: Economic improvements (measured through the increase in average per capita expenditure) generated by growth in broadband access occur mainly because of an increase in the employed population.

To evaluate the impact of last-mile infrastructure deployment[8] on per capita expenditure and labor indicator metrics, an ordinary least squares model was specified according to the following equation. This equation consists of a simple regression that determines the effect generated by the increase in home broadband adoption on per capita spending and labor indicators. The equation is:

$$Ln\ (Y_{it}) = \beta_0 + \beta_1 . Household\ broadband\ adoption_{it} + \beta_2 . Year_t + \beta_3 Area_i + \beta_4 . X_{it} + \mu_{it} \quad (1)$$

Where:

Y_{it} : According to the model, it corresponds to the natural logarithm of per capita expenditure, percentage of the employed population, percentage of the inactive population, and percentage of the unemployed population in each area of the country.

Household broadband adoption$_{it}$: It is the natural logarithm of the percentage of households adopting broadband in each area of the country.

Year$_t$: Corresponds to a fixed effect for each year between 2014 and 2018.

Area$_i$: Corresponds to a fixed effect for each geographic area (1, 2, and 3) included in the regression.

X$_{it}$: Is a matrix of other independent variables that are used as controls in some specifications, such as age and years of education.

μ$_{it}$: It is the error term.

With respect to the dependent variable, different econometric models were applied. The first considered the impact on per capita spending. Next, we considered the impact on different labor indicators, such as percentages of the employed population, the inactive population, and the unemployed population. In all cases, the natural logarithm of the indicators was used to estimate the results as a percentage change.

[8] It is understood that an increase in the deployment of last-mile infrastructure will increase the supply of the service and generate an increase in adoption levels. As explained, given the data available for Jamaica, the household survey was not able to identify the introduction of the service at the regional level, but it was able to quantify increases in adoption levels.

Different specifications of the econometric models were made on the independent variables for each analysis. The first step was to evaluate the direct relationship between the level of broadband adoption and the dependent variables. Subsequently, understanding that the age of the population affects the dependent variables, we included a control for this factor. Finally, we added a third model with an additional control for average years of education of the population. All specifications included controls for fixed effects of year (a binary variable for each year included in the regression) and geographic area (a binary variable for each area included in the regression).

The unavailability of panel data at the household/individual level prevented the possibility of running regressions at that level of disaggregation. This problem was solved by generating pseudo-panels for each area of the country defined in the Jamaica Living Conditions Survey. To do this, the average (weighted by the weight of each individual observation) and the median of the indicators of interest were calculated for each year and area. This yielded a maximum of 15[9] observations between 2014 and 2018 for the analysis.

The results of the analysis in terms of the hypotheses considered led to the following conclusions:

CONCLUSIONS

C1: The hypothesis that the economic impact (measured through average per capita expenditure) of an increase in broadband access is positive is confirmed. In particular, we found that a 10 percent increase in broadband adoption generates a 1.83 percent increase in per capita expenditure. This result shows that, despite the fact that 73 percent of Jamaican households had some form of broadband connection at home in 2018, there are still economic benefits to be achieved through an increase in service adoption.

[9] These observations come from three zones for five years. The limitation of the results is recognized, given the low number of observations. As a control, we doubled the number of observations and divided the zones according to whether or not drinking water was available. The results remained unchanged. We also attempted to obtain a greater regional division with the available data, but the best that could be achieved from the aforementioned survey was to divide the data into the three zones mentioned above.

C2: The hypothesis that the economic impact (measured through average per capita expenditure) of growth in broadband access is conditional on the presence of a computer in the home is confirmed. In particular, we find that a 10 percent increase in broadband adoption in households with a computer and electricity generates a 1.89 percent increase in per capita expenditure. In contrast, this effect is not significant in households that do not have a computer.

C3: The hypothesis that the economic impact (measured through average per capita expenditure) of growth in broadband access is higher for the more educated population, given their higher level of digital literacy, is confirmed. In particular, we estimate that a 10 percent increase in broadband adoption in the population with more than eight years of formal education generates a 2.05 percent increase in per capita expenditure. In contrast, this effect is not significant for the population with fewer than eight years of formal education, which accentuates inequality by educational level.

C4: We reject the hypothesis that the economic impact (measured as average per capita expenditure) of an increase in broadband access is greater for women, which would reduce the gender gap. In particular, we find that a 10 percent increase in broadband adoption at home generates a 1.99 percent increase in per capita expenditure for men and a non-significant effect on women. Once the educational level of the population is controlled for, the impact increases to 2.58 percent for men and 2.52 percent for women. Considering either of the two results, it is evident that an increase in broadband adoption generates an increase in gender inequality, although when education is included in the analysis, the difference between genders does not change significantly.

C5: The hypothesis that economic improvement (measured as average per capita expenditure) derived from growth in broadband access is mainly generated by an increase in the employed population is confirmed. As confirmed in Hypothesis 1, an increase in household broadband adoption results in an increase in per capita expenditure, while implying a 0.78 percent increase in the percentage of the population employed. For this reason, it is likely that the increase in average expenditure occurs in a context of an increase in the employed population.

In summary, despite limitations in the data sources, the body of evidence in the Jamaican case provides a rich empirical basis for formulating strategies for deploying last-mile digital infrastructure and addressing demand gaps. In particular, these results demonstrate that broadband deployment can generate an increase in inequality at two levels (between individuals with more formal education and those with less education, and by gender), if not accompanied by public policies that promote equitable benefit from the technology.

First, the analysis highlights the need to carry out actions to promote digital literacy among the less educated population. Otherwise, the economic impact of connectivity will be limited to the more educated population, thus widening the expenditure/income gaps. Similarly, specific actions are needed to reduce the gender gap. In particular, boosting digital literacy and adoption of technology among women will prevent increases in service adoption from generating an increase in spending/income inequality by gender.

Introduction

The objective of this study was to estimate the socioeconomic impact resulting from the deployment of last-mile digital infrastructure in Jamaica.

The document is structured as follows: Chapter 1 describes the conditions of broadband deployment and adoption in Jamaica; Chapter 2 takes up the working hypotheses proposed in the specialized literature; and Chapter 3 presents the methodology used, the data obtained, the results, and discussion of these results.

1. The State of Broadband in Jamaica

Broadband deployment and adoption in Latin America and the Caribbean have rapidly evolved in recent years. This has also been the case in Jamaica.

Fixed broadband penetration per household[10] in Jamaica grew from 15 percent in 2010 to 47 percent in 2020.[11] Despite this growth, Jamaica continues to lag behind the regional average which, in 2020, reported a fixed broadband adoption of 56 percent of households.[12] The broadband situation in Jamaica improves when considering home internet access through any type of technology (including access through mobile as well as fixed broadband). In 2014, 30 percent of households in the country had some type of broadband access, while by 2018 penetration reached 73 percent.[13]

In this context of growing adoption, as is the case throughout the world, broadband penetration varies significantly between urban and rural areas. The Jamaica Living Conditions Survey, which surveys broadband adoption at home (including all technologies), has data for the period 2014–18 for three areas of the country, with Zone 1 being exclusively urban and Zones 2 and 3 exclusively rural. For the entire period analyzed, the level of adoption was higher in urban than in rural areas, although the adoption gap decreased sharply between 2014 and 2018 (see Figure 1).

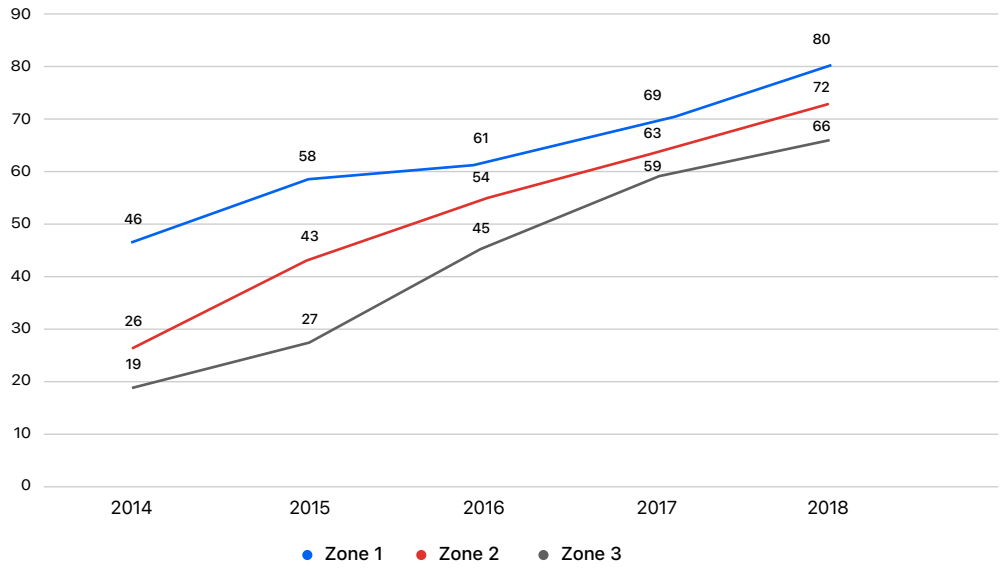
[10] Understood as the number of fixed broadband connections reported by the regulator, divided by the number of households.

[11] Based on ITU World Telecommunication/ICT Indicators (WTI) Database 2021.

[12] Based on a survey of the number of fixed broadband subscribers, based on data published by the region's telecommunications regulators.

[13] Authors' analysis, based on data from the Jamaica Living Conditions Survey and IDB Harmonized Household Surveys.

Figure 1. Broadband Adoption in Households by Zone in Jamaica, 2014–18 (percent)



Source: Authors' elaboration, based on IDB Harmonized Household Surveys (2014–18).

One of the main variables that explains this difference is the supply gap, that is, the limited service coverage. In this dichotomous framework, 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 the rural world, last-mile digital infrastructure is a lever that can help remedy the urban-rural duality. This issue is even more urgent in the context of pandemic conditions, since recent research has linked broadband infrastructure deployment to greater economic resilience.[14]

In Jamaica, where in 2018 the level of broadband adoption at the household level (considering all available access technologies) was relatively high, it is important to understand how a further increase in broadband adoption would affect the country's socioeconomic indicators (level of population spending and labor indicators). This understanding will help the Jamaican government make public policy decisions about the importance of extending last-mile deployment and generating incentives for broadband adoption in households that do not have it today.

[14] See García Zaballos et al. (2020), Katz and Jung (2021), and Katz, Jung, and Callorda (2020).

2. Hypotheses to Be Considered in the Analysis

As can be deduced from the analysis of the research literature, research on the impact of broadband, both using 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 the differential impact on income/expenditure and job creation derived from an increase in household broadband adoption. The evidence has also begun to identify other dimensions of impact, such as differences by gender, educational level, and household possesion of a computer. This evidence has allowed us to formalize a series of working hypotheses to be evaluated in the Jamaica study:

HYPOTHESIS

H1: Growth in broadband access results in an increase in average per capita expenditure.

H2: The increase in average per capita expenditure, as a result of the increase in broadband access, occurs only if the household has a computer.

H3: The economic impact (measured through average per capita expenditure) of growth in the number of broadband accesses is greater for the more educated population, given that they have a higher level of digital literacy.

H4: The economic impact (measured through average per capita expenditure) of growth in broadband access is higher for women, thus reducing the gender gap.

H5: Economic improvements (measured through the increase in average per capita expenditure) generated by growth in broadband access occur mainly because of an increase in the employed population.

3. Models and Results

The objective of this analysis was to quantify the impact on socioeconomic variables (per capita expenditure and labor indicators) stemming from an increase in household broadband adoption.

The analysis was based on the IDB's harmonized database, which compiles original data from the Jamaica Living Conditions Survey between 2014 and 2018. Although this database has surveys for previous years, it was only possible to use data from 2014 to 2018, since only these years are strictly comparable and have details for the three areas of the country. Because of this restriction in the data, in 2014 the area with the lowest level of internet adoption at home was Zone 3, with 19 percent of households already connected. This situation implies that in the period analyzed, all the observations have already surpassed the 10 percent adoption threshold,[15] which explains why in this case it is only feasible to estimate the socioeconomic impact of an increase in the level of broadband adoption at home, rather than the impact of the introduction of the service. Thus, the study focused on the differentiated impact of a growth in broadband adoption on per capita expenditure and on levels of employment, inactivity, and unemployment.

3.1. Methodology

To assess the impact of last-mile infrastructure-based service adoption[16] on per capita spending metrics and labor indicators, an ordinary least squares model was specified according to the following equation. The equation consists of a simple regression that determines the impact on per capita spending and labor indicators generated by an increase in home broadband adoption. The equation is:

[15] While this connectivity threshold is arbitrary, the literature shows that it is a minimum threshold for identifying the impact of broadband on income and employment levels (Whitacre, Gallardo, and Strover, 2014).

[16] It is understood that an increase in the deployment of last-mile infrastructure will increase the supply of the service and generate an increase in adoption levels. As explained, given the data available for Jamaica, the household survey was not able to identify the introduction of the service at the regional level, but it was possible to quantify increases in adoption levels.

$$Ln\ (Y_{it}) = \beta_0 + \beta_1 . Household\ broadband\ adoption_{it} + \beta_2 . Year_t + \beta_3\ Area_i + \beta_4 . X_{it} + \mu_{it} \quad (1)$$

Where:

Y_{it} : According to the model, it corresponds to the natural logarithm of per capita expenditure, percentage of the employed population, percentage of the inactive population, and percentage of the unemployed population in each area of the country.

Household broadband adoption$_{it}$: It is the natural logarithm of the percentage of households adopting broadband in each area of the country.

Year$_t$: Corresponds to a fixed effect for each year between 2014 and 2018.

Area$_i$: Corresponds to a fixed effect for each geographic area (1, 2, and 3) included in the regression.

X$_{it}$: Is a matrix of other independent variables that are used as controls in some specifications, such as age and years of education.

μ$_{it}$: It is the error term.

With respect to the dependent variable, we apply different econometric models. The first one considers the impact on per capita expenditure. Then we consider the effect on different labor indicators, such as the percentages of the employed, inactive, and unemployed population. In all cases, the natural logarithm of the indicators expresses the results as a percentage change.

We applied different specifications of the econometric models on the independent variables for each analysis. First, we evaluated the direct relationship between the level of broadband adoption and the dependent variables. Then, understanding that the age of the population affected the dependent variables, we included a control for that factor. Finally, we added a third model with an additional control for average years of education of the population. All specifications included controls for year fixed effects of (a binary variable for each year included in the regression) and geographic area (a binary variable for each area included in the regression).

The unavailability of panel data at the household/individual level prevented the ability to run regressions at that level of disaggregation. This problem could be solved by generating pseudo-panels across the country's zones defined in the Jamaica Living Conditions Survey. To do this, we calculated the average (weighted by the weight of each individual observation) and the median of the indicators of interest for each year and zone. This yielded a maximum of 15 observations between 2014 and 2018.

3.2. Data Used

As stated above, the analysis was conducted based on information on broadband adoption contained in the IDB's harmonized database, which comes from original data from the Jamaica Living Conditions Survey between 2014 and 2018. The 2008 survey could not be used because it presents a very high level of internet adoption relative to the data for the rest of the years (57 percent in 2008 vs. 30 percent in 2014). However, the 2010 survey was not included because it does not contain information on the availability of the internet at home.[17] We did not have access to the 2009, 2011, and 2013 surveys.

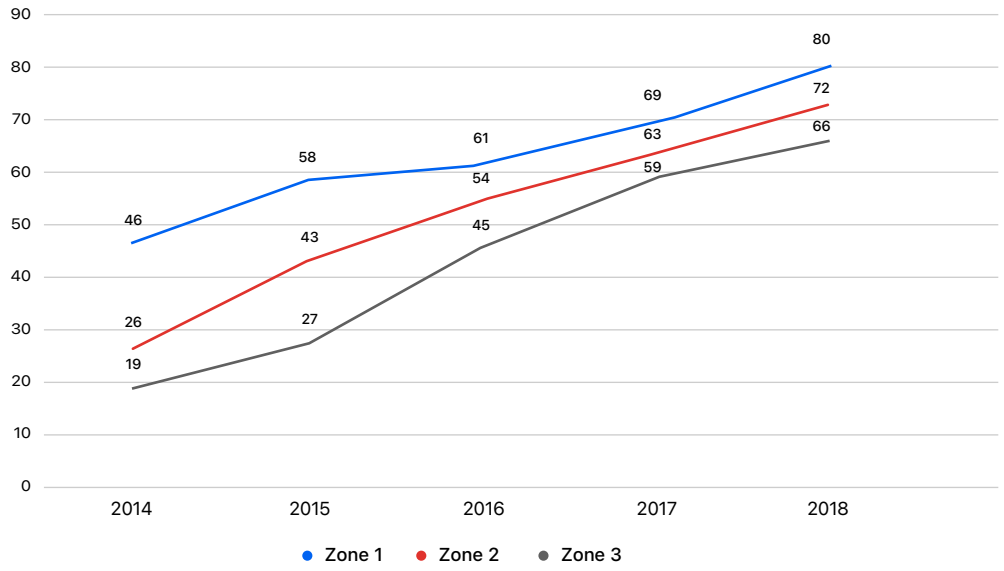
[17] The 2012 survey was used as a robustness check, as an additive to the general model. It was not used in the totality of the analyses because it was not possible to estimate the years of education indicator for it since it could present data consistency problems by generating a two-year jump in relation to the next survey (2014).

The study focused on the differentiated impact of broadband on the level of per capita expenditure and the percentages of the employed, inactive, and unemployed population. This indicator has the advantage of being more stable over time than income, since, for example, in the case of a household that is circumstantially affected by a lack of income, it could maintain part of the expenditure through the use of savings or loans. It also has fewer extreme values, since, in high-income households, for example, only a fraction of the total is spent, with the rest going to savings. We also obtained information from the IDB's harmonized database, whose data come from the aforementioned Jamaica Living Conditions Survey.

For the analysis we used the three regions of the country which are defined in the Jamaica Living Conditions Survey. This survey also has information at the parish level (14 parishes), but the number of observations for 2014, 2015, and 2016 at that level are very low (fewer than 400 in more than half of the cases). Because of this, the statistical average in some indicators was no longer consistent inter-temporally. In particular, in 7 of the 14 parishes for which information is available, there are decreases in the levels of broadband adoption, which may be due to the statistical error of the averages in a sample consisting of few observations. For this reason, the analysis at the parish level was discarded and the analysis at the regional level, which offers more robust statistical averages, was used.

The available data made it possible to observe that in 2014, Zone 3 had the lowest level of household internet adoption, with 19 percent of households connected (see Figure 2). This situation implies that in the period analyzed all the observations had already exceeded the 10 percent adoption threshold, so that in this case it was only feasible to estimate the socioeconomic impact of an increase in broadband adoption at home, rather than the impact of the introduction of the service. Thus, the study focused on the differential impact of a growth in broadband adoption on per capita expenditure and employment, inactivity, and unemployment.

Figure 2. Internet Adoption in Households by Zone in Jamaica, 2014–18 (percent)



Source: Authors' elaboration, based on IDB Harmonized Household Surveys (2014–18).

The Jamaica Living Conditions Survey presents informationj for the period between 2014 and 2018 for three three zones of the country. Zone 1 is exclusively urban, while Zones 2 and 3 are exclusively rural. Thus, the survey allows us to have a panel of data for sub-sovereign units between 2014 and 2018 (five years) for three subsovereign units (1 urban and 2 rural) based on 46,225 microdata.

From the IDB Harmonized database, we first retained only the microdata that responded on internet availability at home, per capita expenditure level, employment status, age, and educational level. To obtain effects in terms of percentage of expenditure, we estimated the natural logarithm of per capita expenditure.

The unavailability of panel data at the household/individual level prevented us from performing regressions at that level of disaggregation. This problem was solved by generating pseudo-panels for each sub-sovereign unit. The next step was to generate the average (weighted by the weight of each individual observation) of the indicators of interest for each year and sub-sovereign unit. To examine the distribution of the effect on spending among the population, we estimated the median of the spending indicators. Thus, a maximum of 15 observations between 2014 and 2018 were counted for the analysis.[18]

3.3. Results

The first econometric model estimated the impact of an increase in the supply of broadband at home on per capita expenditures, considering all available observations. As a control, we also introduced a model similar to the one mentioned above, but with a maximum level of expenditure (to avoid extreme observations), which was equivalent to the average of the indicator plus three standard deviations. In the first specification, where only the fixed effect by year and area is included as a control, we observe that a 10 percent increase in the level of broadband adoption in the home generates a 1.83 percent increase in per capita expenditure. Controlling for the age of the population, we find that a 10 percent increase in the level of adoption generates a 1.75 percent increase in per capita expenditure. These first two models were estimated also including information for 2012, with marginally higher results of 2.04 percent and 2.03 percent, respectively. Finally, we also included a control for years of education, obtaining that a 10 percent increase in the level of adoption generates a 2.56 percent increase in per capita spending. All the results show that a 10 percent increase in adoption leads to an increase in per capita spending of between 1.75 and 2.56 percent (see Table 1).

[18] The results are limited due to the low number of observations. As a control, the number of observations was doubled and the zones were divided according to whether or not they had drinking water. The results remained unchanged. We attempted to obtain a greater regional division from the available data, but the best that could be achieved from the Living Conditions Survey was to segment the data into three zones.

Table 1. Impact of Growth in Home Broadband Adoption on Average Expenditures in Jamaica, 2014–18

General model	Ln total expenses			Ln total expenses (maximum level)		
	(1)	(2)	(3)	(1)	(2)	(3)
Level of internet adoption	0.1827647 **	0.1745019 *	0.2563943 **	0.2063085 ***	0.1921431 **	0.2442956 **
	(0.0687807)	(0.0765806)	(0.067688)	(0.0590923)	(0.0633978)	(0.0674153)
Age	-	-0.0097636	0.0016855	-	-0.0167384	-0.0094471
	-	(0.0257414)	(0.0200824)	-	(0.0213102)	(0.0200015)
Years of education	-	-	0.0624791 *	-	-	0.0397893
	-	-	(0.026691)	-	-	(0.0265835)
Remarks	15	15	15	15	15	15
Groups	5	5	5	5	5	5
P.E. per year	Yes	Yes	Yes	Yes	Yes	Yes
E.F. by area	Yes	Yes	Yes	Yes	Yes	Yes
R-2	0.8666	0.8124	0.9199	0.8769	0.7780	0.8659
Impact from 10% increase in internet adoption	1.83%	1.75%	2.56%	2.06%	1.92%	2.44%

Source: Authors' elaboration, based on IDB Harmonized Household Surveys (2014–18).
Notes: The models in columns (1) and (2) of the table were re-estimated with the inclusion of information for 2012, which raises the number of observations to 18. The results found are (1) 0.2039142 *** and (2) 0.2028624 ***.
Standard errors in parentheses.
Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

Given the low number of observations available, the results of the model without additional controls were retained for the conclusions. It should be noted that in the model that applies a maximum limit to the level of expenditures, the results are within the same range as those of the model that does not apply such a limit.

The following econometric model estimates the impact of an increase in the supply of broadband at home on per capita expenditures considering all available observations and doubling the number of observations from 15 to 30. This is achieved by segmenting each area into two, depending on whether or not potable water is available at home (see Table 2).

Table 2. Impact of Growth in Household Broadband Adoption Growth on Average Expenditures(area split and subdivided by household drinking water provision), 2014–18

General model	Ln total expenses			Ln total expenses (maximum level)		
	(1)	(2)	(3)	(1)	(2)	(3)
Level of internet adoption	0.2532938 ***	0.2068433 **	0.2029352 **	0.2335967 ***	0.2015997 **	0.1967528 **
	(0.0766138)	(0.0804218)	(0.0801022)	(0.0663615)	(0.0712409)	(0.0754841)
Age	-	0.0234255	0.0199698	-	0.0161364	0.0149484
	-	(0.0156237)	(0.015385)	-	(0.0138401)	(0.014498)
Years of education	-	-	0.0794294 *	-	-	0.0518212
	-	-	(0.0377438)	-	-	(0.0355677)
Remarks	30	30	28	30	30	28
Groups	5	5	5	5	5	5
P.E. per year	Yes	Yes	Yes	Yes	Yes	Yes
E.F. by area	Yes	Yes	Yes	Yes	Yes	Yes
R-2	0.8362	0.8872	0.9117	0.8417	0.8806	0.9037
Impact from 10% increase in internet adoption	2.53%	2.07%	2.03%	2.34%	2.02%	1.97%

Source: Authors' elaboration, based on IDB Harmonized Household Surveys (2014–18).
Notes: Standard errors in parentheses.
Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

One assumption of the analysis is that the deployment of drinking water service within each zone is primarily to neighboring households, so households with or without service should be grouped together. This model is used for the sole purpose of verifying the reasonableness of the model presented in Table 1. Considering the model that contains all the expenditure observations reported in the survey (without applying a ceiling), we find that in the first specification (where only the fixed effect, by year and area, is included as a control) a 10 percent increase in broadband adoption in the household generates a 2.53 percent increase in per capita expenditure. Controlling for the age of the population, we obtain that a 10 percent increase in the level of adoption generates a 2.07 percent increase in per capita expenditure. Finally, we also include a control for years of education, obtaining that a 10 percent increase in broadband adoption generates a 2.03 percent increase in per capita spending. The total results show that a 10 percent increase in the level of adoption generates an increase in per capita expenditure of between 2.03 and 2.53 percent. As this result is in a similar range to that found in the original analysis (Table 1), for the rest of the regressions we continued to use the original data corresponding to the three zones and the five years mentioned (2014–18).

The following econometric model estimates the impact of an increase in the supply of broadband at home on median per capita expenditures considering all available observations. This analysis, unlike the one previously performed on the average, allows us to observe whether changes occur only at the extreme end of the sample or also affect the middle (see Table 3).

Table 3. Impact of Growth in Home Broadband Adoption on Median Expenditures in Jamaica, 2014–18

General model	Ln total expenses (median)		
	(1)	(2)	(3)
Level of internet adoption	0.2232617 **	0.2039794 *	0.1779623
	(0.0946438)	(0.102979)	(0.1298358)
Age	-	-0.0227847	-0.026422
	-	(0.0346148)	(0.0385211)
Years of education	-	-	-0.0198495
	-	-	(0.0511975)
Remarks	15	15	15
Groups	5	5	5
P.E. per year	Yes	Yes	Yes
E.F. by area	Yes	Yes	Yes
R-2	0.7860	0.6120	0.5358
Impact from 10% increase in internet adoption	2.23%	2.04%	0.00%

Source: Authors' elaboration, based on IDB Harmonized Household Surveys (2014-18).
Notes: Standard errors in parentheses.
Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

In the first specification, in which only the fixed effect by year and by area is included as a control, we observe that a 10 percent increase in broadband adoption at home generates a 2.23 percent increase in the median per capita expenditure. Furthermore, when controlling for age of the population, a 10 percent increase in the level of adoption results in a 2.04 percent increase in the median per capita expenditure. Finally, when controlling for years of education, a non-significant result is observed (at a statistical efficiency level of 10 percent).[19] In the first two specifications, the impact on the median distribution is greater than that of the total, which implies that most of the benefits go to the population with the median expenditure. This result disappears when controlling for years of education.[20]

The following econometric model estimates the impact of an increase in the supply of broadband at home on per capita expenditures considering all available observations, but under the assumption that a household only has broadband if, at the same time, it has electricity and a computer to maximize the benefits of its use (see Table 4).

[19] This result is significant at the 12 percent level, indicating that a 10 percent increase in broadband adoption generates a 1.78 percent increase in median per capita spending.

[20] Table 6 shows the differences in the results based on the years of formal education of the population.

Table 4. Impact of Growth in Broadband Adoption on Average Conditional Expenditures in Households with Computers and Electricity in Jamaica, 2014–18

General model	Ln total expenses		
	(1)	(2)	(3)
Level of internet, computer, and electric power adoption	0.1894 ***	0.1889356 ***	0.2028303 ***
	(0.0497219)	(0.0457054)	(0.0420869)
Age	-	-0.0259717	-0.0241955
	-	(0.0171825)	(0.0155026)
Years of education	-	-	0.0300625
	-	-	(0.0193606)
Remarks	15	15	15
Groups	5	5	5
P.E. per year	Yes	Yes	Yes
E.F. by area	Yes	Yes	Yes
R-2	0.7942	0.6188	0.6559
Impact from 10% increase in internet adoption	1.89%	1.89%	2.03%

Source: Authors' elaboration, based on IDB Harmonized Household Surveys (2014-18).
Notes: Standard errors in parentheses.
Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

In the first specification, in which only the fixed effect by year and by area is included as a control, we observe that a 10 percent increase in broadband adoption at home generates a 1.89 percent increase in per capita expenditure. Likewise, when controlling for population age, we find that a 10 percent increase in adoption is responsible for an identical increase in per capita spending. Finally, when controlling for years of education, we find that a 10 percent increase in adoption generates a 2.03 percent increase in per capita expenditure. The total results show that a 10 percent increase in adoption generates an increase in per capita expenditure of between 1.89 and 2.03 percent.

The following econometric model estimates the impact of an increase in broadband supply at home on per capita expenditures, segmenting the total sample by gender (see Table 5).

Table 5. Impact of Growth in Household Broadband Adoption Growth on Average Expenditures by Gender in Jamaica, 2014–18

Model by gender	Ln total expenses - Men			Ln total expenses - Women		
	(1)	(2)	(3)	(1)	(2)	(3)
Level of internet adoption	0.199117 **	0.2015092 **	0.2580677 **	0.1544483	0.1659342	0.2519227 ***
	(0.0761753)	(0.0813954)	(0.0948576)	(0.0818899)	(0.0948373)	(0.0597739)
Age	-	-0.0109239	-0.0092011	-	0.006102	0.0127577
	-	(0.0270158)	(0.0265694)	-	(0.0191589)	(0.0112235)
Years of education	-	-	0.0403458	-	-	0.0896087 **
	-	-	(0.036457)	-	-	(0.0248808)
Remarks	15	15	15	15	15	15
Groups	5	5	5	5	5	5
P.E. per year	Yes	Yes	Yes	Yes	Yes	Yes
E.F. by area	Yes	Yes	Yes	Yes	Yes	Yes
R-2	0.8639	0.8159	0.8785	0.8524	0.8867	0.9400
Impact from 10% increase in internet adoption	1.99%	2.02%	2.58%	0.00%	0.00%	2.52%

Source: Authors' elaboration, based on IDB Harmonized Household Surveys (2014-18).
Notes: Standard errors in parentheses.
Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

The results for men show that, in the first specification, in which only the fixed effect by year and by area is included as a control, a 10 percent increase in the level of broadband adoption at home generates a 1.99 percent increase in per capita expenditure. Furthermore, when controlling for age of the population, a 10 percent increase in the level of adoption is responsible for a 2.02 percent increase in per capita spending. Finally, when controlling for years of education, we observe that a 10 percent increase in the level of adoption generates a 2.58 percent increase in per capita spending. When the same analysis is performed for women, we find that the result is only significant in the third specification (which includes a control for age and years of education), such that a 10 percent increase in the level of adoption results in a 2.52 percent increase in per capita expenditure.

In all specifications, the effect of an increase in broadband adoption is greater for men, which highlights the need for specific actions to reduce the gender gap. This could be achieved by boosting digital literacy and the adoption of this type of technology among women, thus preventing increases in service adoption from leading to greater expenditure/income inequality by gender.

The following econometric model estimates the impact of an increase in home broadband supply on per capita expenditures, segmenting the total sample by years of education (see Table 6).

Table 6. Impact of Broadband Adoption Growth on Average Household Expenditures by Years of Formal Education in Jamaica, 2014–18

Model by years of formal education	Ln total expenditures - more than eight years of formal education			Ln total expenditures - less than eight years of formal education		
	(1)	(2)	(3)	(1)	(2)	(3)
Level of internet adoption	0.2053725**	0.2034462*	0.2700366***	-0.0757352	-0.0289238	-0.0348252
	(0.081272)	(0.0856801)	(0.05399)	(0.3472911)	(0.3669889)	(0.4111284)
Age	-	0.0219532	0.0174952	-	0.0202713	0.027502
	-	(0.0395192)	(0.0233401)	-	(0.0275834)	(0.0577505)
Years of education	-	-	0.0634698**	-	-	-0.1019215
	-	-	(0.0181322)	-	-	(0.6889902)
Remarks	15	15	15	14	14	14
Groups	5	5	5	5	5	5
P.E. per year	Yes	Yes	Yes	Yes	Yes	Yes
E.F. by area	Yes	Yes	Yes	Yes	Yes	Yes
R-2	0.8472	0.9260	0.9464	0.3569	0.6364	0.6528
Impact from 10% increase in internet adoption	2.05%	2.03%	2.70%	0.00%	0.00%	0.00%

Source: Authors' elaboration, based on IDB Harmonized Household Surveys (2014-18).
Notes: Standard errors in parentheses.
Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

If we examine the results for individuals with more than eight years of formal education, in the first specification (in which only the fixed effect by year and by area is included as a control) we observe that a 10 percent increase in the level of broadband adoption in the home generates a 2.05 percent increase in per capita spending. If we consider the control by age of the population, we obtain that a 10 percent increase in the level of adoption generates a 2.03 percent increase in per capita spending. A control for years of education is also included, which verifies that a 10 percent increase in adoption generates a 2.70 percent increase in per capita spending. Finally, when the same analysis is performed for individuals with fewer than eight years of formal education, we find no positive effect on the level of expenditure in any specification. This result highlights the need to carry out digital literacy actions among the less-educated population. Otherwise, the economic impact of connectivity would be limited only to the more educated population, a situation that would further increase the expenditure/income gaps.

The following econometric model estimates the impact of an increase in the supply of broadband at home on per capita expenditures, considering only those observations that do not have a computer at home (see Table 7). In this case, in no specification do we find a positive result on the level of per capita expenditure due to an increase in the level of internet adoption. This result shows that, for socioeconomic effects to be generated by an increase in broadband adoption at home, it is necessary to have a computer.

Table 7. Impact of Growth in Home Broadband Adoption on the Average Expenditure of the Population without Computer in Jamaica, 2014–18

General model - without computer	Ln total expenses		
	(1)	(2)	(3)
Level of internet adoption	0.0574734	0.0898657	0.0842687
	(0.0895306)	(0.0985427)	(0.1314596)
Age	-	0.0139207	0.0117871
	-	(0.016071)	(0.0203365)
Years of education	-	-	0.0167017
	-	-	(0.0685585)
Remarks	15	15	15
Groups	5	5	5
P.E. per year	Yes	Yes	Yes
E.F. by area	Yes	Yes	Yes
R-2	0.5451	0.7279	0.7830
Impact from 10% increase in internet adoption	0.00%	0.00%	0.00%

Source: Authors' elaboration, based on IDB Harmonized Household Surveys (2014-18).
Notes: Standard errors in parentheses.
Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

The following econometric model estimates the impact of an increase in the supply of broadband at home on the percentage of the population employed, considering all available observations (see Table 8).

Table 8. Impact of Growth in Home Broadband Adoption on Percentage of Population Employed in Jamaica, 2014–18 (percent)

General model	Ln employed population		
	(1)	(2)	(3)
Level of internet adoption	0.0780111 **	0.0822239 **	0.0767313 *
	(0.030214)	(0.0293794)	(0.032903)
Age	-	-0.0142897	-0.0162408
	-	(0.0116449)	(0.012918)
Years of education	-	-	-0.0068987
	-	-	(0.0127934)
Remarks	15	15	15
Groups	5	5	5
P.E. per year	Yes	Yes	Yes
E.F. by area	Yes	Yes	Yes
R-2	0.0967	0.0067	0.0016
Percentage of population	52.68	52.68	52.68
Impact from 10% increase in internet adoption	0.41	0.43	0.40
Incremental percentage	0.78	0.82	0.77

Source: Authors' elaboration, based on IDB Harmonized Household Surveys (2014-18).
Notes: Standard errors in parentheses.
Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

In the first specification, where only the fixed effect by year and area is included as a control, we observe that a 10 percent increase in the level of broadband adoption at home generates a 0.78 percent increase in the employed population, which in turn is equivalent to a 0.41 percentage point increase in the employed population as a whole. Controlling for the age of the population, a 10 percent increase in adoption generates an increase of 0.82 percent in the employed population (an increase of 0.43 percentage points). Finally, when controlling for years of education, we find that a 10 percent increase in adoption is responsible for a 0.77 percent increase in the employed population (0.40 percentage point increase). The total results show that a 10 percent increase in the level of adoption generates an increase in the employed population on the order of 0.40 to 0.43 percentage points.

The following econometric model estimates the impact of an increase in the supply of broadband at home on the percentage of the inactive and unemployed population, considering all available observations. This analysis serves to find out which sector of the population in the newly employed people in the analysis of Table 8 was affected by the increase in home broadband adoption (seeTable 9).

Table 9. Impact of Growth in Home Broadband Adoption on the Percentages of Inactive and Unemployed Population in Jamaica, 2014–18

General model	Ln inactive population			Ln unemployed population		
	(1)	(2)	(3)	(1)	(2)	(3)
Level of internet adoption	-0.086883	-0.0981763	-0.1190365 *	-0.125892	-0.089162	0.2343137
	(0.0590344)	(0.0506509)	(0.049968)	(0.4416841)	(0.4629074)	(0.2569554)
Age	-	0.0383062	0.0308962	-	-0.1245866	-0.0096802
	-	(0.0200762)	(0.0196179)	-	(0.1834798)	(0.1008828)
Years of education	-	-	-0.0262005	-	-	0.406286 ***
	-	-	(0.0194287)	-	-	(0.0999101)
Remarks	15	15	15	15	15	15
Groups	5	5	5	5	5	5
P.E. per year	Yes	Yes	Yes	Yes	Yes	Yes
E.F. by area	Yes	Yes	Yes	Yes	Yes	Yes
R-2	0.0101	0.1775	0.0670	0.6081	0.4260	0.8223
Percentage of population	43.71	43.71	43.71	3.61	3.61	3.61
Impact from 10% increase in internet adoption	0.00	0.00	-0.52	0.00	0.00	0.00
Incremental percentage	0.00	0.00	-1.19	0.00	0.00	0.00

Source: Authors' elaboration. based on IDB Harmonized Household Surveys (2014-18).
Notes: Standard errors in parentheses.
Statistical significance: ***p<0.01; **p<0.05; *p<0.1.

First, in no specification was there a significant impact on the percentage of the unemployed population as a consequence of an increase in broadband adoption at home. However, we did find a significant impact on the reduction of the inactive population in the third specification (which includes controls for age and years of formal education). In particular, we found that a 10 percent increase in adoption generates a 1.19 percent decrease in the inactive population, which is equivalent to a reduction of 0.52 percentage points. These results indicate that the increase in the employed population comes mainly from a reduction in the inactive population.

3.4. Discussion of Results

The results of the analysis, in terms of the hypotheses evaluated, make it possible to draw the following conclusions:

CONCLUSIONS

C1: The hypothesis that the economic impact (measured through average per capita expenditure) of growth in broadband access is positive is confirmed. In particular, we found that a 10 percent increase in broadband adoption generates a 1.83 percent increase in per capita expenditure. This result shows that, despite the fact that 73 percent of Jamaican households had some type of broadband connection at home in 2018, more economic benefits can still be achieved with an increase in broadband adoption.

C2: The hypothesis that the economic impact (measured through average per capita expenditure) of a growth in broadband adoption is conditional on the presence of a computer in the home is confirmed. In this sense, we verified that a 10 percent increase in broadband adoption in households that have a computer and electricity generates a 1.89 percent increase in per capita expenditure. On the other hand, in households that do not have a computer, this effect is not significant.

C3: The hypothesis that the economic impact (measured through average per capita expenditure) of a growth in broadband adoption is greater for the more educated population, in view of their higher level of digital literacy, is confirmed. In particular, it is estimated that a 10 percent increase in broadband adoption in the population with more than eight years of formal education generates a 2.05 percent increase in per capita expenditure. In contrast, this effect is not significant for the population with fewer than eight years of formal education, which accentuates inequality by educational level.

C4: The hypothesis that the economic impact (measured through average per capita expenditure) of an increase in broadband adoption is higher for women, which would help reduce the gender gap, is rejected. In fact, the analysis showed that a 10 percent increase in broadband adoption at home is responsible for a 1.99 percent increase in per capita expenditure for men, while for women the effect is not significant. It was also found that, after controlling for the educational level of the population, the impact increased to 2.58 percent for men and 2.52 percent for women. Taking either of these results into consideration, we observe that an increase in broadband adoption generates an increase in gender inequality, even though, if educational level is considered, the gender difference in the effect does not change significantly.

C5: The hypothesis that economic improvements (measured through average per capita expenditure) caused by a growth in the number of broadband accesses are mainly generated by an increase in the employed population is confirmed. As verified in hypothesis 1, an increase in household broadband adoption results in an increase in per capita expenditure and a 0.78 percent increase in employed population levels. For this reason, it seems likely that the increase in average expenditure goes hand in hand with an increase in the employed population.

Despite the limitations of the data sources, the totality of the evidence for Jamaica presents a rich empirical basis for the formulation of last-mile digital infrastructure deployment strategies and the resolution of demand gaps. In particular, these results demonstrate that broadband deployment can generate an increase in inequality at two levels—between individuals with more and less formal education and by gender—if the deployment is not accompanied by public policies that allow different segments of the population to benefit equally from the technology.

Thus, the analysis highlights the need to carry out digital literacy actions aimed at the less educated population. Otherwise, the economic impact of connectivity will be limited exclusively to the more educated population, thus widening the expenditure/income gaps. Similarly, specific actions are needed to reduce the gender gap. In particular, boosting digital literacy and the adoption of technology among women will prevent increases in broadband adoption from also generating an increase in expenditure/income inequality by gender.

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